TALLINN UNIVERSITY OF TECHNOLOGY
DOCTORAL THESIS
46/2018

Business Models in Compliance with Sulphur Emissions Control Area Regulations in the Baltic Sea Region

EUNICE OMOLOLA OLANIYI

TTÜ PRESS

TALLINN UNIVERSITY OF TECHNOLOGY
School of Business and Governance
Department of Business Administration
This dissertation was accepted for the defence of the degree 28/05/2018

Supervisor: Prof. Gunnar Klaus Prause
Department of Business Administration
School of Business and Governance
Tallinn University of Technology
Tallinn, Estonia

Opponents: Prof. Dr. Hans-Dietrich Haasis
Chair of Maritime Business and Logistics
Faculty 7: Business Studies and Economics
University of Bremen, Germany

Prof. Dr. Esa Hämäläinen
Director Brahea Centre
Centre for Maritime Studies
University of Turku, Finland

Defence of the thesis: 27/08/2018, Tallinn

Declaration:
I hereby declare that this doctoral thesis, my original research and achievement, submitted for the doctoral degree at Tallinn University of Technology has not been submitted for any academic degree or examination

/Eunice O. Olaniyi/

Signature

European Union
European Social Fund

Investing in your future

ISSN 2585-6898 (publication)
ISBN 978-9949-83-291-0 (publication)
ISSN 2585-6901 (PDF)
ISBN 978-9949-83-292-7 (PDF)

TALLINNA TEHNIKAÜLIKOOL
DOKTORITÖÖ
46/2018

Väävli emissiooni kontrolli ala nõuetele vastavad ärimudelid Läänemere piirkonnas

EUNICE OMOLOLA OLANIYI

TTÜ KIRJASTUS

CONTENTS

LIST OF PUBLICATIONS

Thesis structure entails the following articles. The author is an only author in one of the articles and the first author in the remaining four articles.

I. Olaniyi, E. O.; Viirmäe, M. (2016). The Economic impact of environmental regulations on a maritime fuel production company. *Research in Economics and Business: Central and Eastern Europe*, 8(2). ISSN 1736-9126.
(ETIS Classification 1.2)

II. Olaniyi, E. O.; Prause, G.; Boyesen, J. (2018). The Impact of SECA Regulations on Clean Shipping in the BSR. In: Ölçer, A.I., Kitada, M., Dalaklis, D., Ballini, F. (Ed.). *Trends and Challenges in Maritime Energy Management* (309−323). Springer. (WMU Studies in Maritime Affairs; 6). DOI: https://doi.org/10.1007/978-3-319-74576-3.
(ETIS Classification 3.1)

III. Olaniyi, E. O. (2017). Towards EU 2020: An Outlook of SECA Regulations Implementation in the BSR. *Baltic Journal of European Studies*, 7(2), 182–207.
(ETIS Classification 1.1)

IV. Olaniyi, E. O.; Gerber, P.; Prause, G. (2018). Strategic Energy Partnership in Shipping. In: Kabashkin I., Yatskiv I., Prentkovskis O. (Eds) *Reliability and Statistics in Transportation and Communication*. Lecture Notes in Networks and Systems, Vol 36, pp 102–111. Springer, Cham.
(ETIS Classification 3.1)

V. Olaniyi, E. O.; Atari, S.; Prause, G. (2018). Maritime Energy Contracting for clean shipping, *Transport and Telecommunication Journal*, Volume 19, Issue 1, Pages 31–44, ISSN (Online) 1407-6179, DOI: https://doi.org/10.2478/ttj-2018-0004.
(ETIS Classification 1.1)

AUTHOR'S CONTRIBUTION TO THE PUBLICATIONS

I. The Economic Impact of Environmental Regulations on a Maritime Fuel Production Company

This article was a case study of a maritime supply company - Viru Keemia Grupp (VKG) that investigated the impact of environmental regulations on the business model of a maritime stakeholder. The author contributed to the theoretical framework, the construction of the structured interviews and the analysis of the interviews and other data. The results of the interviews analysis together with Viru Keemia financial yearbook along with the company's SWOT explore the strategic entrepreneurial compliance options possible for VKG. Based on their return on investments and associated risk, the author also did the investment portfolio analysis.

II. The Impact of SECA Regulations on Clean Shipping in the BSR

This work is a co-authored research paper, and it addresses the many compliance processes undertaken by maritime stakeholders towards sulphur emission reduction in the BSR as well as their evaluations on the economic impact of the SECA regulations on their businesses and BSR. This project was a Baltic-wide project and the data gathering process involved several researchers in countries related to the Baltic Sea such as Germany, Estonia, Finland, Denmark, Norway and Poland. The author was part of this team and was the lead author. The author also constructed a 26-page online BSR survey for different classes of maritime stakeholders, coordinated the dissemination of the survey and the result analysis.

III. Towards EU 2020: An Outlook of SECA Regulations Implementation in the BSR

The work was a single-authored paper, which is a continuation of previous work "The Impact of SECA Regulations on Clean Shipping in the BSR". At this stage, total respondents were 122 as against the 60 respondents used in the previous work. The author was responsible for the theoretical framework, analysis of extra interviews and interpretation of the new results but this time focusing on the differences in the perceived impact of SECA regulations on country bases.

IV. Strategic Energy Partnership in Shipping

The author was the lead in the co-authored study. As a model consideration in shipping, work focused on strategic entrepreneurial compliance pathways available for marine fuel producer and the work showed how the costs of the sulphur regulation compliance are minimised through the adaptation of the energy-contracting model into the maritime sector and the shipowners. The theoretical model constructs provided the framework (costing and legalities) for Maritime Energy Contracting model (MEC) through the adaptation of the Energy Service Contracting concept for the maritime sector. The MEC model used the scrubber technology an abatement technology used on ships.

V. The Maritime Energy Contracting in Clean Shipping

As the lead author of this co-authored work, the author was involved in coordinating and interpreting the results. Work presented cases with real-life data to validate the scrubber investments analysis model, associated risks and the Maritime Energy Contracting (MEC) model whose concept was introduced in "Strategic Energy Partnership in Shipping". The author provided data for the case study as well as the empirical validation for the MEC model.

Other Articles and Conference Proceedings of Doctoral Studies

I. Olaniyi, E. O. & Prause, G. (2015). On Entrepreneurial Innovation Strategies in the Context of Smart Specialisation. Proceedings of the 14th International Entrepreneurship Forum (14TH IEF) Conference. *Entrepreneurial Institutions and the Entrepreneurial Society: Creating an Inclusive Agenda for Opportunity Creation*. Cape Town, South Africa. Date: 16-18 September.

II. Olaniyi, E. O. & Reidolf, M. (2015). Organisational Innovation Strategies in the Context of Smart Specialisation. *Journal of Security and Sustainability Issues*, 5 (2), 213−227, 10.9770/ jssi.2015.5.2 (7).

III. Olaniyi, E. O. & Prause, G. K. (2016). Baltic-Russian Innovation Cooperation in the Context of EU Eastern Partnership In T. Kerikmäe & A. Chochia (Eds.), *Political and Legal Perspectives of the EU Eastern Partnership Policy* (pp. 257–279). Switzerland, Springer International Publishing.

IV. Olaniyi, E. O., Viirmäe, M. & Prause, G. (2016). The impact of environmental regulations on the business model of a maritime supply company. Proceedings of the 15th International Entrepreneurship Forum: *15th International Entrepreneurship Forum; Venice, Italy, 2016. Ed. J. Mitra. Essex: Essex Business School.*

V. Olaniyi, E. O., Prause, G. & Boyesen, J. (2017). Economic Impact of SECA Regulations on Clean Shipping in the BSR - First Empiric Results from EnviSuM Project. Proceedings of 2017 International *Conference on Maritime Energy Management.* World Maritime University, Malmö, Sweden January 2017.

VI. Prause, G. & Olaniyi, E. O. (2017). The impact of environmental regulations on the regional development in Eastern Estonia. *New Challenges of Economic and Business Development* - 2017: Ed. Muravska, T. Riga: Latvian State University.

VII. Atari, S., Olaniyi, E. O. & Prause, G. (2017). SECA regulations: Co-operation Alignment Strategies for Maritime Sector. Proceedings of Shipping and the Environment from regional and global perspectives. Second Bonus symposium 2017 F. Gothenburg, Sweden 24-24 October 2017.

INTRODUCTION

Background and Context

Transportation of passengers and goods within and between European Union (EU) and other parts of the world is increasing, and shipping is often seen as a solution for transportation increasing challenges (Daduna, Hunke & Prause, 2012). Unfortunately, shipping is also a source of massive scales of global air pollution and global climate change (Corbett & Farrell, 2002; Notteboom, 2010). The assumption that maritime transport is one of the most environmentally friendly modes of transportation is based on the premise that since ships move large volumes of goods, the emissions are low when distributed per unit weight. Howbeit, emissions from shipping in the form of sulphur oxides (SOx), nitrogen oxides (NOx), carbon dioxide (CO_2) and particulate matter (PM) are significantly detrimental to the environment (Corbett & Farrell, 2002; Eyring, Köhler, Van Aardenne & Lauer 2005; Bergqvist, Turesson, & Weddmark, 2015). Sulphur oxides emissions especially cause acid rain and generate fine dust (PM) (Corbett, 2007) 1,200 times more than through aviation (Eyring et al., 2005). The PM is dangerous to human health and is one of the causes of respiratory and cardiovascular diseases, which may reduce life expectancy for about two years (Eyring et al., 2005; Corbett, 2007 & Notteboom, 2010).

Clean shipping operation was set to create a green maritime transport and targets changed and new attitudes of all maritime stakeholders towards shipping activities. It focuses on shipping induced noise control, emissions reduction, air quality monitoring, waste reception and handling (NSF, 2008; IMO 2008 & Stipa, 2013). As a part of this objective and targeting emissions reduction and air quality improvement, the International Maritime Organisation (IMO) concluded that the use of low quality of heavy fuel has a connection with the high sulphur content of the marine fuel and consequently the harmful emissions that ensue (Nugraha, 2009). Thus, in efforts to reduce airborne emissions from ships and to enhance clean shipping, the Marine Environment Protection Committee (MEPC) in its 53rd session held in July 2005, adopted a “special area” called Sulphur Emission Control Area (SECA) where sulphur emissions from shipping are regulated. The first directive banned the use of residual fuel oil with sulphur volume concentration (% w/w) higher than 1.50% from 19th May 2006.

The Baltic Sea was named the first SECA in Directive 1999/32/EC of the International Convention for the Prevention of Pollution from Ships (MARPOL) Protocol 1997, Annex I. Further amendments to the legislation included the North Sea and the English Channel in MARPOL Annex V and VI in 2007. In 2010, the SECA limit was dropped to 1.0%, and the global sulphur cap was made 3.5%. The North America and the United States Caribbean Sea area joined SECA in 2012 in appendix VII to MARPOL Annex VI. From 1st January 2015, SECA sulphur emission was further reduced to 0.1%. China finally joined in 2016 (North, 2016) and in 2020 the global sulphur cap will be lowered to 0.5% (IMO, 2016).

Problem Statement and Research Gap

While intense shipping activities are responsible for significant environmental pollution, the seas and oceans are drivers for the European economy because of their high potential for innovation and growth (EU, 2010). The maritime transport was marked as a strategic sector for the EU and in this view; “blue growth” became a long-term strategy to support sustainable growth and management in the marine and maritime sector (EU, 2012).

The implications of the compliance with any regulations are diverse; however, one prominent implication is that it connotes significant investment decisions for related stakeholders (EfficienSea2, 2016). There are discussions that the current 0.1% sulphur limit somewhat generates some economic drawbacks to the maritime stakeholders who must comply with stringent law stakeholders in other parts of the world are not exposed to thereby weakening the competitiveness of the European maritime transport (Wiśnicki, Czermański, Droździecki, Matczak, & Spangenberg, 2014). Panagakos, Stamatopoulou and Psaraftis (2014) warned about the magnitude of the costs and implication for the maritime industry. This conclusion is related to the comparative financial disadvantage of the industry regarding transportation costs especially if shipowners are made to change from cheaper fuel to the much expensive fuel since the costs of their operation directly influence the voyage costs, especially in goods freight by short sea shipping (Nugraha, 2009). Other studies expected the SECA regulations to reduce revenue for marine-based exporting industries (AirClim, 2011; Hämäläinen, Hilmola, & Tolli, 2016) which could lead to their relocation to “greener pastures”. Some works like Notteboom (2010) discussed the risk of a modal backshift to other modes of transport that could cause closure of specific ferry routes and a potential shift to road transport, which will affect the environment negatively as well through congestion and reduction of safety (Holmgren, 2014).

Linking the regulations’ implications to their sustainable and successful deployment in the EU and the Baltic Sea region (BSR) on both national and local levels, a gap for synchronised and concise literature regarding SECA regulations and the economic impacts on maritime sector in the BSR is exposed (SHEBA, 2014). Although before the take-off, CONCAWE (2013) insisted that minimal impact would occur, there are still concerns due to the instability and erratic fluctuations of the fuel price (Hämäläinen, Hilmola, Prause & Tolli, 2016). These conflicting views emphasise one of the motivations for this research; which is the need for empirically grounded information related to the economic impacts of clean shipping for knowledge-based investment decisions for the maritime community.

More so, WCED (1987) definition of sustainability as “the process that ensures that the needs of the present generation are met without compromising future generation’s ability to meet their need” puts a stronger emphasis on Risk (2004) assessment that the sustainability of any regulations is essential to achieving desired growth and goal for the present as well as the future. Risk insisted that there should be a renewed focus on the sustainability of clean shipping through innovative activities. This focus is necessary because innovative activities have a cumulative positive effect that can diffuse over time (Kline & Rosenberg, 1986). Besides, Jiang, Kronbak & Christensen (2014) explained that the capacity of the stimulated innovation related to the technological solutions for complying with the regulations could be enormous and very beneficial. Since innovation is the unique occurrences that lead to valuable transformation (Olaniyi & Prause, 2016), the actual capacity of the various technological solutions for complying with the SECA regulations needs to be known (Bergqvist et al., 2015). Furthermore, if new regulations can inspire entrepreneurial innovation for business growth (Panagakos et al., 2014), more than ever, the exploration of possible innovative intervention for sustainable and cost-effective management certainly also necessitate the need for the current study.

These challenges reveal an existing theoretical gap for literature in the maritime sector for a new rule like the SECA regulations. There is a need for the development of business models that can bring a convergence and equilibrium between regulatory demands and regulatory compliances for a neglected sector such as the maritime sector.

Aim and Scope of Work

It has been three years of the 0.1% SECA cap in the BSR, the economic evaluation of the state of shipping since the 2015 SECA's take off is crucial for accurate and concise information for researchers policymakers as well as the maritime stakeholders in public and private sector. The BSR is responsible for a significant share of the world's sea trade, which is about 15% (Nugraha, 2009). Besides, the BSR has been a forerunner in enforcing clean shipping (Helcom 2012), which has reinforced the EU leadership in existing and emerging sectors related to maritime. This work presents another opportunity to exhibit the BSR as a test lab for other regions. Thus, the aim of this research is:

To develop an optimised business model in compliance with Sulphur Emissions Control Area regulations in the Baltic Sea Region.

The thesis seeks first, to evaluate the economic impact of clean shipping in BSR through the assessment of the sulphur regulations compliance activities. Second, because regulations compliance means significant investment decisions for the stakeholders together with the reality that fuel prices are volatile and unpredictable, thesis pursues the development of strategic market mechanisms for compliance cost reduction and sustainability of clean shipping in the BSR. The research will focus on what is happening, how and where these changes are taking place and the resulting implications of these actions to offer new knowledge that can be generalised in some ways in the industry. The thesis does not seek to postulate a cause-effect situation but instead seeks to gain a better understanding of the clean shipping situation in the BSR through different interactions with maritime stakeholders. The results would include input from the maritime industry and their business stakeholders for an optimised identification of enabling indicators that are advantageous for sustainable clean shipping. The stakeholders will be but not limited to shipping companies (i.e. ship operators, shipowners), ports and port authorities, maritime equipment and services suppliers, maritime-related public sector (i.e. ministries, municipals, government agencies, education and research, police/customs and logistics service providers. At the same time, the thesis will identify gaps and patterns for market potentials and compliance business models that can support clean shipping in BSR.

To address the focus of this work, the following research questions (RQ) are drawn:

RQ1: What are the economic impacts of the SECA regulations in the Baltic Sea region?
RQ2: How do the SECA regulations influence innovative activities?
RQ3: How to optimise business models in compliance with SECA?

Both quantitative and qualitative approaches were used to collect data from April 2016 to May 2017. Research started from the previous studies and reports on clean shipping and SECA regulations, which proceeded to face-to-face structured and semi-structured experts' interviews across the BSR, experts' focus group meetings and workshop and a BSR-wide survey.

The first set of results showed that low bunker prices alleviated the economic costs of SECA compliance and the BSR is championing an impressive clean shipping campaign in the EU. However, the economic effects are dispersed unevenly and not the same for all stakeholders. The consolidated results advocate the use of BSR as a reference for a broader platform and refocus policymakers' direction towards developing suitable policy instruments tailor-fitted to specific regions or sector. The focal result presented the conceptualisation and the empirical validation of the Marine Energy Contract model for value creation and energy solutions to sustain a potential private sector in the maritime industry. As a decentralised method, it is suitable in the interim for fuel producers who must eventually develop and upgrade their process permanently at the appropriate time.

The following chapters present the unfolding arguments and reflections of the author. They also portray the processes of arriving at the conclusions. References to the “environment” in the thesis will include land and sea. The focus innovation characters for this study would include incremental innovation, process innovation and business model innovation.

Chapter 1 first presents a narrative of shipping activities in the BSR regarding SECA regulation. The second part shows how different literature and theories contribute to organisational and technological change that resulted from external influences such as the SECA regulations.

Chapter 2 provides the detailed research approach and design of the doctoral research. It also portrays how each RQ was addressed.

In chapter 3, the results are presented in a narrative form, flowing from how SECA affects the maritime industry, clean shipping and innovative patterns in the BSR. Overlapping results and findings triangulate and affirm the findings. The end of the chapter drew the implied implications for the BSR/EU maritime public and private stakeholders as well as for policymakers.

The last section concludes the thesis and presents the author’s contributions to science and management practice, the research limitations and author’s suggestions for future studies.

ABBREVIATIONS

BSR	Baltic Sea Region
CO_2	Carbon Dioxide
EnviSuM	Environmental Impact of Low Emission Shipping Measurements and Modelling Strategies
ESC	Energy Service Contracting
EU	European Union
FDI	Foreign Direct Investments
HFO	Heavy Fuel Oil
IMO	International Maritime Organisation
LNG	Liquefied Natural Gas
MARPOL	International Convention for the Prevention of Pollution from Ships
MDO	Marine Diesel Oil
MEC	Marine Energy Contracting
MEPC	Marine Environment Protection Committee
MGO	Marine Gas Oil
NOx	Nitrogen Oxides
OPS	Onshore Power Supply
PM	Particulate Matter
RQ	Research Question
RBV	Resource-Based View
SECA	Sulphur Emission Control Areas
SO_x	Sulphur Oxides
% w/w	Percentage Volume Concentration
SWOT	Strengths, Weaknesses, Opportunities and Threats
TEN-T	Trans-European Transport Network
ULSFO	Ultra-Light Sulphur Fuel Oil
VKG	Viru Keemia Grupp
WCED	World Commission on Economics and Development

1 LITERATURE REVIEW

This section addresses the mainstream of this research. First, it examines the maritime activities in the BSR as it relates to the sulphur regulations. It establishes the historical context of the events and activities of clean shipping in the region. The second part lays the theoretical perspectives on technological and organisational change. The overall review sets the framework that would guide the analysis of the data. Each theory based on its arguments, interpretations of the subject matter, applicability to the implied setting, conceptual centrality, and associated methodology mirrors how regulations, their compliance, costs, effects, organisational coping mechanism and market changes affect business decisions and choices.

1.1 EU Maritime Activities and Sulphur Regulations Compliance in the BSR

In 2005, the European Union (EU) Commission's thematic strategy on air pollution concluded that if nothing were done to curb sulphur emissions, sulphur emissions from shipping in the EU alone would exceed those from land-based sources by 2020 (Notteboom, 2010). International trade that involves the seas especially the SECA alone was reported to have amounted to about 2.3 million tonnes (mt) of SO_2, 3.3 million tonnes of NOx, and 250,000 tonnes (t) of PM as at 2000 (Concave, 2006). If this situation was left without appropriate monitoring it was projected that shipping emissions of SO_2 and NOx would have increased by 40–50 percent between the year 2000 and 2020 (Jiang et al., 2014). Therefore, to improve its citizen health and protect its environment, the EU focused on different aspects of IMO directed air pollution from maritime transport by harmonising them as a strategic concern for the EU. As a result, the SECA compliance became a part of the implementation of joint climate and energy strategy across EU member states. This action further intensifies the tackling of global climate and resources challenge. It fosters reduction in heavy reliance on fossil fuels such as oil and inefficient use of raw materials that expose the populace to dangerous and costly price shocks, which threatens the economic security and climatic stability of EU member states (EU, 2010).

In the BSR, maritime transport and multimodal container transport plays an essential role in the global transport links (Daduna & Prause, 2016) and about 15% of world trade is conducted on the Baltic waters (SHEBA, 2014). There are concerns that this would have a negative impact on the general environment especially in consideration of the level of emission that would be produced by the ships that operate in this environment. In this light, the choice of compliance is a process that is painstakingly considered by the related stakeholders due to the substantial financial investments and risks involved.

The choice for useful SECA regulations compliance options to a certain extent depend on the time the vessel spends within the SECA, the vessels fuel consumption and the price level of the low sulphur content fuels. For ships that operate less than 4,500 hours annually in SECAs, fuel switching is the lowest cost option (Carr & Corbett, 2015). When refined, crude oil produces waste products called the Heavy Fuel Oil (HFO) commonly used as bunker fuel, which has a higher sulphur content than what is acceptable in the SECA (CONCAVE, 2013). The higher grades of distillate fuels, the Marine Gas Oil (MGO) and the Marine Diesel Oil (MDO) are the most accessible choice for the SECA compliance. The fuel switch to MGO/MDO only requires small modifications to the ship engine, which entails the installation of fuel cooling system to increase the viscosity of the MGO (ABS, 2016). Shipowners can benefit from using low sulphur fuel because apart from causing less pollution to the environment, distillate fuels with low sulphur content have a higher thermal value that can reduce engine wear ensuring they require less frequent maintenance. They also lower the rate of fuel consumption (Wiśnicki et al., 2014). Furthermore, distillate fuel has a lower density than the HFO, and higher energy content (HFO approx. 40 MJ/kg, MDO approx. 42 MJ/kg) (Notteboom, 2010).

Another option is to use the Liquefied Natural Gas (LNG) (Notteboom, 2010). Natural gas is famous for the land industry for heating and transport purposes. It is more convenient for vessels to use the LNG fuel for shipping as LNG is naturally low in sulphur and meets the new SECA regulations (Wiśnicki et al., 2014). In fact, when in liquid form, it contains more energy and is easier to process in a combustion engine. However, keeping it in this state means cooling it below its boiling point, which is about -163 °C that requires pressure and three-times space, sometimes more for large tanks placed above the deck or in the ship (Bergqvist et al., 2015). Bergqvist et al. further explained that ship engine conversion for LNG requires some significant changes in the ship main engine and auxiliary systems. Additionally, there are further installations needed like the inert gas system LNG storage tanks, fuel supply systems, new piping and equipment, tank foundations, deckhouses and foundation. Apart from the additional environmental benefits, converting to LNG could be less costly in the long term, but at present, LNG supply facilities are still too few (Pape, 2015). There are still significant regulatory gaps for bunkering and infrastructure operation for the usage of LNG such as the safety aspect of the fuel, development of small-scale LNG infrastructure and the use of the LNG in general (OECD/ITF 2016).

The scrubber technology is another method used to maintain the sulphur level in the exhaust fume from the ship in the SECAs to achieve the desired environmental protection (Wiśnicki et al., 2014). The scrubbers reduce the sulphur emission by at least 90-99% alongside with the PM emissions (Caiazzo et al., 2012; Carr & Corbett, 2015). The scrubber options have two major types: the wet scrubbers (seawater open loop, fresh water closed loop and the hybrid) and the dry scrubbers (Wiśnicki et al., 2014; Brynolf, Magnusson, Fridell & Andersson, 2014; Bergqvist et al., 2015) as shown in Figure 1.1. Some shipowners are not favourably disposed to the open looped scrubber because the wash water from the ship's exhaust is sprayed back into the seawater even though the sulphur oxides are said to be neutralised before being let back into the sea (Cullinane & Toy, 2000; Brynolf et al., 2014).

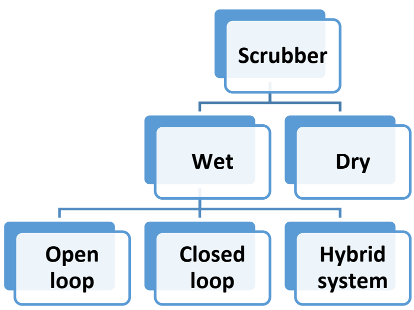


Figure 1.1: *The scrubber systems*
Source: Adapted from Wiśnicki et al. (2014); Brynolf et al. (2014) & Bergqvist et al. (2015)

AirClim (2011) also shared this concern about scrubber's efficiency and the waste production and handling, emphasising that care should be taken not to introduce more harm to the environment than is being resolved. However, extensive work has not been done to determine the significance of letting the treated waste back into the sea and the impact on the sea habitats. The additional fuel consumption for using the scrubber is usually about 3-5% (Brynolf et al., 2014; Wiśnicki et al., 2014). The conversion to the scrubber technology requires some large-scale changes such as new funnel layout, the scrubber, the installation of scrubber itself, auxiliary machinery and pipe connections, installation of new tanks and some steel work (Notteboom, 2010).

Other alternatives to SECA compliance as discussed by AirClim (2011) are alternative energy sources such as fossil fuel, wind power (e.g. SkySails), biofuels and fuel cells, batteries and Selective Catalytic Reduction (SCR) (an abatement technology used to treat exhaust gases). There are already around 500 ships fitted with SCR worldwide.

Finally, because the auxiliary engine of a ship still run when ships dock at the ports, another way to reduce sulphur and PM is if ships would shut off their propulsion and auxiliary engines and connect to a shore-side power called the onshore power supply (OPS) when docked. This power grid is used to supply the ship's refrigeration, lights, pumps and other equipment (OECD/ITF, 2016).

1.2 Theoretical Perspectives

1.2.1 Regulatory Demand for Organisational and Technological Change

Regulations are said to have cumulative effects (Jaffe, Peterson & Stavins, 1995). Under what is considered "crisis", Kinzerska (2012) explained that the uncertainties regulations bring affect the quality of economic forecast and investment decisions. In this situation, business owners usually make significant re-adjustment to their service or product delivery due to the change in demand or taste of end users (Jaffe et al., 1995). In their response to regulations, companies incur considerable expenses to change their operations or sometimes products to comply (Bourlès, 2013). They embark on activities that include the general overhaul of their service system by procuring new equipment, facility upgrading, training of staff and other strategic decisions (Wiśnicki et al., 2014). Consequently, because of the resulting increased costs of doing business, companies may end up transferring the costs of products and services to the end users (Kinzerska, 2012).

The 2020 global sulphur cap was predicted by OECD/ITF (2016) to have a substantial overall effect on shipping costs, which would be between 20% and 85% increase depending on the general sailing assumptions on speed, fuel price and ship size of a vessel. The relatively large margin according to the OECD/ITF will be primarily due to the uncertainty surrounding the availability of low-sulphur ship fuel. They predicted the regulation requirements might probably add an annual cost that is between 5 to 30 billion USD to container shipping industry alone. Even if the regulation take-off is postponed to 2025 as being agitated by some, the maritime transport costs are still likely going to have an increase of 4% to 13%. Arguably, these extrapolations could suggest that the economic effect of regulation is tough on related markets and their economic growth.

Inferring from the endogenous growth theory that expresses how the economic well-being of a country relies on the actions its people (Aizenman & Marion, 1993), perhaps, we can deduce that the impact of governmental policies would have both short and long-term effect on a country's economic growth. Especially regarding policies that result in public spending. Barro (1991) explained that the introduction of new regulations distorts the markets through “unreasonable” tax rates and capital expenditures. In agreement with Barro, after testing the endogenous growth model using a period data from the OECD, Bleaney, Gemmell & Kneller (2001) concluded that most times, the long and short-term effects of public spending often result to stagnant economic outcomes. However, unlike these studies, Solow (1994) argued that the productivity dividend from the collective activities of regulation compliance actions is essential for the growth of the country involved and that innovative compliances often lead to technological development or push. Supporting this line of thought, Dosi, Fagiolo & Roventini (2010), in their work provided evidence showing that innovative exploration of new technologies even though in the short-term is characterised by substantial spending and perceived as risky, have a mild effect on the long-term. New technologies also have the potential to deliver a balanced equilibrium between demand and supply. Olaniyi & Prause (2016) explained that innovative activities are the primary drivers of economic and social growth and that the economy of a country is directly proportional to the development of its markets and technologies.

On another dimension, the new institutional economics theory indicates a clear correlation between the institutions and the combined character of a nation by inferring that the institutions in a country determine its economic growth (Coase, 1998). In this case, “institutions” in new institutional economics are “active rules” such as laws, customs and regulations. The theory’s major argument is that institutions encompass “transaction costs”, which are expensive (Eggertsson, 2013). Transaction costs are called “enforcement of contract” or “compliance costs", and Eggertsson insisted that often, transaction costs are so high that they obstruct or impede the proper administration of the intended institutions (regulations) referring to them as “gaps”. In this regard, the gaps can be assuaged with what Blind (2012) called “regulatory instruments”. Efficacious regulatory instruments can create a balance between the costs and the benefits of regulations and prevent societal waste, which is why strategic management stresses why a company must combine the structures of internalisation and the environment to reduce transaction and production costs (market exchanges) (Coase, 1960). It is only wise that companies strive to create different opportunities for an additional resource and use the strategic fit between their internal characteristics (strengths and weaknesses) and their external environment (opportunities and threats) (Chesbrough, 2010).

To rely exclusively on a single type of resource is not useful in the present day competitive environment. As Barney (2001) explained, the capabilities of firms change over the time, and the competitive implications of those changes must be exploited using both the internal and the external stimuli. Introduced rules and policies are external stimuli a company must be prepared for at all time. Rumelt (1984, pp. 557) found essentially that the resource-based view (RBV) theory uses the notion that a company’s competitive position can be differentiated by the array of unique resources and relationships that provide a much-needed balance between the company and its environment. The innovative capacity of a firm could be explained from this point of view because technology advances demand new strategies to maintain a competitive position in the market. It is not enough to compete only with technological innovation, and it is necessary to design a winning innovative and competitive business strategy (Howells, 2005).

1.2.2 Propulsions from the Business Environment

The fast terrain of technological change makes it necessary for business strategies and relationships to change along with the dynamic business environment. Companies should challenge themselves to look "outside of the box" for their business strategies and at the same time refine their business relationships to capture maximum value by ensuring that only useful related resources are combined (Bowser, 2001) as a process of resource collaboration (Baden-Fuller & Morgan, 2010).

Alliance formation can be borne out of technological needs, apparent environmental uncertainties and other strategic drives (Das & Teng, 2000); one of such could be regulatory compliance. The RBV can be used to understand strategic management through alliances because cooperative relationships are motivated by the rationality of strategic resource requirements and social resource prospects (Das & Teng, 2000). Eisenhardt & Graebner (2007) study suggests that alliances are most likely formed when companies in vulnerable situations (e.g. that lack some resources) and companies in advantageous positions are within sight of each other's strengths or weaknesses. A situation that can lead to a deliberate collaboration that focuses on achieving competitive advantage from the partnership (Das & Teng, 2000).

At times, when companies are collectively or normatively regulated, there is an intensified probability for general adoption of same strategies and similar activities i.e. isomorphism (DiMaggio & Powell, 2000) explained by the institutional theory of organisations whose fundamental construct is that external or internal pressures influence organisational activities (Peters, 2000). The SECA compliance activities is an example to confirm that institutions do influence the behavioural pattern of organisations within the same environment or industry as it is witnessed in the BSR maritime industry today.

On some occasions, companies make efforts to differentiate themselves through their structure (Reynolds, 1981). This notion is further explained by the neoclassical paradigm of the institutional theory. For example, in the process of reworking its resources or competencies, an organisation could end up changing its entire organisational systems, such as a change in delivery or supply chain system (Baden-Fuller & Morgan, 2010). Equally, changes in the value network or value chain could lead to changes in the resources and competencies available, such as in managing customer service or end-user relationships (Demil & Lecocq, 2010). Neo-institutionalism thus evokes a practice that expects organisations to be research fields, a realist ideology about modern society and preservation of stable philosophies that the society is made up of restricted but sensible actors (Dosi et al., 2010).

1.2.3 Change in Business Model for Compliance Outcomes

The theories discussed (i.e. endogenous growth, new institutional economics, institutional theory and RBV) showed similarly, yet different views on regulations and its position in the strategic stance of a company (figure 1.2). For example, RBV emphasises that external stimuli (e.g. regulations) can differentiate a company, the institutional theory dwells on how same external stimuli cause companies to act similarly. At the same time, endogenous growth theory infers that regulatory interventions have the potential to lead to productivity loss or a much positive result like innovation, while the new institution theory insists that transactional costs (compliance costs) are expensive. This divergence points to the need for business strategies that can bring equilibrium between regulatory demands and their compliances so that regulatory compliance will not lead to societal waste in the maritime industry.

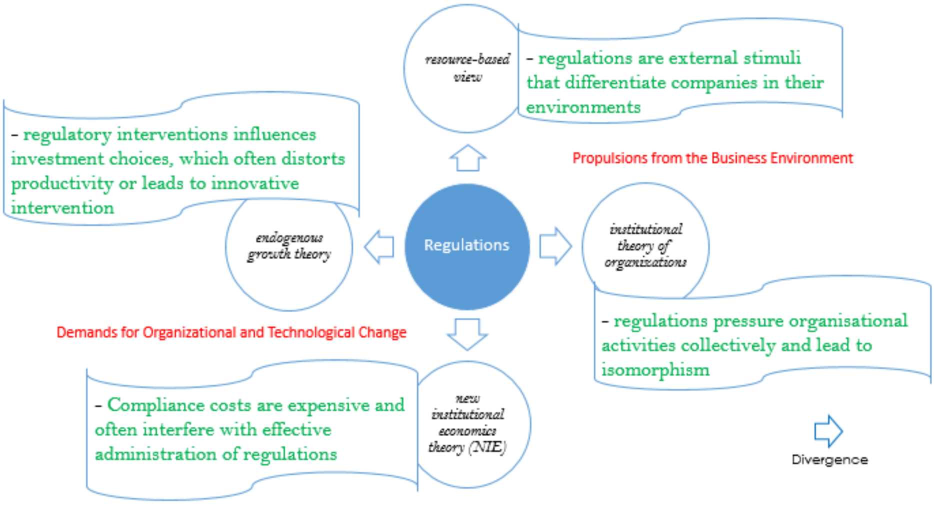


Figure 1.2. *The Divergence of Regulation Based Theories*
Source: Based on Jaffe et.al. (1995); Coase (1998); Rumelt (1984); Das & Teng (2000)

Business strategies are sometimes made through changes in business models because a business strategy is considered as a valuable intangible resource of a company, and innovative products or services are more likely to offer unique benefits and occupy distinct places in the market (Barney, 2001). Business models are building blocks used to construct a business strategy that can create value for both the company and its products end users (Osterwalder & Pigneur, 2009). Companies can take a dynamic approach by using the business model as a blueprint that defines critical functions of the different transformational activities undertaken using the business model as a tool used to focus on change and innovation in the company for radical transformation (Osterwalder, 2004; Demil & Lecocq, 2010). With proper handling, business models can be used as laboratories that will create enablement of new concepts and theories (Baden-Fuller & Morgan, 2010).

It is true that generating a sustainable competitive advantage requires the exploitation of a company's resource. However, according to Jaffe et al. (1995), when companies cannot fully access limited resources or by themselves lack the competence to handle opportunities or challenges; combining their adequate skills with an external source can help to achieve the needed goal. In this context, since the compliance costs are overwhelming for maritime stakeholders, developing business models that can leverage their strengths or/and weaknesses to achieve a marketing strategy for the SECA regulations implementation challenge is crucial. This process will be similar to the concept of smart specialisation that emphasises potentials and the mechanisms (Olaniyi & Reidolf, 2015). Even though at the beginning, the process is experimental, experimentations are said to have the ability to create competitive differentiation, and first successful experiments are usually the quickest to creating market advantage (McGrath, 2010). This way, the new entrepreneurial process can champion the identification and distribution of potential opportunities (Olaniyi & Reidolf, 2015).

2 RESEARCH METHODOLOGY AND SETTING

This chapter overtly provides how the research design, its instruments, samples and measurement methods were used to enact the assumptions and conclusions of the thesis. It gives an overview of the research setting and the rationale behind each setting and how the research method was chosen to answer each research question. The chronicle presented are drawn from the theoretical framework, synthesis of existing knowledge and insights elucidated in the previous chapter to build a system of interfaces that show the realities regarding ways and how change is taking place through clean shipping campaigns in the BSR maritime industry and from the SECA regulations. Results are principally optimised by the evaluation of the economic impact and the overall success and challenges of the SECA regulations.

2.1 Research Design

Due to the exploratory and descriptive nature of this research, the data collection, organisation and analysis methods were both quantitative and qualitative (Marshal 1995 pp. 78-80; O'Leary, 2009; Mkansi & Acheampong, 2012). This approach was taken to enhance, converge and corroborate the results outcomes as explained by Klein & Myers (1999); Creswell & Clark (2007); O'Gorman, Lochrie & Watson (2014).

According to Easterby-Smith, Thorpe & Jackson (2012, pp. 22-29), research questions should determine the selection of research design, i.e. having an understanding of the problem, what should be done to solve them and the assessment of the result. As shown in figure 2.1, to address the dynamism of the RQs, first, information from the desktop research provided the background for both the quantitative and qualitative research approaches, which involved the interactions with maritime stakeholders in the BSR. The quantitative analysis was used to generate a generalizable result on SECA compliance in the BSR while the qualitative approach was used to deduce the social intricacies and implications of these events.

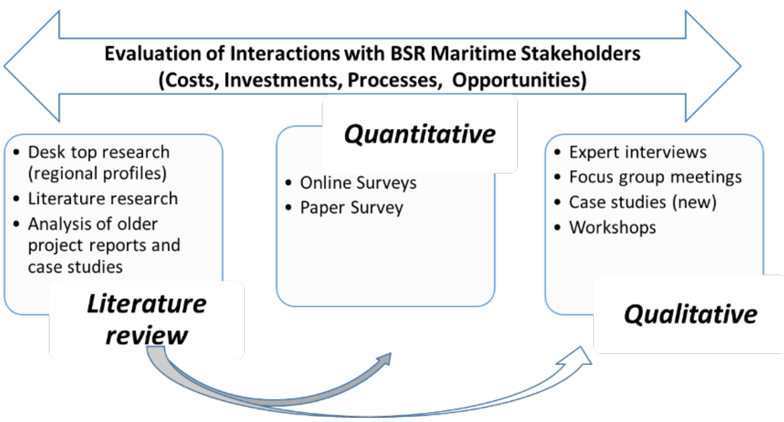


Figure 2.1. *Research Design*
Source: Author's compilation

2.1.1 Data Collection

All empirical data was gathered between May 2016 and September 2017 in the frame of "EnviSuM" project - Environmental impact of low emission shipping measurements and modelling strategies, an EU funded project where TTÜ studies SECA Investment Analysis.

Data collection was based on the interactions with BSR maritime stakeholders and their views on issues that border on their investments, costs of compliance, the process of compliance and their general evaluations on the impact of the regulation. Stakeholders with executive level of management were targeted, centred on the assumption that they are core part of an everyday decision process in most maritime organisations.

There are five groups of the maritime stakeholders namely:

1. Shipping companies (Ship operators, Shipowners)
2. Ports
3. Ship Suppliers (maritime equipment and services)
4. Port authorities, Non-governmental organisations (NGO), Public sector (Ministry, Municipal, Government agencies, Education, Research), Police/customs
5. Shippers (Logistics service providers, Production and Trading, Real Estates/Facilities Managers).

Based on their impact factor, i.e. how closely they are influenced by the SECA regulations, priority for data collection was on the shipping companies (Ship operators, Shipowners), Ports and Ship suppliers.

2.1.2 Instruments and Materials

Document Reviews: Included desktop research that involved scoping literature research, analysis of older project reports case studies using keywords like SECA, sulphur regulations, clean shipping and IMO regulations and so on. These research activities were done to obtain secondary data and background check related to clean shipping and SECA regulations in the BSR as well as regional data profiles, data and reports examinations before SECA.

Primary Data collection*:* Four instruments were used:

1. Expert interviews: First, a pilot was conducted to ensure the interviewer gets comfortable with the role, check the appropriateness of the questions and know the length of the interviews according to O'Leary (2009). Thirty-eight (38) structured and semi-structured interviews (Appendix 2) were conducted in different parts of the BSR. The interviews involved different representatives of the groups of stakeholders and were face-to-face, telephone calls and through Skype videos. All interviews lasted between 1 and 2 hours depending on the venue and place or type of interview. Notes were taken during the interviews. Both closed and open questions were asked. The closed questions were used to obtain background information on the interviewees regarding SECA and other related environmental regulations while the open questions were related to their present and future activities regarding the SECA regulations, which gave room for more in-depth discussions and reflections.

2. Focus group meetings and workshops: The focus group meeting was named the "learning café", and along with other four workshops, groups of maritime stakeholders were brought together to share information based on their professional experience and opinions.

3. Case studies: Different cases were constructed to understand the process and to conceptualise ideas and concepts for the thesis. Compliance case studies were made on three major shipping lines in BSR (Tallink, Estonia; Viking Line, Finland and DFDS, Denmark). Other cases were on the Maritime Energy Contracting (MEC) and the investment and risks analysis of the scrubber; both are proposals for the maritime sector to reduce the costs of regulatory compliance.

4. Surveys: A BSR-wide survey was conducted at http://sgiz.mobi/s3/EnviSuMSurvey. A pilot survey was done for content validity as well as for clarity. The survey was targeted at all groups of maritime stakeholders earlier mentioned. 520 surveys were sent. The first part of the survey was drawn to understand each stakeholder, their background and knowledge on SECA while the second part included a 10-factor question on SECA impact on economic parameters. These are *blue growth, costs, pricing, development, innovation, foreign direct investment (FDI), cargo flow, modal split* and *BSR reputation*. 122 responses were collected from a cross-section of maritime experts from Estonia, Denmark, Finland, Germany, Norway, Sweden and Poland provided through a network of EnviSuM project partners.

2.1.3 Data Measurement and Analysis

Different analyses were used in the articles to address the overall objective and research questions. Analysis of the data from the interviews, focus group and workshop meetings were made according to Yin (1989). Statistical software was used to analyse the survey data with a 5 - point summative rating scales from -2 to +2 – showing the degree to which the impact is very negative to very positive. The overall data measurement and analysis for each research question as reported in each article is presented in Table 2.1.

RQ1 - *What are the economic impacts of the SECA regulations in the Baltic Sea region* was examined in **Articles I, II and III**. In these studies, observations, case studies, expert interviews, focus group meetings and a BSR-wide survey was used for data gathering. **Article *I* -**"the economic impact of environmental regulations on a maritime production fuel company" zooms in on the economic implication of the sulphur regulations on maritime fuel producer. Through a case study, the article highlights how a seemingly beneficial environmental directive could affect a traditional maritime fuel company due to a change in their market demand. This was the first stage of the research because fuel is key to achieving the 0.1% sulphur emissions and because of the current low price of fuel. Furthermore, the introduction of the 2020 sulphur global cap introduced an interesting twist to the discussion since it made sulphur emissions a global issue. **Article II** - "the impact of SECA regulations on clean shipping in the BSR" and **Article III** - "towards EU2020: an outlook of SECA regulations implementation in the BSR" are "twin-articles", where the former was a spin-off and the latter an update on the previous results and continuation from the former. In both articles, the first parts concentrated on the various activities witnessed in the BSR because of the SECA regulations. In the second parts, both articles through statistical analysis gave the accounts of the reactions of maritime stakeholders to the SECA regulations. While **Article II** focused primarily on the differences in sectorial reactions, **Article III** focused among other things, on the differences in the reactions of the stakeholders on a country bases using Estonia's and Denmark's stakeholders.

Research Question	Article	Analysis Instruments
RQ1: What are the economic impacts of the SECA regulations in the Baltic Sea region?	Article I	observations, case studies, expert interviews
	Article II Article III	BSR–wide survey, expert interviews, case studies, focus group and workshop meetings
RQ2: How do the SECA regulations influence innovative activities?	Article II Article III	BSR–wide survey, expert interviews, case studies, focus groups and workshop meetings
RQ3: How to optimise business models in compliance with SECA?	Article I	observation, case studies, expert interviews
	Article IV Article V	case studies, expert interviews

Table 2.1: *Research Data Measurement and Analysis*
Source: Author's compilation

RQ2 - *How do the SECA regulations influence innovative activities* was addressed in **Articles II and III**. Both articles made the connection between clean shipping, blue growth and the SECA regulations. Since the SECA regulations and other related regulations were borne to enhance clean shipping, a direct subset of blue growth, the analysed results were from the experts' interviews, documents reviews and focus group meeting on the activities of maritime stakeholders in BSR. Different innovative alternatives and technologies that were created for or/and are enhanced by SECA compliance activities were identified.

RQ3 – *How to optimise business models in compliance with SECA* was tackled in **Articles I, IV and V**. By scanning both the internal and external environment of a fuel producing company, **Article I** through a case study puts forward possible investments pathway (models) for the case company. The investment portfolio analysis was further used to show the return on investments and their associated risks. **Article IV** – "Strategic Energy Partnership in Shipping", a prequel to Article V introduced the theoretical framework for the "Maritime Energy Contracting (MEC) package" as a market mechanism for the delivery of emissions reduction. It focuses on the business model change and the contract details. As the sequel, **Article V** – "Maritime Energy Contracting in Clean Shipping" delivered grounded real-life scenarios and case studies on scrubber investments and the MEC. This study first appraised the investment risks and payback period associated with the scrubber using different capital budgeting methods. It went further to illustrate how the MEC model can be an optimised model that can deliver cost-effective and sustainable emissions reduction using the scrubber technology with real-life data from the BSR.

2.2 Ethical Considerations during Research

Ethical values stimulate the standards that are critical to co-operative work. It involves "trust", "accountability", "mutual respect", and "fairness" (Gajjar, 2013). There are different codes of conducts when regarding research ethics as listed by Gajjar, however, author paid careful attention to the following:

Honesty – Author strived for honesty in data reporting, results, methods and procedures, and publication status.

Objectivity – Knowing that there is an intense criticism for subjectivity related to experts' opinions and other face-to-face data collection, which questions the reliability and validity of informant's testimonies, author avoided bias in data analysis, data interpretation, stakeholders' testimonies and other aspects of research where objectivity is expected. The author triangulated research data and presented a fair representation of participants together with the connectivity in their responses to provide credence to the data gathered according to Seidman (2006 pp 9).

Integrity – Author made efforts to keep promises and agreements with sincerity and consistency.

Carefulness – Author sought to avoid mistakes and laxity, examined personal work and others with careful critical deliberations and kept good records of research activities and data collection.

3 RESULTS, DISCUSSION AND IMPLICATIONS

Chapter 3 presents the accounts of the empirical results from the research activities discussed in the earlier chapters and articles I-V. First, a summary of results from the study is reported in the chronological order of the RQs followed by the implications of these results. Afterwards, inferences were made together with lessons from the results and what they mean for the BSR maritime sector, SECA regulations and the future of the BSR shipping. The discourse is finalised by giving policymaking based suggestions.

3.1 SECA Compliance Activities

At the introduction of SECA, there were many speculations and predictions, and some of them were not promising for the BSR. Results from the three years since the 0.1% SECA law entered into force revealed the many actions taken by the maritime stakeholders around the region. There are positive achievements, mistakes were made, and some shipowners and fuel producers still struggle with their decisions on compliance options while some have been able to enjoy some profit one way or another (articles I-III).

So far, compliance measurement of air emission on the Baltic waters is an impressive record of 95% and 85% around its borders. The favourite choice for most shipowners is switching to the low sulphur fuel because it only slightly increases the cost of operations for a voyage and the shipowners do not necessarily have to make any investment decisions or risky undertakings. Most shipping companies like the Tallink, Estonia are using this strategy. However, many of them are still wary that there could still be a surge in fuel cost at any time in the future (article II & III).

Results revealed how some shipowners embraced the use of LNG as an alternative to marine fuel because the LNG combustion emits next to zero harmful emissions, ensuring its acceptance as a form of insurance towards other predicted future emission regulations. As of 2016, there were 27 LNG of powered ships in Europe, of which three are retrofitted. Apart from these, 40 ships are presently scheduled to be delivered by the end of year 2018. LNG engine installations are preferable on a new ship because of the costs of the retrofit, which being over 10 million is quite expensive. The *Viking Grace* of Viking line, Finland was the first LNG driven vessel in the BSR. Another LNG powered ship is scheduled for delivery by 2020. Most ports in the BSR (i.e. ports of Stockholm, Gothenburg, Nynäshamn, Lysekil (Sweden), Świnoujście (Poland), Klaipeda (Lithuanian), Pori (Finland) and Hirtshals (Denmark) are already equipped with one form of the LNG facilities or another. Further LNG infrastructures are steadily developing in other ports because of the EU Directive 2014/94/EU that mandates all TENT-T (Trans-European Transport Networks) core seaports to be equipped with LNG bunkering terminals by the year 2025.

The installation of the scrubber is also typical in the BSR. The scrubber is mostly preferred for retrofit for old ships that are nine years and above. The costs of the retrofit are between 2-5 million euros depending on the ship, its age, size and the type of scrubber. Mostly installed on ferries, RO-RO and general cargo (feeder container ships), as at the first quarter of 2017 there were 83 scrubber-retrofitted ships in the BSR. The dry scrubbers are no longer used in shipping, while the hybrid scrubber is most preferred among the wet scrubbers. DFDS Seaways, Demark is known for their scrubber strategy and has 21 scrubber-retrofitted ships as of January 2017. There are already clear rules on how to dispose wash water from the scrubber and the pH limit testing criteria stated in the “2015 guidelines for exhaust gas cleaning systems” of IMO, 2015, annexe 1.

However, from other reports, interviews and visits, the ports are still vague in their positions towards the waste management of the scrubber sludge and wash water.

3.2 Impact of SECA Regulations on Maritime Business Activities

3.2.1 Economic Impact of SECA Regulations

The result from a case study of a fuel producing company (article I) showed that some small-scale fuel producers face possible loss in revenue from the costly and risky investments associated with their compliance with the sulphur regulations.

The results from the survey analysis regarding the impact of SECA regulations on maritime business activities in the BSR (article II & III) are as follows:

All results are in percentages of the overall responses of 122 survey respondents. All (100%) respondents are acquainted with the SECA regulations, and the employees of 67% of respondents are familiar with the essentials of the SECA. 91.7% monitor and evaluate their clean shipping activities mostly because it is mandatory. 60% are interested in an available tool that could help them decide optimal compliance solutions. 63% are pleased with the SECA preparations by IMO but acknowledged some noticeable gaps such as information gap, underdeveloped services, underdeveloped and unclear rules for sanctions, monitoring and controlling activities.

From the standard deviation analysis of the survey data, the mean scores for all economic parameters were nearly zero, suggesting a similarity in the stakeholder responses. The respondents considered factors such as *costs, pricing, FDI, cargo flows* and *modal splits* on SECA as insignificant while *innovation* and the *branding of the BSR* are seen to be a positive impact from SECA. To find out which of the nine variables have a significant impact on the variable "overall economic impact of SECA", additional linear regression analysis according to Mendenhall and Sincich (1989) was used. The F-test indicated a substantial fit for the subsequent model. Variable *blue growth, cargo flows* and *branding* from the regression analysis coefficients and are statistically significant with a positive leading sign of r = 0.56, 0.33, 0.32 respectively. Their ß-Coefficients percentages also show they accounted for about 56% of the "overall economic impact of SECA". Regression coefficients showed that *blue growth*, c*argo flows*, *branding* and their related t-test are statistically significant with positive sign*s.* The sum of their ß-Coefficient percentage of 56% accounts for the ***overall impact of SECA***, suggesting that *blue growth*, c*argo flows* and the *BSR branding/reputation* are the closest factors linked to the “overall impact of SECA”. The sum of their ß-Coefficient also connotes that the improvement of the “overall impact of SECA” works in parallel with these factors. Factor *pricing* has a negative sign of “nearly significant” implying that any surge in costs of commodities in BSR will negatively influence the “overall perception of SECA”.

The variance analysis results exhibit that, *modal split* shows significant differences in the responses from the shipowners and the ports. While the shipowners are positive that the SECA regulations will not lead to a modal split in the BSR, the ports believe the modal split could be imminent. Further variance analysis also shows significant differences in the responses of stakeholders form Estonia and Demark. These differences were in the *overall impact, development, blue growth* and *FDI* with a probable error of $p < .05$. The Danish participants are six (6) times more positive about the *overall impact* of SECA regulations than the Estonians. Estonians are neutral to *development* and are less enthusiastic towards SECA influence on *blue growth*. Danish stakeholders also believe that the SECA regulations will attract *foreign investments* whereas their Estonians counterparts do not think so.

3.2.2 SECA Regulations Innovation Patterns

The results in this section was from expert interviews, case studies, focus groups and workshop meetings. The resulting innovation outcomes that will be mentioned are process-innovation (i.e. Onshore Power Supply, emission-monitoring drones) and product-innovation (i.e. ULSFO, scrubber, SECA Compliant Dual Tank Ship Engines). Aforementioned, for this study innovations are: incremental - improved already existing, i.e. better, faster and cheaper; process and business model innovation - implementation of new/improved products and services according to Janszen (2000). Not all of the innovative compliance solutions mentioned were borne from SECA, but their development and deployment were fast-tracked by the SECA regulations and its compliance activities.

a. **The Ultra-Low Sulphur Fuel Oil (ULSFO)** is a unique hybrid of fuel that is gradually finding its way as a cheaper marine fuel since 2015. Its advantage over the distillates apart from the lower price is that it is higher in viscosity and has lower volatility. Market reports from Platts (2016) showed a market demand increase from the 180,000mt Amsterdam – Rotterdam – Antwerp every month in 2016 and predicted a monthly growth of 300, 000mt towards the end of 2017 - a demand setting to tie with the MGO current monthly demand of 320, 000mt. There are fears, however, on the unknown effect of a prolonged usage on ship engines that were not initially made for this particular type of fuel. The ULSFO will help the fuel supply constraints that may ensue from the 2020 global sulphur cap.
b. **The Scrubber** emanated from the flue gas desulfurization (FGD) technology that washes or scrubs sulphur emissions from the exhaust of a ship that uses the HFO. Initially, the use of scrubber was prominent in chemical industries. However, the technology has been extensively upgraded over the years from the "cumbersome" big and bulky dry scrubber to the wet scrubbers now commonly used on the ships. While there is only one known dry scrubber retrofitted ship in the BSR, many wet scrubbers are noticeably installed. The upgrade of the open-loop and the closed-loop scrubber to the hybrid scrubber system, a technology that combines both the open and closed-loop systems has proven to be very useful in the BSR because of its flexibility of use while on a short or deep-sea sail. The space needed for the scrubber installation has also reduced considerably. The switch is reported to be straightforward and automatic.
c. **SECA Compliant Dual Tank Ship Engines** is a useful technology where shipowners believe that the easiest way to manage the SECA regulations is to use the HFO in non-SECA and switch to the MGO/MDO in SECA. However, while the claims were that the switch is automatic and does not pose any threat to its compliance stance, some shipowners have admitted that sometimes due to a mechanical error such as a leakage there can be a default. Besides, for a switch to be perfect, it must take place around 30 minutes before entering SECA to ensure the HFO burns out completely, which may not always be the case. Nevertheless, most shipowners have claimed to be consistently successful in making the switch and to lay rest to this discussion, the concept for a dual engine was developed. An example is the Tallink *Megastar*, a dual fuel tank engines vessel powered by both the LNG and the MGO,

built by the Meyer wharf in Turku (Finland). The *Megastar* ship's propulsion is fortified with a 5-engine capacity (a 3 Wärtsilä 12V50DF - 11.4 MW/machine and a 2 Wärtsilä 6L50DF - 5.7 MW/machine) which runs about 6000h/yr. The engines can be automatically switched from MGO to LNG at an automatic 1-minute switch that gives room for the MGO to slowly change to LNG or vice versa.

d. **Onshore Power Supply** is a useful technology when a ship docks at the port. The SECA directive has hastened its development across the BSR ports. The ports of Gothenburg, Lübeck, Helsinki, Ystad (with a large OPS system for both 50 Hz. and 60 Hz.) and Stockholm are already using this solution. The Helsinki port introduced shore power in 2012 for Viking Line's ferries. Already, in order to ensure SECA complaint and standardisation the port of Stockholm is currently having five of its quays equipped with the OPS system.

e. The OECD/ITF emphasised **Monitoring and Control** for sustainability and effectiveness of the SECA regulation. In Poland for example, even if there was no abnormality indication, fuel samples are still collected and analysed. Air pollution monitoring activities made at strategic locations such as the great belt bridge of Denmark use surveillance aircrafts and drones that monitor emissions using an ultraviolet optical and sniffer measurement. The European Maritime Safety Agency (EMSA) is responsible for making inspections and from 2015 to March 2016, made about 6,801 inspections. In 2016 and 2017, about 4,000 inspections were made in the frame of the EnviSuM project using these drones.

3.3 Entrepreneurial Compliance Options for Maritime Fuel Producers

Because shipowners are not making any significant changes and there is much pressure on fuel producers who must step up to produce the demanded volumes of fuel, the author put forward two categories of compliance options. First, five strategic investment models (options) were proposed for the fuel producing companies. Then, to determine their risk levels and returns on investments, a multi-criteria analysis of their impact scale were calculated (article I). The second category of options is a model that involves a change of business model strategy for the fuel producers and the shipowners called the Marine Energy Contract (article IV & V).

3.3.1 Investments Models (Options)

Leveraging on the environment, the opportunities and strengths as well as the threats and weaknesses of VKG (the first case company), five investment strategies were suggested. First is the ***upward vertical integration of VKG supply chain process***. With this investment option, the company considers selling its fuel directly to the end-users by making its fuel complaint, achieved by mixing shale oil with 0.1% distillate oil to reduce the sulphur content. Some of the advantages of this option are that it removes intermediaries and transaction costs in the distribution process. While the fuel producing companies may be able to increase their share in the market this way, productivity is likely going to reduce because of an inflexible supply chain. The next investment strategy is ***product upgrade,*** which entails building a new refinery that will lead to change and upgrade the company's products and derivatives. It will also increase their production capacity, but the primary outcome will be the possibility of producing the 0.1% sulphur marine fuel along with oil V Diesel and stabilised naphtha. For VKG, a medium size refinery of a processing capacity of 133% increase of shale oil production at 14 000 barrels per day and 750 000 tons per year will cost about 400 million euros (Front-End Engineering Design (FEED) stage) plus 30-50 million costs of operations every year. An expensive venture for a business undertaking that will take additional five (5) years before reaching its full capacity. Next is ***Hydrodesulphurisation*** that removes sulphur from the product through partial hydrogenation (Kabe, Ishihara & Qian, 2000) to produce the ULSFO. Hydrodesulphurisation will cost 100 – 150 million euros. Another investment strategy is ***Product Discount,*** an easy way out if the future price spread between HFO and distillates is wide, remains so and can only serve as an interim option due to the volatility of the fuel market. Lastly is ***Process innovation***, which will improve the company's efficiency - a long-term plan regardless of the other options used.

Even though most companies could be willing to take on risky investments, this would depend on their perceived guaranteed or expected return on investment. A multi-criteria decision analysis tool was used to create a matrix of scenarios for the impact scale for each option if the price spread was to change. The results revealed that hydrodesulphurisation is the investment with the highest return followed by product upgrade. An investment of this magnitude will prove futile in the face of a substantial reduction in the cost of fuel and make it difficult for the company to recoup the investment made. Product upgrade was the riskiest option because it is expensive and its failure could be the company's final downfall. The risk is also associated with the uncertainties in fuel prices. Upward vertical integration is the least risky option. Product discounts, upward vertical integration and process innovation will yield the least return respectively.

3.3.2 Maritime Energy Contracting Model (MEC)

The MEC model is a market mechanism that uses the Energy Supply Contract (ESC) concept and the scrubber technology where the fuel producers pre-finance the scrubber installation on contracted ships and at the same time supply HFO. This result yielded a business model change for high sulphur bunker-oil producers as a great edged market strategy that is experimental. The resulting model delivered a pragmatic approach to the SECA regulations compliance and aims to reduce emissions and transaction costs of compliance with the following advantages:

- Reduction of SOx emissions.
- Savings related to investment costs and other costs.
- Creation of jobs and careers.
- Operational costs reductions.
- Free technology and expertise backing for the shipowners.
- Flexible investment option for the fuel company.
- Higher margin for the fuel production company.
- Customised contracts.

Using the Osterwalder (2004) business development model (table 3.1 & article IV), the analysed data from the expert interviews and documentation-review empirically presents how the business model of the fuel company would change. The key partners are the first to change, i.e. there is a switch from bunker traders to banks or other loan servicing companies, scrubber companies, maintenance companies, ship operators/shipping companies/shipping operators and other fuel producing companies. The key activities focus will change from marine fuel production to services that will introduce compliance solutions. Key resources will still be the mines and fuel production facilities but also include the scrubber and other resources. Value proposition will shift from economies of scale approach to an economy of scope concept.

Table 3.1. *Change of Business Model for Fuel-Producing Companies*

	Business model block	Company's Model	MEC Model
1	Key partners	Bunker traders	Financial houses, scrubber producers, maintenance companies, ship operator/shipping company/shipping operators and other fuel producing companies
2	Key activities	Fuel production and sales	Fuel production. Sales will become service driven (i.e. new solution services to sulphur emission compliance), maintenance and data information exchange and information management
3	Key resources	Physical infrastructure, e.g. production and warehousing	Physical infrastructure, i.e. production, warehouse, including the scrubber, together with intellectual and financial resources (i.e. liquid assets)
4	Value proposition	Marine fuel, fast delivery	Optimisation and economies of scales (cost reduction, infrastructure sharing/outsourcing, total package offerings) Risk reduction (financial risks, market risks and price uncertainties), ease of transactions and accessibility (removal of intermediaries)
5	Major customers	Bunker traders	Shipowners/shipping companies/ship operators
6	Customer relationships	Fuel pooled with other fuel producers and sold directly to intermediaries	Co-creation alliance between the company and their contractual customers. Services will include personal assistant customised to fit each customer according to their need
8	Channel of distribution	Own logistics, third party	Owned, involve the use of electronic data exchange (EDI) for inventory and supply management
9	Cost structure	Fixed	Low cost to ensure the achievement of the economics of scales (increased output, new distribution channels), the economics of scope (cost advantage and increased distribution channels) and fixed cost contract
9	Revenue streams	Sales	Sales, banks and services charges from negotiation, risk planning, savings sharing, liquidation fees and so on

Adapted from Osterwalder (2004)

The catch for this model is costs and risks reduction with business relationships becoming “co-creation alliances” between the fuel producing company and its contractual customers. Cost structure will change from fixed to a more differentiated system. Lastly, the revenue streams, mostly from selling fuel will include service charges. The MEC price is:

$$\boldsymbol{MEC\ Price = Fuel\,price\ +\ Scrubber\ costs\ + Adjustments}$$

A RoPax ferry ship that plies Tallinn-Helsinki route, with a daily fuel (HFO) usage of 60t daily and 21 600t yearly empirically validates the MEC model. The baseline cost was set using the cost of MGO as at 06.10.2017while the adjustment costs were based on the current Estonian consumer goods index at 01.01.2017, the average salary index at 01.01.2017 and a fictive fuel price of 450€/mt from 01.01.2017.

At the same time, the annual scrubber cost is a 10% additional scrubber fuel p.a., 2% additional scrubber service p.a., 15 years depreciation of scrubber p.a. and interest costs p.a. Thus, from the calculation, the MEC cost savings for the shipowners using the scrubber technology is 99 €mt, and at the same time, the fuel production companies enjoy an extra 97 €/mt as additional income.

Other contract terms and conditions will include:

a. Specification regarding the owner of the scrubber asset during the contractual period, which in this case will be the fuel company.
b. Definitions regarding *Maritime Energy Contracting Price, Scrubber costs, Energy price* and *Adjustments*.
c. Interests' rate as determined by the market.
d. List of "partner network" including rebates with the affiliated partnering companies.
e. Compensations for defaults.
f. Assurance of stable adjustment costs except in the event of factors mentioned above.
g. Procedures for a continuance of contract.
h. Procedures in the case of the sudden end of the contract.
i. Other issues arising, such as the *border of the property, space for scrubber* and *retrofit, quality of supply, scrubber efficiency* and *additional energy consumption.*

3.4 Discussion of Results and Implications

SECAs was created to enhance and promote clean shipping, results from **RQ1** illuminate first, that the SECA regulations have been an excellent incentive to lower the emissions from shipping activities. Since most ships stopped using the HFO, good results have been recorded that showed the reduction in the PM and sulphur emissions. Nevertheless, while substantial progress is noticeable in the ports, enhanced infrastructures and services financing are essential to facilitate improved ports performances and standards, which needs to be unified across the BSR. The unification of standards is necessary because it can be difficult for the shipowners to cope with the different standards at different ports mostly where necessary infrastructures for compliance activities are needed. In other words, it is crucial for regulators to put in place some fundamental and unified clarifications regarding authorities and monitoring activities in the ports. A gap that further emphasises the need to harmonise policy instruments and at the same time calls for closer cooperation and agreement on standards between the ports and the shipowners. This particular situation has slowed down the establishment of the LNG infrastructure in the ports. For instance, while the intra-traffic within BSR may be able to focus on LNG use, it will be a challenge for the inter-traffic who ventures outside the BSR where the LNG infrastructures are non-existent, and ships powered by LNG cannot bunker fuel. Furthermore, if there are no additional uses of LNG outside shipping, the necessity for LNG may not increase. An indication is an already reduced hype for the LNG.

RQ1 outcome further suggests that even though general economic effects are negligible for most, some companies still have to make a significant adjustment to comply. This result revealed some negative impact on regional growth and cohesion in smaller regions where some of the maritime companies are linked to the economic well-being of such regions. While the summation that environmental regulations are beneficial is right, the effects are different for each stakeholder. To push this argument further, the fuel producers for instance, who already are plagued with the insistent fuel price decrease face a continued loss in revenue from costly and risky investments, especially when combined with the rapid increase in environmental charges. Emerging from some of the mythos and arguments of the endogenous and new institutional theories are some of the circumstances seen in the SECA regulations, where the compliance costs are high leading to increased social costs. Medium-sized companies at times may not have the capacity to handle the demands that come with such compliance. The portfolio analysis carried out confirmed how risky and expensive the compliance investments could be for such companies. While the environmentalists would rightly debate that the environment must be protected *at all costs* and that stringent rules must be made to achieve this, perhaps, arguably one may wonder what “at all cost” actually implies. While sacrifices are expected to be made, at the same time, not providing a unifying and even measure might be counterproductive, and policymakers owe it to the public to protect them, their environment and at the same time protect their source of livelihood. For example, the region can be encouraged to develop their innovation around existing schemes and interconnected diversification that can bring about an improvement of local cohesion for new entrepreneurial activities for their regional development, i.e. integrate the shale oil into the Estonian smart specialisation strategy. To facilitate structural changes, policymakers may consider stimulating the use of the Estonian oil shale industry’s annual contribution to the public budget.

Interestingly, another part of **RQ1** that concerns the economic impact of the SECA regulations on maritime business sector reveals that, although before the SECA regulations implementation many discussions were centred on its negative implications on modal split and costs of trade, the study results showed that the effect has not been as detrimental as speculated. From the survey, most shipowners and ports in the BSR did not experience much negativity from the SECA regulations but believed the SECA regulations stimulated innovation and improved the reputation of the BSR. Some shipowners on the interim are taking advantage of the low fuel costs by using the distillates and the new hybrid ULSFO rather than investing in abatement technologies or other forms of alternative fuel leading to monetary savings for some shipowners. This status quo explains the current excess capacity witnessed in the shipping business with some shipowners closing down routes or have had to change some of their routes. Some have even changed to larger ships to slow steam, a situation likely to continue for a while. Even at this, most shipowners still feel they would have been able to avoid sub-optimal choices if they had enough time and adequate information on compliance options. Unfortunately, the unwilling disposition of the shipowners towards investments will stall the technology push that abatement technologies such as the scrubber technology can deliver to the EU. However, the overall maritime stakeholders’ dispositions appeared to be sectorial and country-specific as seen in the ANOVA analysis. A possible answer to the country disparities can be culturally explained using the Hofstede 6-D cultural index (2018). Estonians' score on "uncertainty avoidance dimension" is high (60) when compared to the Danish (23) implying that the Estonians are prone to avoiding uncertainties while the Danish are more "relaxed" and accepting of new situations.

Results emerging from **RQ2** revealed the various innovative actions and strategies taken by stakeholders to comply or to reduce the impact of SECA compliance on their businesses. It highpoints how various stakeholders have contributed to the clean shipping objectives in BSR. The introduction of the hybrid marine fuel, surveillance drones for monitoring and compliant checks, the scrubber's technology hybrid system as well as the dual engines of the *Megastar* of Tallink shipping line emphasised that institution such as the SECA regulations influence the sets of actions and behavioural pattern in any environment. Encouraging innovation in the maritime sector for a cleaner environment is critical because technology development from innovative choices can resolve some of the challenges associated with the compliance delivery. The innovations that stemmed from various compliance activities can be the key driving factor for economic growth and social wealth. However, there is a need to harmonise the requirements on maritime sulphur emissions concerning the technical solution for emissions such as the scrubbers wash water, especially regarding the open-loop scrubbers.

Lastly, **RQ3** results provide both conventional and pragmatic entrepreneurial pathways for maritime stakeholders addressing the RBV arguments that unique resources and relationships can differentiate an organisational need for balance between a company and its business environment. The portfolio assessments of the proposed standard compliance options for medium scaled refinery shows that only hydrodesulphurisation and product upgrade could yield a significant return on investments, however, both are very expensive and highly risky.

Considering this, together with the admission by most stakeholders that the scrubber technology could increase the rate and direction of technology boost in the EU, the MEC model proposes a focal concept for a strategy that can create unprecedented opportunities in the maritime sector. The model conceptually and empirically charted an instrument that offers a converged view of the theories used in this work (figure 3.1). Its details are fresh, feasible, actionable, and cost-effective and at the same time allow a low magnitude of risk for an unpredictable environment as the maritime sector. Since the scrubber installation is preferred for old vessels that are around ten (10) years (article II & III), the average fifteen (15) years lifespan of the scrubber is suitable and aligns with the remaining average lifespan of a modern passenger ship of 25 - 30 years (Shippipedia, 2018). The MEC model can set the ball rolling for win-win cooperation by those involved and create a defined resource for all related companies. Its details demonstrated how any organisational weakness could be valuable against all the odds.

Most literature in the RBV are anchored in economic concepts of market influence, and while some literature (i.e. Rumelt, 1984; Barney, 1991; Peteraf, 1993) discussed the merits and de-merits of resources in a generalised way, the MEC demonstrated another context within which a resource can be considered valuable. Porter (1996) says resources can only be useful if they can achieve some sort of competitive advantage putting much emphasis on the fact that resources should not be imitable.

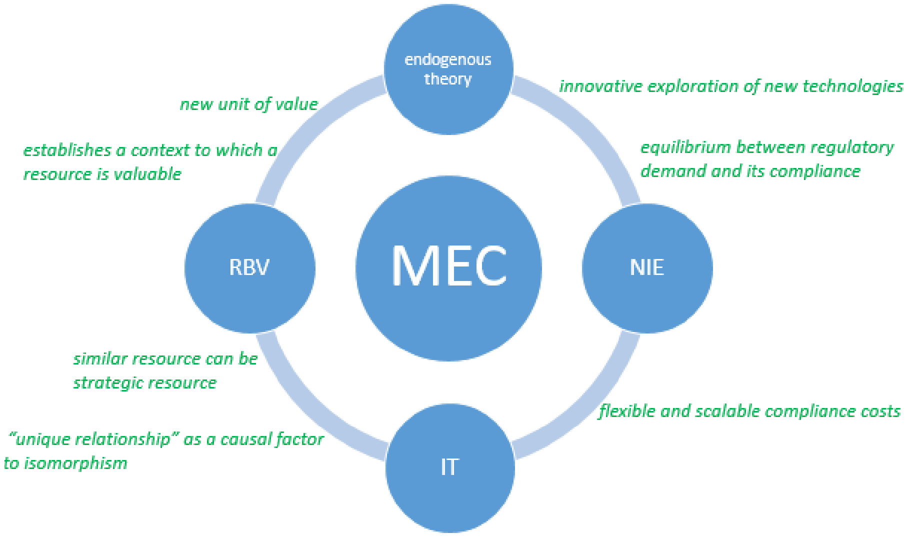


Figure 3.1. *Reconciliation of Theories Divergence*
Source: Author's compilation

However, the development of the MEC model suggests that, arguably, while it is possible to consider a resource inexistent in a short or medium-term, any company can redesign some or a few of its processes to create a much-needed potential resource efficiently and effectively. More so, institutional forces (i.e. regulations) do not weaken companies because all situations have the potential to create unparalleled advantages. External stimuli such as regulations can compel some organisations to develop a unique array of new capabilities.

CONCLUSIONS

The primary goal of this thesis is to develop an optimised business model in compliance with Sulphur Emissions Control Area regulations in the BSR for sustainable solution and effective clean shipping policy deployment. The significant inference from the interactions with experts is that the sulphur emissions regulations have been able to yield significant health benefits for the BSR and may have reduced the potential acidification damage that sulphur compounds can cause to the environment. Noteworthy is a general agreement that the benefits of reduced emissions far exceed the costs of control measures. However, even though the BSR has witnessed commendable compliance activities, the success level is not so satisfactory from an economic point of view, especially as it relates to the substantial and risky compliance investments.

There are still many uncertainties concerning the available compliance options and unfortunately, the reduced fuel prices, even though on the one hand being positive have made many investments meaningless and wasteful. With the upcoming 2020 global sulphur restrictions, demand for the low sulphur fuel oil will increase and the maritime industry may yet experience another game changer, which might force an increment in the price of the fuel. Beyond that, there might be a shortage in the low sulphur fuel supply.

Along this line, the MEC model, unlike the usual conventional strategies and business model concepts, accentuates a mechanism that gives room for financial flexibility and scalable investments. With appropriate state-enabling policy, the MEC model can be used to boost the maritime industry by shifting the focus of the scrubber technology towards selling ‘‘energy solutions’’ and at the same time jump-start a viable private sector. The following quote from a report by the World Commission on Environment and Development tilted “Our Common Future” summed it up concisely:

“Yet in the end, sustainable development is not a fixed state of harmony, but rather is a process of change where the exploitation of resources, the direction of investments, the orientation of technological development and institutional change are consistent with the future as well as with the present needs…Painful and radical choices have to be made. Thus, in the end,
***Sustainable development must rest on political will**.”*
- *WCED (1987), Our Common Future*

Contributions of Research

This research has contributed to the body of knowledge in the following ways:

Theoretical Contributions

First, the development of the MEC model synthesises the extension of the institutional theory to the maritime sector under the new SECA rules. This output further extends the classical RBV theory in the light of new institutions into the maritime sector by giving a theoretical foundation for institution-triggered innovation of business models, which has been a gap in literature until now. The MEC business model extends RBV theory under environmental regulations for the maritime sector by incorporating abatement technology and the energy service-contracting concept into the existing theory. This concept’s advantage is in threefold: (a) it guarantees emissions reduction; (b) it provides a business model innovation together with a value proposition for maritime stakeholders to stimulate a sustainable deployment of the SECA regulations and; (c) it opens up a potential profitable private sector in the maritime industry.

Second, using the endogenous growth and new institutional economics theory, the work assesses how to reduce the transactional costs for fuel producers and shipowners since some results inferences suggested that the build-up of regulatory costs is high and risky (article I). The thesis provided a balance for optimised solutions to compliance strategies. Furthermore, the need for a reasonable allowance for level playing among related stakeholders for regulations was met through a model that provided a flexible and scalable compliance expenditure, which empirically demonstrated that regulations do not have to be disruptive or expensive.

Third, work contributes to literature that studied the institutional theory and examined how institutional forces (i.e. SECA regulations) influence the sets of actions, behavioural patterns and decision-making process of a business sector (article II & III). The thesis highlights how SECA regulations are influencing changed behaviour and new technologies in the maritime industry in concerted and integrated efforts of multiple measures. However, their reactions and actions to these rules are different implying that reactions to the same rules and laws can be strategically different within the same sector. In other words, even though regulations can influence the goals of similar companies to pursue similar routines, they do not necessarily hinder diversified strategies and outcomes or result to isomorphism.

Fourth, the study used the RBV theory to establish a context to which a resource is valuable in the maritime environment. The implication of the RBV in this context is that all organisations have the potential to convert any entity to a “valuable” resource to gain a competitive advantage - even if imitable or substitutable. Implied “weaknesses” can pivot opportunities for innovation and do not weaken any company (article IV & V).

Additionally, the MEC model advances the conceptualisation of a potential interdisciplinary discourse in the energy industry and the maritime industry.

Lastly, the thesis contributes empirically to the on-going discussions on the economic impact of the SECA regulations. Its findings centralise that even though the SECA regulation is expensive, the economic effect is not as adverse on the maritime stakeholders as was speculated before the take-off. The new theoretical proposition from this conclusion is that the economic impact of the clean shipping regulations may be detrimental for a few marginalised stakeholders, but they are industry-specific as well as country-specific.

Practical Contributions

The thesis contributes to the overall goals of the EU Baltic Sea Region Strategy, i.e. *"save the sea, connect the region and increase prosperity*" by promoting economic development in the maritime sector and advocating for equal opportunities for all maritime stakeholders (article I).

Contributes to the EU2020 objectives for blue growth by highlighting the link between the maritime stakeholders’ compliance activities and the stimulated innovation that stemmed from them for sustainability (article II & III). The study drew out different patterns of technological change emanating from clean shipping and SECA and further put to rest the anticipated fear that SECA will increase the cost of goods and cause a modal shift from marine to land. Even though the ports are still somewhat sceptical, maritime stakeholders and policymakers are still able to gain a better understanding of investments costs, measures and decisions. The work further displayed the BSR as an incubator and exhibition platform for clean shipping solutions globally. A useful prospect at the advent of the 2020 sulphur global cap.

The thesis shows how the implementation of the MEC model can be linked to a business model change for the fuel producers and at the same time allow the shipowners to lower freight rates without own financial engagement. This contribution will help to increase the capacity of private companies in the maritime sector to make profitable investment decisions related to clean shipping (article IV & V).

The study also contributes to the overall objective of MARPOL Annex VI, EU Sulphur Directive 2012/33/EU by providing the economic impacts of shipping in the BSR, their economic consequences and the market potential for abatement technologies that will be beneficial for the BSR and Europe.

Finally, this study, through the creation of the MEC model facilitates collaborative problem solving and flexible investment-management among enterprises that can help them adjust efficiently to changing market demands and new production technologies.

Limitations and Future Research

One of the limitations of this work relates to the low turnout in the BSR-wide survey but is overcome through the triangulation of the survey results through the interviews, workshops and focus groups. The study did not actively include Lithuania and Latvia because the consortium of the project that funded the study did not include participants from these countries making the opportunity to have access to needed respondents limited. However, part of the study included the Port of Klaipeda, Lithuania. Another limitation borders around using only HFO/MGO spread scenario for the MEC modelling. Considering other sources of fuels like the LNG will be an interesting perspective for a future research. Further research can also be the measurement of the administrative burdens of clean shipping regulations on Maritime industry in the BSR, which is also a crucial indicator for clean shipping sustainability.

Lastly, results showed a very high compliance rate in the BSR and achieved at a short period. A future study could also address the reasons for such high compliance rate. The consequence for noncompliance was not definite, yet the result was positive. What does value have to do with the compliance rate results and how does it influence or shape the belief system of the BSR citizens? The answer to these questions might provide a much-needed insight regarding compliance culture of the BSR.

Figures

Tables

References

ABS (2016). *Ship energy efficiency advisory* http://ww2.eagle.org/content/eagle/en/search.html?q=Ship%20Energy%20Efficiency%20Measures%20status%20and%20guidance, Accessed on 28/07/2016.

AirClim (2011). Air pollution from ships. https://www.transportenvironment.org/publications/air-pollution-ships-0. Accessed 23/05/2016. *Air Pollution & Climate Secretariat Seas at Risk Bellona Foundation North Sea Foundation Transport & Environment European Environmental Bureau*.

Aizenman, J. and Marion, N. (1993). Policy uncertainty, persistence and growth. *Review of International Economics,* 1 (1993), pp. 145-163.

Barney, J. B. (1991). Firm resources and sustained competitive advantage. *Journal of Management*, 17 (1), 99-120.

Barro, R. J. (1991). Economic growth in a cross-section of countries. *Quarterly Journal of Economics,* 106:40755.

Bergqvist, R., Turesson, M. and Weddmark, A. (2015). Sulphur emission control areas and transport strategies-the case of Sweden and the forest industry. *European Transport Research Review*, Vol. 7(2), pp.1-15.

Bleaney, M., Gemmell, N. and Kneller, R. (2001). Testing the endogenous growth model: public expenditure, taxation, and growth over the long run*. Canadian Journal of Economics/Revue* canadienne d'économique, 34(1), 36-57.

Blind, K., (2012). The influence of regulations on innovation: A quantitative assessment for OECD countries. *Research Policy*, Vol. 41, No. 2, pp. 391-400.

Bourlès, R., Cette, G., Lopez, J., Mairesse, J. and Nicoletti, G. (2013.) Do product market regulations in upstream sectors curb productivity growth? Panel data evidence for OECD countries. *Review of Economics and Statistics*, Vol. 95, No. 5, pp. 1750-1768.

Bowser, J. (2001). Strategic co-opetition: The value of relationships in the networked economy. *IBM Global Services,* New York.

Brynolf, S., Magnusson, M., Fridell, E. and Andersson, K. (2014). Compliance possibilities for the future ECA regulations through the use of abatement technologies or change of fuels. *Transportation Research Part D: Transport and Environment,* Vol. 28, 6-18.

Caiazzo, G., Di Nardo, A., Langella, G., & Scala, F. (2012). Seawater scrubbing desulfurization: A model for SO_2 absorption in fall-down droplets. *Environmental Progress & Sustainable Energy*, 31(2), 277-287.

Carr, E. W. & Corbett, J. J. (2015). Ship compliance in emission control areas: technology costs and policy instruments. *Environ. Sci. Technology*, 49(16), 9584-9591.

Chesbrough, H. (2011). Business Model Innovation: *Opportunities and Barriers. Long Range Planning*, Vol. 43(2), pp.354-363.

Coase, R. (1998). The new institutional economics. *The American Economic Review*, Vol. 88(2), pp.72-74.

Coase, R. H. (1960). The problem of social cost. In Classic Papers in Natural Resource Economics, pp. 87-137. UK: *Palgrave Macmillan.*

Concave (2006). *Techno-economic analysis of the impact of the reduction of Sulphur content of residual marine fuels in Europe* (Report No. 2/06).

Concave (2013). Oil refining in the EU in 2020, with perspectives to 2030. *The oil companies' European association for Environment, Health and Safety in refining and distribution, report* 1/13R, Brussels, Belgium.

Corbett, J. (2007). Mortality from ship emissions: A global assessment. *Environmental Science and Technology*, Vol. 41 (24), pp 8512–8518.

Corbett, J. J. and Farrell, A. (2002). Mitigating air pollution impacts of passenger ferries. *Transportation Research Part D: Transport and Environment*, Vol. 7(3), 197-211.

Creswell, J. W., & Clark, V. L. P. (2007). Designing and conducting mixed methods research.

Cullinane K, Toy N (2000) Identifying influential attributes in freight route/mode choice decisions: a content analysis. *Transportation Research Part E* 36(1):41–53

Cullinane, K. R. and Bergqvist, R. (2014). Emission control areas and their impact on maritime transport. *Transportation Research Part D*, Vol. 28, pp.1-5. 4.

Daduna, J. and Prause, G. (2016). The Baltic Sea as a maritime highway in inter-national multimodal transport. *In: Proceedings of the International Conference on Operations Research OR 2015: Optimal Decisions and Big Data",* 1.-4. September 2015, Vienna. Berlin: Springer-Verlag.

Daduna, J., Hunke, K. and Prause G. (2012). Analysis of short sea shipping-based logistics corridors in the Baltic Sea region. *Journal of Shipping and Ocean Engineering* 2(5):304–319.

Das, T.K. and Teng, B.S. (2000). A resource-based theory of strategic alliances. *Journal of management*, 26(1), pp.31-61.

Demil, B. and Lecocq, X. (2010). Business model evolution: in search of dynamic consistency. *Long range planning*, 43(2), pp.227-246.

DiMaggio, P. and Powell, W. (1983). The iron cage revisited: Institutional isomorphism and collective rationality in organizational fields. *American Sociological Review*, 48: 147.

Dosi, G., Fagiolo, G. and Roventini, A. (2010). Schumpeter meeting Keynes: A policy-friendly model of endogenous growth and business cycles. *Journal of Economic Dynamics and Control,* 34(9), 1748-1767.

Easterby -Smith, M., Thorpe, R. and Jackson, P. (2012). *Management Research.* Los Angeles, California London: SAGE 4th ed.

EfficienSea2 (2016). Report on the available technologies and sensors that can be utilized in the new system and on business model on incentives for monitoring and enforcement. http://efficiensea2.org/publications/. Accessed 12/09/2016.

Eggertsson, T., (2013). Quick guide to new institutional economics. *Journal of Comparative Economics*, Vol. 41, No. 1, pp. 1-5.

Eisenhardt, K. and Graebner, M. (2007). Theory building from cases: opportunities and challenges, *Academy of Management Journal*, Vol. 50 No. 1, pp. 25-32.

EU (2010). EUROPE 2020: *A European strategy for smart, sustainable and inclusive growth.* Retrieved from http://ec.europa.eu/eu2020/EuropeENversion.pdf (accessed on 20th may 2017).

EU (2012). *Europe 2020: Europe's growth strategy: Growing to a sustainable and job-rich future.* Retrieved from http://ec.europa.eu/europe2020/pdf/europe_2020_explained.pdf (accessed on 20th may 2017

EU Directive 2014/94/EU of the European Parliament and of the Council of 22 October 2014 on the deployment of alternative fuels infrastructure. *Official Journal of the European Union,* L307/1-20.

Eyring, V., Köhler, H. W., Van Aardenne, J., and Lauer, A. (2005). Emissions from international shipping: 1. the last 50 years. *Journal of Geophysical Research*: Atmospheres, 110(D17).

Foray, D., David, P.A. and Halll, B.H. (2011). *Smart specialisation from academic idea to political instrument, the surprising career of a concept and the difficulties involved in its implementation* (No. EPFL-WORKING-170252). EPFL.

Hämäläinen, E., Hilmola, O.P. and Tolli, A. (2016). North European Export Industry and the Shadows of Sulphur Directive. *Transport and Telecommunication Journal*, 17(1), pp.9-17.

Hämäläinen, E., Hilmola, O.P., Prause, G. and Tolli, A. 2016. Forecasting maritime logistics costs – Will the low oil price remain? In A. Serry and L. Lévêque (Eds.). Le transport maritime à courte distance (Short-Sea Shipping), *Devport 2016 Conference, pp. 19-34. Le Havre, France: EMS Geodif.*

Hofstede, G. (2018). Analyses of the cultural dimensions indexes. http://geert-hofstede.com.html. Accessed 12/05/2018

Holmgren, J., Nikopoulou, Z., Ramstedt, L. and Woxenius, J. (2014). Modelling modal choice effects of regulation on low-sulphur marine fuels in Northern Europe. *Transportation Research Part D: Transport and Environment*, 28, 62-73.

Howells, J. (2005). Innovation and regional economic development: A matter of perspective? *Research Policy* Vol.34 (8), pp.1220-1234.

IMO (2008). Revised MARPOL Annex VI: Regulations for the prevention of air pollution from ships and NOx technical code London: *IMO Marine Environmental Protection Committee (MEPC)*.

IMO (2009). *Prevention of air pollution from ships Second IMO GHG Study 2009 Update of the 2000 IMO GHG Study Final report covering Phase 1 and Phase 2: noted by Secretariat* (MEPC 59/INF.10)

IMO (2013). Sulphur oxides (SOx)—Regulation 14. Retrieved from http://www.imo.org/OurWork/Environment/PollutionPrevention/AirPollution /Pages/Sulphur-oxides-(SOx)- Regulation-14.aspx (Accessed 2016-09-20).

IMO (2014). Third IMO GHG Study 2014, *International Maritime Organisation,* London, UK.

IMO (2015). Guidance on the application of regulation 13 of MARPOL annex VI tier III requirements to dual fuel and gas-fuelled engines. *MEPC.1/Circ.854. London*

IMO (2016). IMO sets 2020 date for ships to comply with low sulphur fuel oil requirement. *Press briefing release* 28/10/2016. Retrieved from http://www.imo.org/en/MediaCentre/PressBriefings/Pages/MEPC-70-2020sulphur.aspx (Accessed 30th Nov, 2016)

Jaffe, A. B., Peterson, S. R., Portney, P. R. and Stavins, R. N. (1995). Environmental regulation and the competitiveness of US manufacturing: what does the evidence tell us? *Journal of Economic Literature*, Vol 33, No. 1, pp. 132-163.

Janszen F. (2000). The Age of Innovation. Financial Times-Prentice Hall, London.

Jiang L., Kronbak J. and Christensen L. P., (2014). The costs and benefits of sulphur reduction measures: Sulphur scrubbers versus marine gas oil. *Transportation Research Part D*, Vol. 28, pp. 19–27.

Kinzerska I. (2012). *Assessment of investment attractiveness. Donetsk University of Economics and Law* http://www.rusnauka.com/11_NPE_2012/Economics/4_107425.doc.htm. Accessed 7/2/2017

Klein, H. K., & Myers, M. D. (1999). A set of principles for conducting and evaluating interpretive field studies in information systems. MIS quarterly, 67-93.

Kline, S. J. & Rosenberg, N. (1986). An Overview of Innovation. In: The Positive Sum Strategy: Harnessing Technology for Economic Growth (Landau, R., Rosenberg, N. Eds.). National Academy Press, Washington D.C., 275-304.

Leary, Z. (2009). The essential guide to doing your research project. Los Angeles, *[Calif.] ; London: Los Angeles, Calif*. ; London : SAGE.

Marshall, C. (1995). Designing qualitative research. *Thousand Oaks, Calif. ; London: Thousand Oaks, Calif*. ; London : Sage.

McGrath, R.G. (2010). Business models: A discovery driven approach. *Long range planning*, 43(2), pp.247-261.

Mellqvist, J. (2016). SOx compliance monitoring, EnviSuM partner meeting, 26th.October.2016. Copenhagen.

Mkansi, M., & Acheampong, E. A. (2012). Research philosophy debates and classifications: students' dilemma. *Electronic Journal of Business Research Methods*, 10(2), 132-140.

North (2016). China: Emission Control Areas. http://www.nepia.com/news/industry-news/china-emission-control-areas-starupdatestar/. Accessed on 22.12.2016.

Notteboom, T. (2010). The impact of low sulphur fuel requirements in shipping on the competitiveness of roro shipping in Northern Europe. *WMU Journal of Maritime Affairs,* Vol. 10(1):63–95.

Nugraha F. (2009). Effective implementation of emission control area towards cleaner shipping operations: focusing on Sulphur oxides (SOx) emission reduction. *World Maritime University*

O'Gorman, K., Lochrie, S., & Watson, A. (2014). Research philosophy and case studies. *Research Methods for Business & Management,* 152-172.

OECD/ITF (2016). *Reducing Sulphur Emissions from Ships: The Impact of International Regulation*. http://www.itf-oecd.org/reducing-sulphur-emissions-ships-impact-international-regulation. Accessed 10/06/2016.

Olaniyi, E. O. and Reidolf, M. (2015). Organisational Innovation Strategies in the Context of Smart Specialization. *Journal of Security and Sustainability Issues,* Vol. 5, No. 2, pp. 213−227.

Olaniyi, E.O. and Prause, G. K. (2016). Baltic-Russian Innovation Cooperation in the Context of EU Eastern Partnership. *In T. Kerikmäe and A. Chochia (Eds.). Political and Legal Perspectives of the EU Eastern Partnership Policy*, pp. 257-279. Switzerland: Springer International Publishing.

Orlikowski, W. J., & Baroudi, J. J. (1991). Studying information technology in organizations: *Research approaches and assumptions. Information systems research,* 2(1), 1-28.

Osterwalder, A. (2004). The Business Model Ontology-a proposition in a design science approach.

Osterwalder, A. and Pigneur, Y. (2009). Business Model Creation. Amsterdam, *The Netherlands*: Modderman Drukwerk.

Panagakos, G. P., Stamatopoulou, .E.V. and Psaraftis, H.N. (2014). The possible designation of the Mediterranean Sea as a SECA: A case study. *Transportation Research Part D: Transport and Environment*, 28, 74-90.

Pape, M. (2015). Cutting sulphur emissions from ships. *European Parliamentary research service Blog*. https://epthinktank.eu/2015/02/05/cutting-sulphur-emissions-from-ships/. Accessed 11/11/2016.

Peteraf, M. (1993). The cornerstones of competitive advantage: A resource-based view. – *Strategic Management Journal*, 14, p. 179-191.

Peters, B.G. (2000), Institutional theory: Problems and prospects. Dissertation of *Department of Political Science, Institute for Advanced Studies* (IHS), Political Science Series.

Porter, M.E. (1996), "What is strategy?" Harvard Business Review, Vol. 74 No. 6, pp. 61-78.

Prause, G. and Hunke, K. (2014). Sustainable Entrepreneurship along green corridors. *Journal of Entrepreneurship and Sustainability Issues,* Vol. 1 (3), 124−133, 10.9770/jesi.2014.1.3(1).

Reynolds, L. (1981). Foundations of an institutional theory of regulation. *Journal of Economic Issues*, 15(3), pp.641-656. 20.

Risk, S. A. (2004). Air pollution from ships. Sea, 6(8,000), 10-000.

Rumelt, R. P. (1984). Towards a strategic theory of the firm. *In R. B. Lamb (Ed.), Competitive strategic management*: 556–570. Englewood Cliffs, NJ: Prentice-Hall.

Seidman, I. (2006). Interviewing as qualitative research : a guide for researchers in education and the social sciences. *New York: New York : College Press*. 19.

SHEBA (2014). - *Sustainable shipping and Environment of the Baltic Sea* http://www.bonusprojects.org/bonusprojects/the_projects/sustainable_ecosystem_projects/sheba. Accessed 30.06.16.

Shippipedia (2018). Life cycle of ship. http://www.shippipedia.com/life-cycle-of-a-ship/. Accessed 14.05.2018.

Solow, R.M. (1994. Perspectives on growth theory. *The Journal of Economic Perspectives*, Vol. 8(81) pp. 45-54.

Sorrell, S. (2007). The economics of energy service contracts. *Energy Policy,* 35(1), pp.507-521. 22.

Stipa, T. (2013). Clean shipping current in in Pan-Baltic Manual of Best Practices on clean shipping and port operations. Eds. Breitzmann, K & Hytti, M. UBC Environment and Sustainable Development Secretariat, Vanha Suurtori 7, FIN-20500 Turku, Finland

WCED (1987). *Report of the World Commission on Environment and Development: Our Common Future.* www.un-documents.net/our-common-future.pdf accessed 09/10/2017.

Wiśnicki, B., Czermański, E., Droździecki, S., Matczak, M. and Spangenberg, E. (2014). *Sulphur Regulation–technology solutions and economic consequences for the Baltic Sea Region shipping market.* In: Ernest Czermański (ed) Institute of Maritime Transport and Seaborne Trade, University of Gdańsk.

Yin, R. K. 1989. Case study research: Design and methods. Revised edition*. Applied Social Research Methods Series, 5. Newbury Park (Calif.) [etc.]: Sage Publications*

Acknowledgments

The doctoral research was funded by the EU (European Regional Development) in the frame of EnviSuM (Environmental Impact of Low Emission Shipping: Measurements and Modelling Strategies) project.

My profound thanks to Professor Gunnar Prause, my supervisor, mentor and boss for his intensive teaching all this time. Thank you for your support, your patience, your encouragement when I could not find a reason to continue and the opportunities you have given to me career wise. Thank you for giving me wings to fly. Most especially, thank you for believing in me.

I will like to express my thanks to my professors in Tallinn University, to Professor Urve Venesaar who took her time to instruct and guide me when I was writing one of my articles and this thesis. To Professor Maksim Saat for his interest in my works and always taking time to read them especially for Doctoral seminars.

My sincere appreciation to my opponents, Professor Dr Esa Hämäläinen and Professor Dr Hans-Dietrich Haasis and other reviewers for their constructive critical observations, remarks and evaluations.

I am also grateful to my colleagues at EnviSuM project (all over Europe) and the Department of Business Administration, TTÜ, for the enabling environment for learning and growth. To Merle, Merli, Marianne, Laima, Sina, Robert and Tarmo for their kindness, open-mindedness and readiness whenever I needed their help. Maria, Hovhaness and Julio for the support we give to each other to reaching our goals. Thank you Godswill for telling me about studying in Estonia. To the entire Grace Chapel family especially Pas. Chidi and the leadership team - Biodun, George and Stephen, thank you for your tolerance and for giving me a place to call home in Tallinn. Many thanks to Ogechi, Amaka, Gbenga, Dayo and Funmi who were there for me from the start to the end, especially the time it was the "hardest"- you know when.

My heartfelt thanks to my support system - my family. My mother and my best friend, the person whose steps I try to follow, thank you for being there and guiding me towards becoming my own. If I can be half the woman you are, I am sure I would be fine. To my father whose love for me is unreserved. Your faith and encouragement that I can be the best at all times makes me work hard because I want you to be proud of me always. My brothers, Kunle, Seni and Dotun who believe I am a strong and intelligent woman and would do everything to help me achieve my dreams or put a smile on my face. Many thanks to my sisters-in-law, Seun for doubling as my friend and Tobi for always rooting for me. My cousins, Wumi and Lolade for accepting me as their younger sister and giving me the push I needed to start my doctoral study.

Finally and most importantly, to my creator, in whom I live, I move and have my being. Thank you, Jesus, for all you have done for me, for all these people, and more you brought my way and strategically placed in my life. My eternal gratitude for bearing me on the eagle's wings.

Abstract

Business Models in Compliance with Sulphur Emissions Control Area Regulations in the Baltic Sea Region

Transportation of passengers and goods - both within the EU and between Europe and other parts of the world is increasing. Congestion, air pollution, energy demand and environmental and safety risks are linked to the growing demand for mobility, making the need for sustainable transport stronger. Although much of the pollution emitted by shipping are deposited over the sea, it does not undermine that fact that it is the most significant single source of acidifying and eutrophy fallout on land in many countries in Europe. It also contributes significantly to the increased levels of health-damaging particulate matter and other emissions in the environment. Because of this, the Sulphur Emission Control Area (SECA) was created in May 2005 to enforce a stricter control to minimise airborne emissions from ships. This way vessels that operate within SECA must use fuel with sulphur content of no more than 0.1%w/w from 1 January 2015. The implications of this clean shipping regulation on the activities of the maritime stakeholders directly link to the economic decision that will ensue in their efforts to comply.

There are different options available to reduce sulphur emissions in the SECA. However, the scope of the research was limited to options of switching to MGO, changing to LNG and the installation of the scrubber because they are the most popular options for compliance. While many authors already have extensively evaluated the different options for the SECA regulations compliance and their costs. There is still a need for empirically consolidated results on economic impacts useful for knowledge-based investment decision making for shipping stakeholders. Moreso, the actual capacity of the stimulated innovation from the various technological solutions for complying with the regulations and supporting the maritime businesses and economic growth is still vague. Lastly, because regulations compliance means significant investment decisions for the stakeholders together with the reality that fuel prices are volatile and unpredictable, it is essential to develop market mechanisms for compliance cost reduction.

The mentioned gaps further exposed an existing theoretical gap for the development of business models that can bring a convergence and equilibrium between regulatory demands and regulatory compliances with a new rule like the SECA regulations in the maritime sector which has been neglected.

Thus, the objective of this work is to develop an optimised business model in compliance with Sulphur Emissions Control Area regulations in the Baltic Sea Region.

The author used both quantitative and qualitative research methods for the empirical gathering of data. Research started from previous studies and reports made on SECA. The primary research conducted were face-to-face structured and semi-structured experts' interviews across the BSR, experts' focus group meetings and workshops and a BSR-wide survey.

Results show that low bunker prices alleviated the economic costs of SECA compliance and the BSR is championing clean shipping campaign in the EU. However, the economic effect is spread unevenly and is not the same for all stakeholders, which may likely bring negative consequences on regional growth and cohesion on smaller regions where jobs and income are strictly dependent on maritime companies. At the moment, the popular choice for most shipowners is switching to the low sulphur fuel. The use of LNG is considered and embraced by some shipowners, but the sustainability is at stake

especially since LNG is not finding a use outside marine bunkering. The installation of the scrubber is also typical but only preferred for retrofit on old ships. Results from the survey show SECA impact on economic parameters like costs, pricing, FDI, cargo flows and modal splits are considered negligible. However, significant SECA impacts were attributed to innovation and reputation of BSR. Results further showed that the ports are somewhat cynical about modal split while shipowners are positive. Country wise, the Danish are more positive about the SECA regulation than the Estonians which may be attributed to the cultural difference that has to do with “uncertainty avoidance”. The work also brought forward different clean shipping related innovative activities as seen in the region such as the dual tank engine for vessels and ultra-low sulphur fuel oil. Finally, traditional and pragmatic entrepreneurial opportunities were proposed for the fuel producers and shipowners for their compliance options. While some of the conventional options are risky and expensive, the practical compliance option is an enhancing model called the Maritime Energy Contracting (MEC) model that has the potential to mitigate the economic effect of the SECA regulations.

The development of the MEC model is a synthesised (conceptual and empirical) mapping of a tool that extended existing organisational theories to the maritime sector where a gap exists in the literature.

Additionally, by providing the economic impacts of clean shipping in the BSR, this research is directly supporting the aims of the International Convention for the Prevention of Pollution from Ships (MARPOL) Annex VI, Convention on Long-Range Transboundary Air Pollution, EU Sulphur Directive 2012/33/EU. Shipowners, other marine stakeholders and regulators can also gain a better understanding regarding the costs and potentials of using the sulphur reduction measures.

Lühikokkuvõte

Väävli emissiooni kontrolli ala nõuetele vastavad ärimudelid Läänemere piirkonnas

Reisijate ja kaupade transportimine nii Euroopa Liidus kui ka Euroopa ja muu maailma vahel suureneb pidevalt. Suureneva mobiilsusvajaduse tulemuseks on ummikud, õhusaaste, energianõudlus ning keskkonna- ja turvariskid, mis omakorda suurendab vajadust jätkusuutliku transpordi järele. Kuigi suur osa laevadelt pärinevatest saasteainetest ladestuvad kõikjal maailmameres, ei saa alahinnata seda kui peamist happestumise ja eutrofeerumise allikat, millel on suur mõju ka paljudele Euroopa riikidele. Samuti põhjustab laevadelt paiskuv õhusaaste tervistkahjustavate osakeste ja ainete kõrgendatud tasemete teket ja teisi keskkonda kahjustatavaid emissioone. Et vältida keskkonnaseisundi edasist halvenemist, loodi 2005. a. mais Väävli emissiooni kontrolli ala (Sulphur Emission Control Area, SECA) eesmärgiga suurendada kontrolli laevadelt õhku eralduvate heitgaaside üle. Seetõttu peavad laevad, mis opereerivad SECA piirkonnas, alates 1. jaanuarist 2015 kasutama kütust, mille väävlisisaldus ei ole kõrgem kui 0,1%. SECA kui puhta merelaevanduse regulatsiooni tähendus ongi selles, et merenduses tegutsevad sidusrühmad siduda majandusliku otsusega, mis omakorda toetab nende jõupingutusi keskkonnanõuete järgimisel.

Väävli emissiooni vähendamiseks SECA piirkonnas on erinevaid võimalusi. Antud uurimus hõlmab kolme lähenemist, mis käsitlevad lülitumist madala väävlisisaldusega kütusele (MGO-le), veeldatud maagaasi (LNG) kasutuselevõttu ja gaasipesuseadmete (scrubber) paigaldamist laevadele. Nimetatud kolm teguviisi on kõige enam levinud moodused, et tagada SECA nõuetega ühilduvus. Paljud autorid on oma uurimustes juba hinnanud SECA regulatsioonide rakendamise erinevaid võimalusi ja selle kulusid. Siiski eksisteerib vajadus uuringute järele, mille hinnangud majanduslike mõjude suhtes põhinevad empiirilisel analüüsil, et neid oleks ka laevanduse sidusrühmadel võimalik kasutada teaduspõhiste investeerimisotsuste tegemisel. Tegelik stimuleeritud innovatsiooni maht, mis tuleneb erinevatest tehnoloogilistest lahendustest ja on vastavuses regulatsioonidega ning toetab merendusettevõtlust ja majanduse kasvu, on siiani väga ebamäärane. Kuna regulatsioonidele vastavus tähendab sidusrühmadele olulisi investeerimisotsuseid koos kütusehindade ebastabiilsuse ja ootamatute muutustega, on oluline välja arendada turumehhanismid, mis võimaldaks kulusid kokku hoida.

Ülalmainitud puudujäägid tõid esile praeguse teoreetilise tühimiku selliste ärimudelite arendamisel, mis peaksid looma konvergentsi ja tasakaalu seadusandlike nõuete ja nende rakendamise vahel. Seda tüüpi nõuded, mida pole varem ärimudelitega seoses käsitletud, seonduvad eeskätt väävli emissiooniga merenduses.

Seega, antud töö eesmärgiks on välja arendada optimeeritud ärimudel, mis vastaks Väävli emissiooni kontrolli ala nõuetele Läänemere piirkonnas. Autor kasutas oma töös nii kvantitatiivseid kui ka kvalitatiivseid andmekogumismeetodeid. Uurimus algas varasemate SECA-ga seonduvate uuringute ja aruannete analüüsist. Põhilised uurimismeetodid olid Läänemere piirkonna ekspertide struktureeritud ja poolstruktureeritud näost-näkku intervjuud, samuti ekspertide fookusgruppide arutelud, lisaks töötoad ning kogu Läänemere piirkonda haarav küsitlus.

Tulemused näitasid, et madalad punkrikütuse hinnad leevendasid SECA rakendamise majanduslikke kulusid ja Läänemere piirkond on Euroopa Liidus puhta merenduse

lipulaevaks. Sellele vaatamata jaotub majanduslik efekt ebaühtlaselt ja ei ole kõikide sidusrühmadele sama, mis omakorda võib viia negatiivsete tagajärgedeni regionaalses kasvus ja väiksemate regioonide sidususes, kus töökohad ja sissetulekud on merendusettevõtetest otseses sõltuvuses. Käesoleval hetkel on laevakopaniide seas vägagi populaarne ümberlülitumine madala väävlisisaldusega kütustele. LNG kasutuselevõttu kaalutakse ja seda on juba teatava osa laevaomanike poolt ka rakendatud. Selles suunas liikumist raskendab asjaolu, et LNG-le ei leita kasutust väljaspool merendusega seotud punkerdamist. Kütuse väävlisisalduse vähendamiseks on samuti levinud gaasipesuseadmete paigaldamine laevadele, kuid see on eelistatud lahendus üksnes vanade aluste moderniseerimise korral. Küsitluse tulemused näitavad, et SECA mõju sellistele majanduslikele näitajatele nagu kulud, hinnakujundus, FDI, kaubavood ja nende jaotumine erinevate transpordiliikide vahel on vähetähtis. Seevastu olulised SECA mõjud puudutasid innovatsiooni ja Läänemere piirkonna reputatsiooni. Tulemused näitasid samuti, et sadamad on mõnevõrra küünilised transpordiliikide eristamise suhtes, seevastu laevaomanikud suhtuvad sellesse positiivselt. Riikidevahelises võrdluses ilmneb, et Taani on enam innustunud SECA regulatsioonide järgimisest võrreldes Eestiga, mis võib olla seotud kultuuridevaheliste erinevustega ja suurema "ebakindluse vältimisega" Eestis. Töö tõi välja samuti erinevad puhta laevandusega seotud innovaatilised tegevused nagu näiteks kahe kütusepaagiga alused ja ultramadala väävlisisaldusega kütuseõlid. Lõpuks, nõuetele vastavuse tagamiseks, pakuti kütusetootjatele ja laevaomanikele välja traditsioonilised ja pragmaatilised ettevõtlusvõimalused. Kuigi mõned standardsed mudelid on riskantsed ja kulukad, pakub antud doktoritöö välja praktilise SECA nõuetega vastavuses oleva ärimudeli, mida nimetatakse Merendusega seotud energia lepingute sõlmimise mudeliks (Maritime Energy Contracting, MEC) kui suurima potentsiaaliga meetodi, et leevendada SECA nõuete majanduslikku mõju.

MEC mudel, mis on kontseptuaalse ja empiirilise kaardistamise sünteesi tulemusena saadud instrument, laiendab olemasolevaid organisatsiooniteooriaid merendussektori tarbeks täites sellega senise teaduskirjanduse tühimiku. Lisaks toob käesolev uurimus välja puhta laevanduse majanduslikud mõjud Läänemere piirkonnas, toetab otseselt Laevade Põhjustatud Merereostuse Vältimise Rahvusvahelise Konventsiooni (MARPOL) 6. Lisa, Piiriülese Õhusaaste Kauglevi Konventsiooni ja EL Väävlidirektiivi 2012/33/EU. Antud uurimus väävlisisalduse vähendamisega seotud meetmetest on mõeldud kasutamiseks laevaomanikele, reguleerijatele ja teistele merendusega seotud sidusrühmadele.

Appendix 1

Publications

Publication 1

Olaniyi, E. O.; Viirmäe, M. (2016). The Economic impact of environmental regulations on a maritime fuel production company. *Research in Economics and Business: Central and Eastern Europe*, 8(2). ISSN 1736-9126.

(ETIS Classification 1.2)

The Economic Impact of Environmental Regulations on a Maritime Fuel Production Company

Eunice Omolola Olaniyi
Department of Business Administration, Tallinn University of Technology, Akadeemia tee 3, 12618 Tallinn, Estonia
E-mail: eunice.olaniyi@ttu.ee

Marti Viirmäe
Department of Business Administration, Tallinn University of Technology, Akadeemia tee 3, 12618 Tallinn, Estonia
E-mail: mviirm@ttu.ee

Abstract

The International Maritime Organization (IMO) and the European Parliament (EP) in 2005 and 2012 established Sulphur Emission Control Areas (SECA) in Northern Europe where from 2015 ships must use fuel with a sulphur content not exceeding 0.1% and 3.5% in non-SECAs. This has spurred active discussion that the regulation has created economic disadvantages for maritime stakeholders who must comply with strict regulations that competitors in other parts of the world are not subjected to.

Through a case study, this work investigates the impact of environmental regulations on the business model of the maritime supply company Viru Keemia Grupp (VKG), which is of national importance to the Estonian economy, especially in the eastern region. It explores the strategic entrepreneurial compliance options for VKG based on their return on investments and associated risk. The findings show that VKG is currently struggling to keep afloat under the weight of the consequences of changes in maritime consumer demand due to sulphur emission regulations and that the most viable compliance options are expensive and risky.

JEL classification codes: **L26, M11**
Keywords: **SECA regulations, business models, entrepreneurship, clean shipping, strategic management, BSR**

Acknowledgements

The authors acknowledge the management of VKG AS for the opportunity to conduct interviews and access their company's processes and documents.

This work is also in principle linked to the EnviSuM – Environmental Impact of Low Emission Shipping: Measurements and Modelling Strategies project sponsored by the European Regional Development Fund.

1. Introduction

By carrying approximately 90% of the world's cargo, shipping plays an important role in international trade and the world economy (Unctad, 2015). Unfortunately, in the process of doing this, it releases harmful emissions such as carbon dioxide (CO_2), sulphur oxides (SOx), ozone depleting substances (ODS), volatile organic compounds (VOC) and nitrogen oxides (NOx) (Jiang, Kronbak, Pil, and Christensen, 2014). International legislation on clean shipping was strengthened because of this and emissions legislation in various nations were further harmonised to make it difficult for the shipping industry to operate without cognisance of the environment (NSF, 2008). There have been several regulations from the Marine Environment Protection Committee (MEPC) aimed at reducing emissions of toxic substances from burning fuel oil which are the main causes of air pollution from ships (IMO, 2015, annexe 1). These emissions are also harmful especially in terms of their social costs to the environment (Notteboom, 2010). One of the significant benefits of environmental improvements is the reduction of the acidification damage to ecosystems, which is expected to improve the standard of living, making it very easy to choose between the long-term cost of taking no action to reduce air pollutant emissions from ships and the short-term cost of implementing control measures (AirClim, 2011).

The sulphur emissions regulation - "Regulations for the Prevention of Air Pollution from Ships" was imposed during the sixth annexe of the MARPOL (International Convention for the Prevention of Pollution from Ships) Convention of the International Maritime Organization (IMO). It was first adopted in annexe VI of MARPOL, 35, in 2005 through the creation of Sulphur Emission Control Areas (SECA) limiting sulphur emissions in these areas at no more than 1.5% (15,000 parts per million (ppm)). SECAs represent about 0.3% of the world's water surface and include the North Sea, the English Channel (together with the coastal waters around the USA and Canada) and the Baltic Sea region (BSR) (IMO, 2008). This regulation also applies to other airborne emissions like NOx, ODS and VOC from 1 January 2015, that sulphur emissions from ships in SECAs cannot be more than 0.1% (1,000 ppm) (IMO, 2014).

On 1 January 2012, MARPOL annexe VI also enforced a new global SOx cap for marine bunker fuels from 4.5% (45,000 ppm) to 3.5% (35,000 ppm) for all ships that operate in non-SECAs (IMO, 2015). At the MEPC 70th session held in London in October 2016, the SOx for bunker fuel was lowered yet again to 0.5% (5,000 ppm) from 2020 (IMO, 2016). This means that irrespective of the outcome of the IMO review in 2018, a ship does not have to operate in a SECA before it must pay attention to the sulphur content of the fuel it uses. In order to increase life expectancy and protect the EU environment by reducing acid rain and particulate matter, which are dangerous to human health, the EU shipping regulations have also included waters and ports in the EU (Directive 1999/32/EC amended in Directive 2012/33/EU), which sets EU-sulphur limits the same as in SECAs. This also includes any vessel at quays in EU ports whether it falls in SECA or non-SECA.

Since the introduction of SECAs, significant changes have been seen with the vessels that operate in the Baltic Sea who now use fuel that is low in sulphur content (Bergqvist, Turesson, and Weddmark, 2015). Despite the seemingly good changes witnessed, there have been discussions on how the sulphur regulation seems to have somewhat created economic disadvantages for maritime stakeholders who must comply with strict regulation which competitors in other parts of the world are not subjected to (Notteboom, 2010). Another flank of the argument is the possibility that the regulations will weaken the competitiveness of

European maritime transport especially in the modal shift of cargo flows from marine transport to inland transport routes (Wiśnicki, 2014; OECD/ITF, 2016). It has already been speculated that the implementation will cost the maritime sector between €2.6 billion and €11 billion by 2020 (AirClim, 2011).

Normally, affected companies respond to regulations by changing their strategies to include the compliance activities as well. Some of their responses are embedded in activities such as research and development, expansion, equipment upgrades and processes triggering discussions on the impact of sulphur regulations on maritime stakeholders. There is still limited information available on the economic impacts of the regulation on some minority stakeholders such as fuel supply companies for knowledge-based and economic decision-making for shipping stakeholders. Maritime fuel producers in recent times have been plagued by downward price fluctuations alongside the usual sector challenges of speculations and economic forecasts, conflicts in different parts of the world, production estimates from the oil producing countries, stock levels, seasonality, weather and accidents (Nugraha, 2009). Fuel producers now have to deal with producing Marine gas oil (MGO) and Marine distillate oil (MDO) which are distillate oils and expensive to refine (Notteboom, 2010).

This study explores the economic impact associated with sulphur emissions regulations and by extension the SECA regulation on maritime enterprises. It uses the case of Viru Keemia Grupp AS (VKG), one of the largest Estonian companies and a producer of shale oil, which has a sulphur content that exceeds both SECA and global sulphur emissions limits. Up until 2015, VKG was able to produce shale oil as a bunker fuel without restraints. Due to the strict MARPOL regulations, the company is presently faced with the challenge of producing the stricter sulphur reduction to 0.5% from the 0.8% sulphur content fuel. In order to meet the demands of the new regulations and survive in a highly competitive market, going forward, VKG must make tough and strategic business decisions linked to high investments and serious financial risks in the maritime fuel market, since successful value propositions are said to be embedded in great business models (Osterwalder and Pigneur, 2009).

The objective of this study is to assess the economic impact of sulphur regulations on the business processes of a maritime stakeholder in the Baltic Sea Region (BSR). It uses VKG, a maritime fuel supplier as a case for studying the possible strategic entrepreneurial compliance options for VKG based on the return on investments and associated risks. By using elements of the business model and in light of the summary by Panagakos (2014) that the new regulation should encourage entrepreneurial innovation for business growth, this study probes VKG business activities as they relate to the sulphur directives by focusing on these research questions: What are the economic implications of the sulphur emission regulations for VKG's business activities? What are the strategic compliance options available for VKG? How attractive are these options for the sustainability of VKG?

This paper is organised as follows: Section II discusses the sulphur regulations and the activities of the maritime sector stakeholders in their bid to comply with the environmental stipulations. It also provides a theoretical analysis of the impact of accumulated regulations on the business activities of enterprises using endogenous growth and strategic management theories. Section III describes the methods used for this research. Section IV highlights VKG's business processes, its challenges, how it is coping with the sulphur and other environmental regulations as well as suggested strategic options for VKG's continued success together with the risks associated with each investment. Section V discusses the implications of the results and Section VI concludes.

2. Literature Review

2.1. Sulphur Regulations and Compliance Options for Maritime Sector Stakeholders

Environmentally-induced regulations usually spark many interests. One of the significant benefits of regulations for improving the environment, such as the sulphur regulations, is the reduction of the acidification damage to ecosystems, which is expected to reduce respiratory and cardiovascular diseases and increase life expectancy (AirClim, 2011). Some studies reported that international shipping produced about 80 times more SOx emissions than aviation in 2000 (OECD/ITF 2016). Sulphur dioxides (SO_2), one of the compound states of SOx, is described as a colourless toxic gas formed by burning sulphur in air through different processes like manufacturing, shipping, aviation or volcanic processes. As a reactive gas, SO_2 reacts with other compounds to form secondary particles that have bad consequences for the health of inhalers (Duke Energy, 2016). This makes it very easy to rationally choose between the short-term cost of control measures and the long-term cost of taking no action to reduce air pollutant emissions.

Usually, regulations accumulate over many years, piling up over time. The build-up of regulations over time often leads to constraints on different stakeholders and sometimes complicates and distorts the decision-making processes of stakeholders operating in such an economy. In its efforts to reduce the compliance costs, the European Commission has put forward a set of measures and has expressed its support for the promotion of innovations for new abatement technologies (IMO, 2013). Maritime stakeholders like ship operators and ports have also been forced to look for innovative ways to adhere to the stipulation of emission reductions from ships and at the same time stay afloat profit wise (Wiśnicki, 2014). On the other hand, ship equipment vendors are venturing into ways of increasing their capital base and gain new business opportunities (EfficienSea2, 2016). Principally, two paths exist for the shipping industry to comply: one is the switch to low sulphur fuels, including LNG and other alternative fuels, or to install exhaust gas cleaning devices – scrubbers in ships (Brynolf et al., 2014).

Seemingly, the easiest solution to the sulphur emission regulation will be the complete change of the use of fuel to low sulphur fuel. However, according to the OECD/ITF (2016), approximately 80% of total bunker fuel is heavy fuel oil (HFO) with sulphur content that is higher than allowed in SECAs. One option for complying with the sulphur regulation will be for ships to travel with more expensive and cleaner low sulphur fuel (marine diesel oil (MDO) – a distillate oil, or marine gas oil (MGO) – a higher grade distillate oil that can be treated to reach a maximum sulphur content of 0.1% for short sea shipping in SECAs. However, ships that sail on other waters other than SECAs have the option of using higher sulphur content fuels rather than the 0.1% sulphur fuels mandatory for SECA, whenever they are out of SECAs (IMO, 2015). The use of the low sulphur content fuel does not require any major investments in remodelling ships, except minor adjustment to tanks and engines. And large ships could choose a hybrid solution that would allow them to switch between high- and low-sulphur fuels whenever they are within a SECA (Bergqvist, et al., 2015). It is noteworthy to point out that distillate fuels do not just serve as just a good option for SECA regulation compliance. They have other beneficial qualities such as a high thermal value that reduce engine wear and the need for frequent engine maintenance and reduced fuel consumption due to the higher energy content resulting in less sludge onboard ships (OECD/ITF 2016).

Liquefied natural gas (LNG) is another type of low sulphur content fuel that has arguably been widely accepted as a promising energy source for shipping in order to solve the sulphur content dilemma. LNG is less costly when compared to distillate oil and heavy fuel oil; however, the costs of distributing LNG to ports and ships is very high and depends on the distance of the port from the LNG import terminals, which is the method of distribution for LNG volumes (Brynolf et al., 2014). Ships also need to be converted to be able to use the LNG fuel. The conversion costs, for example, for a 19,000-tonne Great Lakes bulk carrier is estimated to be USD 24 million (Carr and Corbett, 2015). This high initial cost makes LNG retrofitting less cost-competitive when compared to other options. Apart from the initial costs, there are other added costs like the opportunity costs and a large space required for the LNG fuel tanks. Although it is claimed to completely remove shipping emissions like sulphur, particulate matter, NOx by approximately 90% and CO_2 by 20–25%. It has the negative side effect of methane slip – the emission of non-combusted methane. There are no conclusive studies on the effect of this element yet, but there is a good reason for a careful consideration of its use, the rationale for this is that it might lead to the introduction of a new problem while trying to solve another (Sköld, 2012).

The second abatement option is the use of the scrubber. This is a flue gas desulfurization (FGD) technology, which removes or "scrubs" SO_2 emissions from the exhaust gas. Traditionally, the principle behind the scrubber is the reaction of slake lime – $Ca(OH)_2$ (a white caustic alkaline substance consisting of calcium oxide). When SO_2 combines with limestone and water with the production of heat the primary by-product is calcium sulphate ($CaSO_4$, $CaSO_3$) commonly known as synthetic gypsum – a recyclable product used in the manufacturing of wallboard and cement, and as a soil improver in agricultural and construction applications (Duke Energy, 2016; EfficienSea2, 2016).

The chemical reactions behind the use of scrubbers:

$$Ca(OH)_2 + SO_2 + 1/2O_2 = CaSO_4 + 2H_2O \quad (1)$$
$$Ca(OH)_2 + SO_2 \rightarrow CaSO_3 + H_2O \quad (2)$$

A ship scrubber is a cleaning system that removes sulphur from the exhaust of ships that use heavy fuel oil (HFO). Through some technical consideration and upgrades, there are currently two major types of scrubbers: The dry and the wet scrubbers (Brynolf et al., 2014).

The Dry scrubbers reduce sulphur through chemical reactions that bound SOx to calcium hydroxide in granules to form calcium sulphate in a solid state as stated above. In the past, the dry scrubbers used to be popular for their use in power plants, but recently although not so common some of these scrubbers have been installed on ships (EfficienSea2, 2016).

The Wet scrubbers absorb sulphur oxides in water and are more popular and mostly installed on ships. There are three types of wet scrubbers and are differentiated by the type of water they used to absorb the sulphur oxide from the exhaust. They are open loop scrubbers, closed loop scrubbers and hybrid scrubbers.

Open loop scrubber systems, also called Seawater scrubbing uses the natural alkaline characteristic of sea water to neutralise the acidic exhaust gases. It absorbs the SOx molecules through the seawater, and then discharges the water back into the sea after extraction, storing the sludge which is discharged at port waste facilities. **Closed loop scrubber system**s, also called freshwater scrubbing, uses caustic soda (NaOH) to create a chemical reaction that absorbs the sulphur emission from the exhaust gas. It makes scrubbing possible in shallow and fresh waters that lack sufficient alkaline seawater to buffer the SOx in the exhaust gas. In this system, sodium hydroxide, an alkaline substance, is used to wash out the SOx from the exhaust gas by reacting on its own with a sulphuric product (Bergqvist, et al., 2015). Because of its closed nature, the wash water is continuously recycled making it necessary to have additional equipment like a process tank, sodium hydroxide storage, cooling and other storage tanks on board. The rate of Sodium hydroxide solution use is approximately at a combustion enthalpy of 6L/MWh/(ha.a) and stored according to the quantity needed for the entire voyage (EfficienSea2, 2016). The closed loop system prevents the sediment building up in filters, while the sludge is treated as with the open loop system. **The Hybrid scrubber system** combines the technologies of both the open and closed loop systems and is more flexible to use because it is able to switch depending on the alkalinity of the water. However, its installation is more complex and costly (OECD/ITF, 2016).

The initial investment costs of scrubbers range from €4 to €8 million per ship. The cost depends on certain features such as ship type, scrubber type and new build versus retrofit. In addition, apart from the initial investment, operating the scrubbers increases the rate at which the engine consumes fuel and is estimated to increase between 1–3% (EMSA, 2010). The scrubber needs space for installation and extra space for the equipment for the wash water, piping systems and monitoring on the ship, making it possible to use the scrubbers only in large vessels (Bergqvist, et al., 2015).

2.2. Endogenous Growth Theory and the Ripple Effect of Accumulated Regulations

Endogenous growth theory builds on the premise that the economic growth of a country is primarily dependent on decisions made by actors in the economy—firms and individuals—rather than on external factors (Barro, 1991). Because productivity growth plays an important role in any economy, any distortions that adversely affect entrepreneurial activities have great significances for the growth of any economy (Solow, 1994). The innovation that stems from these activities is the key driving factor for economic grow and social wealth. Innovative products and services emerge more often as a result of a cross-sectorial combination of technologies, design and business models (Olaniyi and Prause, 2016). In other words, the general well-being of the economy of any nation is directly proportional to the growth of the markets therein (Barro, 1991). There have been a lot of debates on the impact of government policies and regulations on national growth. Barro (1991) explained that regulations generally introduce distortions, such as high tax rates, spending, or heavy investments, which do not provide compensating incentives but give room for price and markets alterations that are investment deflators and negatively related to market growth.

Furthermore, there are debates that regulations have cumulative effects. Supporting this theory, Jaffe, Peterson and Stavins (1995) have said that regulatory decisions are too time-consuming and are often characterised by litigation and other legal power struggles that last for decades with more policies being added to the existing ones leading to what they called "transition costs". Regulatory interventions impact investment choices, which ultimately have a great effect on the economy because the build-up of regulations over time often leads to duplicative, conflicting, and even contradictory rules, and the multiplicity of regulatory constraints complicates and distorts the decision-making processes of companies or stakeholders operating in such an economy (Martin and Sunley, 1998). Affected companies usually respond to individual and accumulated regulations by changing their innovation strategies, which are embedded in activities such as research and development, expansion, equipment upgrade and processes (Bourlès, 2013). Rebelo (1991) claimed regulations can be considered the major cause of a decrease in productivity. He used the ratio of outputs (goods and services) divided by the inputs (resources such as labour and capital) as the definition of productivity of affected companies to support this argument. He explained that invariably the productivity of the affected companies would fall because the measured inputs of capital, labour, and energy will be deviated to the production of an additional output (i.e. regulation compliance) or result in inconclusive investment decisions that were not originally included in conventional measures of output/productivity.

New Institutional Economics (NIE) theory, which emphasises that the economic development of a country is governed by its institutions (Coase, 1998), can be used to support this view. Its overview depicts a strong interdependence between institutions and the collective character of a nation. NIE uses an economics perspective to focus on "social and legal norms" and "institutions" and how these elements affect the economic activities of a system (country) (Eggertsson, 2013). However, in NIE, "institution" does not mean organisations like government agencies, industrial associations, corporations, hospitals, and so on, but is defined as the "active rules" (e.g. laws, customs, regulations) of a social game where the players are particular actors and their respective governing bodies (Coase, 1998).

A key feature of this theory is that institutions involve transaction costs (enforcement of contract) that are often undermined during the process of institution creation (Eggertsson, 2013). The purpose of every institution is to provide an established set of expectations for both the actors and their governing bodies, but more often than not, these institutions and their enforcement instruments create limitations that reduce or prevent their total success (Nabli & Nugent, 1989). Transaction costs in NIE can be referred to as regulation compliance costs and the summary of this perspective is that transaction costs are expensive. Transaction costs often interfere with the effective administration of any institution. In his work "The Problem of Social Cost", Coase (1960) argued that low transaction costs would have a lower impact on the productivity level of any given institution (regulations). The use of the approach taken by NIE to endogenous growth theory can be applied to the gap between regulations (institutions) and compliance (transaction costs), which always reduces productivity. Regulations impose large direct and indirect costs on the stakeholders or even more on society. This makes it imperative to balance the cost-benefit of any regulation by identifying and implementing flexible and cost-effective regulatory instruments, whether conventional or the newer kind of market-based interventions because if businesses are constantly subjected to avoidable expenses and investments it could lead to societal waste (Blind, 2012). Jaffe et al. (1995) pointed out that innovation will always divert resources to R&D, and that environmental regulations could especially significantly affect productivity when the costs associated with reduced investments is considered.

In a different light, Solow (1994) argued that irrespective of the distortion any regulation might bring, every economy depends on investments in knowledge creation like research and development and how or the manner in which they lead to the innovation that creates productivity. Economic competitiveness also depends on strong links between research, innovation and actors in an industry (Olaniyi and Reidolf, 2015). This means that theoretically, companies that are imposed upon by regulations are forced to invest in more resources in the production process and although the "production" of new technology may require high financial input sometimes this may yield high returns. Another inference from this is that the impact of government intervention on economic growth is not simply the sum of the direct and indirect costs associated with each regulation. The OECD (2005) explained that even though enterprises are constantly subjected to a series of requirements and obligations through regulations, regulations should not be seen in a negative light, as these obligations are necessary legal impositions in order to regulate the manner in which businesses are being conducted that consider the plight of society. Regulations may sometimes not bring financial gains and sometimes not for everybody, but they create a stability which invariably is connected to wider macroeconomic benefits such as GDP increases, competitiveness and productivity effects and other intangible benefits, such as the protection of fundamental rights, social cohesion, international and national stability, and the economy status of any nation (Renda, 2013). It is important, therefore, that while the benefits of regulations are being analysed, the economic impact, compliance costs, as well as the administrative burden of such additional rules, are also measured (Repetto, 1990). Earlier in 2016, before the new sulphur global cap was confirmed OECD/ITF studies had shown that if the 0.5% global sulphur cap was considered, the cost impact of the regulations will be substantial with increases up to 7.5% in agricultural goods, 3.5% in manufactured goods and 16.4% for industrial raw materials. Since maritime transport costs make up a substantial share of the value of traded goods, this may likely translate into increases in the costs of traded goods.

2.3. The Craft of Strategic Management in Sulphur Emission Regulations Compliance

From the summations of endogenous growth and NIE theories, it will not be gainsaying to imply that compliance with government regulations often leads to the dilemma of investment choices. A lot of the costs embedded in regulations are direct such as capital investments and operational costs. There are also indirect costs such as the costs associated with new and changed personnel, materials purchased, legal costs, paperwork and the like. A single investment choice made per year has the ability to affect the proceedings of future years. Any wrong investment decision can cause an adverse setback, so also can indecision. The strategic decision that is made and the actions that follow by related enterprises are therefore crucial.

According to Porter (1996), because of the ever-evolving markets and demands, the aim of strategic management is to create the future by visualising a company's horizon, planning for the long term, analysing market changes and creating sustainable competitive advantages. Another study, Guohui and Eppler (2008), explained that strategic management creates innovative strategies that are capable of building a market position that is sustainable despite the uncertainties of the fast changing environment, potent competition, and internal challenges. Furthermore, based on the premises of Doz and Kosenen (2010), enterprises need to have the strategic ability to transform their business models if they want to pursue strategic innovation through the process of formulating, implementing and evaluating managerial actions, making strategic management a craft rather than a science (Noble, 1999). This means focusing on continuous adaptation and improvement that is constantly evolving in ways that put the actors in an active situation rather than in a reactive state (Eisenhardt & Brown, 1998). Chesbrough (2010), elucidated that companies with discovery driven attitudes could model their market uncertainties to their advantage. This involves a number of critical steps including scanning the environment for information, selecting relevant data and interpreting it, building a strategic model, testing it and putting it into action (Cray and Mallory, 1998).

The "scanning of the environment for information, selecting relevant data and interpreting them" are some of the bases on which the SWOT analysis is built. For this work, the SWOT analysis will serve as part of the creative strategies for programme-building, evaluation, financial appraisal, and ultimately for implementing or action planning at VKG. The SWOT outcome will enable the company to leverage this strategy with its inherent strengths through opportunities in the environment, and at the same time, exposing its weaknesses. This will be in line with Piercy and Giles (1998) summation that SWOT uses a knowledge of the company's threats to calculate its risk so that actions are taken to mitigate, exploit, avoid any adverse effects and remove the helplessness that comes with the burden of constant changes in the market environment.

The strategic management process also ensures that plans evolve into actions and are executed in a manner that accomplishes the stated objectives and that the resulting committed resources achieve the intended returns (Guohui and Eppler, 2008). One critical challenge for companies implementing regulations and policies, such as the sulphur emission regulations, is the gap between the transformation of investment decisions that stem from regulation compliance, and the investment returns that should ensue in its wake. In principle, compliance to regulations could lead to wide and abiding transformations, but it also has the potential to bring deep risk constraints in their implementation. This is important to note because sometimes the best-formulated strategies may fail to yield the intended result if they are not successfully implemented. It is not surprising that, after a strategic option is put forward, there are usually significant difficulties in the implementation process (Chesbrough, 2010). One of the difficulties in implementing the sulphur emission regulation is in investment choice for compliance.

Taking on an investment does not necessarily translate into the best of returns. It is also difficult to separate the quest for best returns and the associated risk exposure. Investments are usually long-term, so must be carefully chosen, diversified into a broad variety of asset classes (portfolios) and further adjusted to match the company's strategic aims and objectives. As time goes by, these goals will change dynamically to match the volatility of the environment. Consequently, the risks are further adjusted by reviewing the company's tolerance for any volatility that has occurred. Therefore, portfolios can be described as a range of investments held by any company to fulfil its strategic goals (Shipway, 2009).

The portfolio selection method used in this work is based on the theory that investors should focus on selecting optimal portfolios as opposed to optimal assets so as to minimise the risk of a given level of expected return. In order to understand the properties of multiple portfolios, there is a need to know the average figures of highly correlated outcomes from these portfolios. The results of portfolio analysis are logical consequences of its information concerning the intending investments (Markowitz, 1991). The principle of portfolio selection entails three factors; the expected return, the risk associated with the elements of the portfolio and the correlation between each element of the portfolio (Shipway, 2009).

3. Methodology

3.1. Study design

This study explores the activities of a maritime fuel company in Estonia, in the Baltic region of Europe (VKG) with the aim of studying how its business activities were affected as a result of the sulphur emission regulation and by extension the SECA regulations. VKG was used as a single study unit since a case study is a type of research, which investigates an individual, community or group to answer a specific question by seeking evidence that lies in the case setting (Gillham, 2000).

Between September and November 2016, data were collected from the company's records and the yearly financial statement of the company. Face to face structured interviews was conducted in October 2016 with the company's director of sales and the product development manager. Each interview lasted 2 hours and 3 hours respectively. The first part of the interviews focused on the VKG business model using the Osterwalder and Pigneur (2009) business canvas. This was done to gain insight into VKG's key business activities, key partners, key resources, value proposition, customers and customer relationships, distribution channels, cost structure, revenue streams and innovation activities. This information was also used to build the VKG profile. The second part of the interview was based on VKG's sulphur emissions regulations related activities if any, and the actions VKG is taking or planning to take in the future as a result of the change in market demand.

3.2. Data verification and analysis

A day of detached observations of the company's activities was conducted together with a tour of the production site for some first-hand experience. During this, the authors had several interactions with VKG employees from the administration and production department. In order to triangulate the data and to gather a richer contextual description needed for exploring the case according to Miles and Huberman (2014), additional information and clarifications were further accessed through email interactions with the company's certified respondent. Care was taken to look out for discrepant data especially between the records, interviews, interactions and the observation processes.

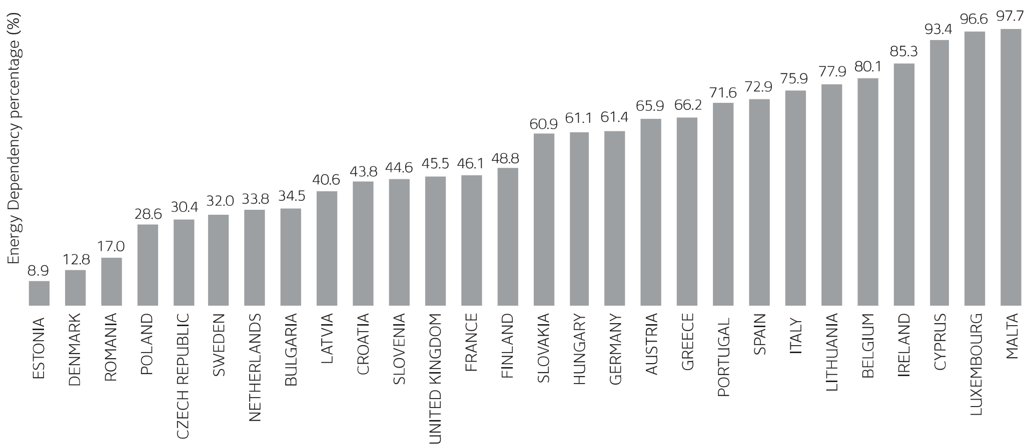
To provide an account of the company in order to generate a VKG profile, a descriptive analysis of the interview data was used. Each statement was put in a grid to classify the responses to each question. An accumulated reflective overview of the summaries and reviews of the data were made to discover how the multiple sources of evidence are related. This was followed by the interpretation and narration of the data according to Yin (1989).

Knowing that the knowledge and understanding of how the environment impacts any business decision is key to the growth of any company (Fleisher and Bensoussan, 2003), VKG's SWOT analysis was carried out through a brainstorming session as a diagnostic technique. The interview data together with the information from the SWOT brainstorming session was used to evaluate VKG's strategic position and to analyse each category (strengths, weaknesses, opportunities and threats), their properties and how they relate to each other vis-à-vis a highly volatile and competitive fuel market to map out different suitable strategic investment options for VKG. Finally, a portfolio selection analysis of all the investment options was made to determine the investment decision factors and their relative significance.

4. Viru Keemia Grupp AS

Viru Keemia Grupp AS (VKG) is the largest oil shale producing company in Estonia. It is situated in Ida-Viru County, an area in Estonia with a population of 148,000. Estonia is a small country at the eastern border of the European Union (EU) close to the Baltic Sea with a population of 1.3 million. It used to be part of the Soviet Union up until 1991. Estonia is the least energy importation dependent country in Europe due to shale oil produced electricity (Eurostat 2016, Figure 1). Estonia predominantly uses 78.3% of solid fuels to produce energy – mainly oil shale.

Figure 1. Energy dependencies in the EU



Source: Eurostat (2016)

Oil shale covers about 65% of the country's needs for primary energy, which has guaranteed the energy independence of Estonia. While the EU imports 53.4% of its total consumed energy, Estonia only needs 11.9% of imports for its energy requirements (Eurostat, 2016). The oil shale industry contributes about 4–5% to Estonian GDP and about EUR 300M to the state budget (including employment taxes, environmental taxes). As a producer of shale oil, VKG can be said to be one of the companies that have a significant impact on the Estonia economy. In 2015, VKG's contribution to the state budget of Estonia was up to €35 million and the company's total turnover was €167 million. From the turnover, €87 million was contributed from shale oil alone (Table 1). VKG started solely as a shale oil producer, but over the years has expanded and diversified its value chain to about 10 enterprises: oil, heat and power generation, heat distribution, electricity distribution, power system construction, oil shale mining, cinder block production, metal structures, pipelines and pressure equipment production, logistics, and assembly and repair companies. As of 2015, VKG employs over 2,100 employees.

Table 1. Business Analysis from 2006–2015

Year	Turnover million (€)	Shale oil Contribution Million (€)	Investment Million (€)	Percentage of investment to turnover (%)	Profit Million (€)	Number Of Employees
2015	166.8	87	59	19.5	-31.9	2101
2014	195.2	128	98	50.2	19.8	2206
2013	220.4	146	90.9	41.2	26.2	2013
2012	215.8	148	65.9	30.5	26.2	2000
2011	183.6	124	51	27.7	37.4	1610
2010	125.5	83	34.4	27.4	19.2	1406
2009	107.5	59	39.9	37.1	9.2	1312
2008	131.5	78	77.3	58.7	14.7	1381
2007	114.2	62	49.5	43.3	18.8	1369
2006	97.1	55	29.0	29.8	19.1	1374

Source: VKG 2015 Financial statement

Oil shale is a sedimentary rock which in its mineral state contains a solid, combustible organic matter commonly called "kerogen" (Siirde et al., 2013). As a solid material, it undergoes thermal treatment to produce shale oil and other products (coke and phenols). VKG uses two types of technology to produce shale oil: The Kiviter technology (a gaseous heat carrier) and the Petroter technology (a solid heat carrier method). The by-product – a waste gas formed in shale oil production is used as a fuel for heat and power cogeneration in Estonia. The produced shale oil is useful as a quality-improving supplement for HFO or diesel supplements in industrial boilers and furnaces.

The majority of VKG shale oil customers are some of the largest oil traders in the world. VKG Transport, a VKG subsidiary is responsible for its logistics and uses freight on board (FOB) – Sillamäe delivery for most of its distribution activities. The distribution process starts from the production site through rail, which transports the shale oil directly to the Sillamäe port where tankers can pick it up for delivery to Rotterdam. Currently, there are marginal sales of VKG products to refineries, however, the majority of the liquid product mass is not sold to refineries but blended directly into product bunker fuel instead.

5. Results

5.1. The Impact of Sulphur Regulation on Business Activities

The sulphur content of shale oil is around 0.8% w/w; this is higher than the 2020 global sulphur limit and even higher than the SECA limit. Although VKG sells its fuel directly to oil traders and not to the end-users, considering the sulphur content of 0.8% w/w as average in shale oil products, might mean it is unlikely that the product is being used in a SECA bunker fuel blend. Apart from its high sulphur content according to the IMO SECA sulphur regulation standard, shale oil has a viscosity-density relationship preferable for specific purposes: especially for improving HFO flow properties and pour point. This is one of the key selling points of shale oil. The density and viscosity are both within the range of the ISO 8217 residual marine fuel specification. Depending on the fraction, the largest portion of blended oil products has a density between 0.99 -1.02 kg/L and a kinematic viscosity between 20 -105 cSt. In the context of ISO 8217:2012 residual marine fuel characteristics, the majority of shale oil products marketed fall into the marine oil density RMK and the viscosity RMD low range. This fact, however, does not separate VKG from the realities of the evolution in bunkering fuel and the regulations that surround it.

Table 2 shows the results of the VKG SWOT analysis. It shows a sustainable company with an advantage of a long value chain from oil shale processing. VKG has access to oil shale resources with its subsidiary operated mining. However, the resource mining limits the allocation system in Estonia coupled with the 60% fine grain and 40% coarse grain oil shale proportions achievable in mining, and VKG's historical oil shale processing capacities have resulted in imbalanced oil shale production capacities.

In 2015, 14.9 million tonnes of oil shale resource was mined in Estonia (Ministry of the Environment, 2016), which was about 25% less than the allowable and acceptable yearly limit set in the oil shale development plan 2016–2030 (Ministry of the Environment, 2015), and VKG has insufficient oil shale mining resource allocation for all processing capacities. VKG is differentiated from other shale oil producers in Estonia through the valorisation of phenolic water formed in the pyrolysis process – a thermochemical decomposition of organic material at high temperatures in the absence of oxygen. VKG has an agile and flexible supply chain considering the fact that most of its logistics operation is carried out by its own subsidiary company.

The SWOT also revealed that VKG has a thriving environment department. As an oil production firm, the company is subjected to diverse environmental laws and regulations, and therefore uses a centralised environmental department (ED) to provide services to all subsidiaries in the VKG group. This department is responsible for the preparation of applications for environmental permits, environmental reporting including reporting of resource consumption and pollution for the determination of environmental taxes, and managing environmental impact assessment procedures if designated. VKG ED is also responsible for European Union (EU) Emission Trading System (ETS) reporting, registration and applications for VKG group subsidiaries. It monitors the best available technology (BREF) documents, EU environmental legislation, and Estonian and other government draft legislation information systems. Because of its industrious promotion of environmental awareness activities, VKG has been consistently awarded the title "Responsible Estonian Business" from 2010 to 2015. Intensive VKG investments in environmental causes had enabled a significant reduction in ecological footprint. About €100 million out of the €900 million in investments VKG made over the years were spent on environmental related activities. One of such is the construction of Kohtla-Järve conveyor, an environmental project that cost about €14 million. From the company's report, emissions of volatile organic compounds have decreased by 53%, sulphur oxide by 69%, and monobasic phenols by 98%. In addition, the Petroter plants' energy efficiency is reported to be as high as 81% due to the improved environmental protection measures and the ecological footprint is said to be several times lower than the formerly used technologies in the company.

From the interviews, it was discovered that the VKG response to the SECA regulation was to lead with a refinery project (a project that was in the pipeline) along with process innovation and the elongation of its product portfolio, especially by-products. Before the SECA regulations, VKG had started a feasibility study on building its own refinery and bunker fuel market change research, a project that cost VKG about €5.5 million. Business wise, running a refinery would have meant a product innovation that will yield Euro V Diesel (the majority of the production) and 0.1% sulphur marine fuel oil and stabilised naphtha outputs. However, the the outcome of the research could not dispel the uncertainties that surrounded the 2015 sulphur regulations and the uncertainties that surround the market reaction to the sulphur regulations.

Table 2. SWOT analysis

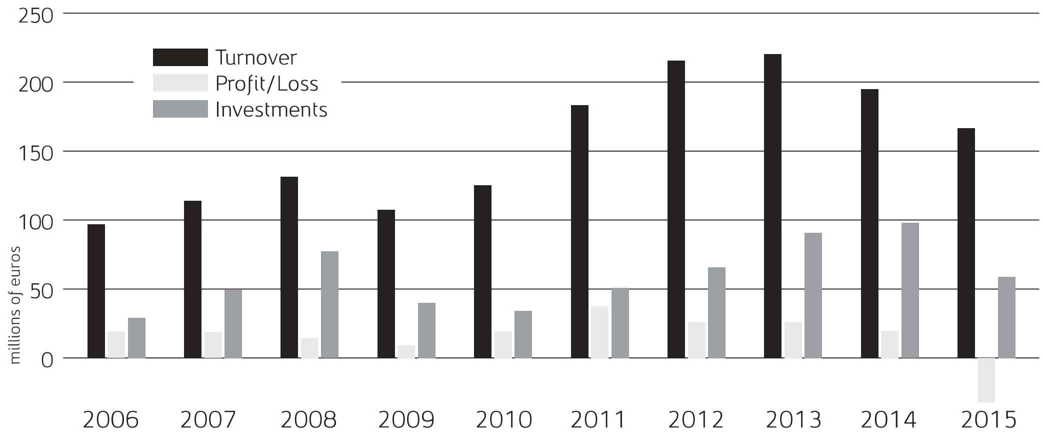
Strengths	Weaknesses
• Access to resource-group operated mining. • Processing technology innovation. • Favourable oil product viscosity properties. • Large-scale project management. • Agile and flexible management. • Long oil shale processing value chain. • Sustainability management. • Effective and sustainable environmental department. • Sell directly to the traders, so do not have to deal with regular end users. • Has control of its logistics by using own transport company.	• Uncompetitive and high fixed costs when compared to pumping costs of crude oil. • Products not common in refineries. • The uniqueness of oil shale - need for adaptation of technologies. • 70% production output (510,000 instead of 750,000 tonnes/year) limitation because of oil shale resource allocation. • Oil shale resource allocation smaller than processing capacity due to the absence of open markets for oil shale. • Ageing workforce due to decreased labour age population in Ida-Viru area of Estonia. • Sell directly to the traders, so do not have the normal interface with end users.
Opportunities	**Threats**
• Redeeming the poor public image caused by historical contamination of production sites. • Readiness for Industry 4.0. • High fixed costs, uncompetitive compared to pumping costs of crude oil. • Product uncommon for refineries giving room to build own-refinery. • The uniqueness of oil shale – need to adapt technologies. • Oil shale resource allocation smaller than processing capacity, no open market for oil shale.	• Poor public image due to historical contamination of production sites by oil companies. • High fixed costs, uncompetitive compared to pumping costs of crude oil. • Product uncommon for refineries. • The uniqueness of oil shale – need to adapt technologies. • Oil shale resource allocation smaller than processing capacity, no open market for oil shale. • Environmental legislation and regulations and taxes. • Resources policies. • Unstable prices – decrease in fuel price. • Dollar/EUR exchange rates. • High market demand for low sulphur content fuel.

Source: Compiled by the authors

Furthermore, the feasibility studies showed that the Front-End Engineering Design (FEED) stage – the cost of the refinery for the raw material processing capacity of 133% VKG shale oil production at 14,000 barrels per day and 750,000 tonnes per year will cost a staggering sum of 400 million EUR coupled with the 5% depreciation of 20 million EUR annually. This confirms how expensive a project of that magnitude would be, forcing the management of the company to put the refinery project on hold. The risk is further magnified because VKG has had to constantly struggle with uncompetitive high fixed costs of its fuel production when compared with that of crude oil and because of the downward trend in fuel prices. Because oil shale is not a common product found in regular refineries, its refining process and activities are quite limited. These attributes also make it difficult to use standard technology in the refining process. Even though VKG has access to a resource based mining group, the oil shale resource allocation is smaller than its processing capacity forcing VKG to only use 70% of its shale oil production capacity (520,000 tonnes/year).

A look at the 10-year breakdown trend of VKG financial activities in Figure 3 and Table 1 shows the sizeable contribution of shale oil to annual turnover, although 2015 shows a decrease in the contribution of shale oil. The fact that for the first time in 10 years VKG recorded a loss in 2015 is also noteworthy. One sellable explanation for this occurrence is that oil prices have fallen drastically, a bitter pill any oil producing company have had to swallow. Further examination also shows that VKG investment was low in 2015 as a percentage of annual turnover (19.5%) when compared to previous years.

Figure 2. Financial Statement for 2002–2015



Source: VKG AS 2015 Financial statements

5.2. Strategic Options for Sulphur Regulations Compliance

The evaluation of the market environment (SWOT), as well as the company's present financial appraisal, were used to create strategic sulphur emissions regulations compliance actions. The SWOT also revealed some weaknesses and threats. The harsh reality is that VKG will continue to be threatened by legislations, regulations and environmental laws that will keep the company on its toes. It will also continue to face the challenge of available open markets for its products and the uncertainties that surround fuel markets. The use of alternative fuel sources (LNG, renewable fuels (II generation biofuels) and methanol) are also gaining more ground as bunker fuels. One of the targets of this work is to use this knowledge to mitigate, exploit and avoid any adverse effects of these threats and weaknesses.

VKG is faced with two major challenges: first, the fuel price collapse and its highly volatile market, and second, sulphur emission regulations compliance investments. From the analysis carried out, there are realistically 5 investment strategies VKG could choose from. These are upward vertical integration, products upgrade, hydrodesulphurisation, product discount and process innovation.

1) **Upward vertical integration:** Blending VKG shale oil with 0.1% MGO or another low-sulphur content fuel, which will basically be an upward vertical integration in its supply

chain process. In this case, VKG will sell directly to its suppliers and will be in charge of how these products are supplied. Apart from serving the end result of being able to sell its 0.8% sulphur fuel, VKG may be able to increase its share in the market by minimising the bottlenecks created by middlemen and reduce its transaction costs, leading to an increase in profits. However, it might lead to decreased supplychain flexibility and end up hindering productivity (Mahoney, 1992). Due to the scarcity of open markets for oil shale, VKG currently sells directly to traders. This has helped the company greatly in its supply chain agility and flexibility. Having to deal with an increase in its distribution chain will increase complexity in its straightforward supplychain system.

2) **Products Upgrade:** Building a new refinery which could result in a change in the marketable products portfolio for VKG such as V Diesel, 0.1% sulphur marine fuel oil and stabilised naphtha. Refining shale oil will also yield commercially valuable products that can be used as a substitution for petroleum derivatives with only minor modifications and adjustments of the operating conditions (Akash, 2003). The refinery would seem like a good investment decision for VKG due to the increased process capacity. An improvement to the present capacity by a mile and according to the preliminary report would produce an output of stabilised gasoline fraction of 61,000 tonnes/year, Euro V diesel of 349,000 tonnes/year as well as SECA fuel oil of 303,000 tonnes/year. In addition, 7,300–7,500 tonne/year elementary sulphur would also be produced. However, the costs involved would be higher than the stated capital expenditure (CAPEX) of 400 million euros. For instance, there will be additional investments in operational costs (OPEX) that involves employing more staff, maintenance, insurance and administration. The cost of operations without depreciation is estimated to be between €30–50 million/year, which will also depend on the price of natural gas and on the amount of raw material (oil shale) processed. It will also take about 5 years before any refinery can adapt to full operation even after such a heavy investment (OECD/ITF, 2016). Building a refinery wedges VKG between volatile market segments (cost and price), and exposure to significant risks, one of which is the susceptibility to closure if unsustainable (CFA, 2013).

3) **Hydrodesulphurisation:** The removal of sulphur (partial hydrogenation) from product oil (desulphurisation) involves a chemical reaction between molecular hydrogen (H2) and another compound or element in this case sulphur, with the help of a catalyst (Kabe, Ishihara, & Qian, 2000). Heavier distillates are usually broken down through this process. While this process will solve the sulphur content challenge of shale oil, hydro-desulphurization could cost VKG between 100 – 150 million euros in capital investments. This option is in direct competition with VKG keeping the status quo of selling its products to the bunker fuel traders. Before taking this step VKG must be able to answer some pertinent questions. What difference will it make if they proceed with an investment of this scale? What if the price spread between HFO and MGO is negligible in the future? What is the return on this type of investment? Part of the speculation over the price of MGO before the SECA limit related to how an increase in demand could affect its price (Notteboom et al., 2010). Other studies, WoodMacKenzie (2016), postulated that a global sulphur cap of 0.5% could result in an increase in the overall price of fuel by 2020. Experts are finding it difficult to speculate fuel prices. Hämäläinen et al. (2016) in their studies discussed several failed attempts by market experts to forecast fuel prices. The uncertainties that surround fuel prices have made it risky for VKG management to make any calculated investment decision.

4) **Product Discount:** VKG can continue marketing its existing 0.8% w/w sulphur content product but at a discount to traders if the future price spread between 0.5% sulphur fuel oil and 0.1% sulphur fuel oil is insignificant. In the first place. Because shale oil is already being sold to traders, there is a negligible likelihood that this oil could still be used in a SECA bunker fuel blend. Therefore, with proper incentives and trade terms, VKG will likely keep their current or most of their current customers. Presently, the greatest threat to this will be increased demand and supply of low sulphur fuel on the market. Some of the things that were considered while appraising the cost impacts in 2020 were the low capacity of refineries for low-sulphur fuel and the resulting price spread between HFO and MGO.
5) **Process innovation:** Process innovation to implement a significantly improved production method (Utterback, 1994) will increase and improve VKG's efficiency (energy efficiency, a mass yield of products and labour productivity) as a key factor for sustainability post-2020 under a global sulphur cap. VKG can also make use of Industry 4.0 automation and data exchange in manufacturing technologies to improve its business and process efficiency, pay better attention to the potential of its other products and convert their opportunities to maximum profits. Because of the fluctuations that are seen in the fuel market, VKG can leverage its fixed fuel price. The need for efficiency improvement will not only be useful for MARPOL regulations, but it will come in handy when other trends and influences like climate policy, stricter environmental legislation, demographics and workforce deficiency trends are combined. Further efforts in waste reduction – such as the greater valorisation of the waste gas and the conversion of solid by-products such as limestone from oil shale mining and ash from shale oil plants, decreasing process losses – can be intensified. Productivity can also be improved by addressing the ageing workforce due to the decrease in labour age population in the Ida-Viru area of Estonia where the VKG production site is situated. Ida-Viru as a county is susceptible to the migration of upwardly mobile and young working population to more attractive pull centres or cities. A situation Prause (2014) said will be a significant disadvantage for the operations of knowledge-intensive companies in rural areas.

5.3. Investments (Portfolio) Selection

The HFO/MGO price spread was used as the major impact factor for selecting the right investment for VKG because based on the 0.5% sulphur emission global cap, there is an expectation that in 2020 there will be a sharp reduction in HFO demand, consequently, an increased demand for MGO or ULSFO. According to the analysis by WoodMacKenzie (2016), by 2020 there would likely be a sharp increase in oil distillates (MGO, MDO, ULSFO-Ultra light sulphur fuel oil) forcing a reduction in the installation of scrubbers on ships. The use of HFO will decrease as a result of this. At such, scrubber installations will only become a viable option for 75% of the existing ships that are less than 10 years old with an engine capacity greater than 17 MW. Furthermore, because the installation capacity of available ships will be limited, coupled with the likelihood that refineries are not going to be very eager to make huge investments in refining HFO, it is predicted that HFO will gradually return to the market. These uncertainties will contribute greatly to the volatility of the fuel price market and further increase VKG investments risks.

As a multi-criteria decision analysis tool, a matrix of the different strategic options for VKG was created using different scenarios related to price spread (table 3). Each scenario of HFO/MGO price spread was defined as, very high, high, constant, low and very low. A constant was used to depict what is presently obtainable. The scale for the outcome of each scenario was set up between -2, -1, 0, +1 and +2. Each scenario was further assessed with two VKG respondents to weigh their relative significance related to VKG as seen in Table 2. The major focus was the impact scale for each option if the price spread was to change.

Where:
0 is comparable to now
+ is company has a better position (+1, +2)
– is company will be worse off (-1, -2)

To determine the probabilities of the HFO/MGO price spread, the spread distribution of July 2015 to the current spread in 2016 was used. First, the range of the price spread was calculated as the difference between the lowest spread (\$120) and the highest spread (\$220) within this period, which is \$100. Second, the intervals between the fuel prices (≥\$120 and ≤\$220) were calculated using the spread fluctuations within this range. These are \$185, \$155, \$145 and \$135. Next, to find the probability (p_s) for each scenario, the differences between the spread intervals (e.g. 220-185 = 35) were each divided by the range ([(220-185) ÷100 = 0.35]).

The total weighted score for each outcome was then calculated by multiplying the probability (p_s) for each scenario by their respective scales as shown in Appendix 1.

Table 3. Decision matrix analysis for investments options

	HFO/MGO Price spread scenarios (Outcomes)						
Options	Very High p=0.35	High p=0.3	Constant p=0	Low p=0.1	Very low p=0.15	Expected value (μ)	Risk (SQRT σ^2)
Upward vertical integration	-1	-1	0	0	-1	-0,8	0,40
Products Upgrade	2	0	-1	-2	-2	0,1	1,58
Hydrodesulphurization	1	1	0	-1	-2	0,25	1,13
Product Discount	-2	-1	0	0	0	-1	0,84
Process innovation	-1	-1	1	1	1	-0,3	0,95

The expectation value (μ) for each option d is:

$$\mu_d = \sum_s P_{ds} \times out_{ds} \tag{3}$$

Where:
P_{ds} = the probability of spread scenarios option for d
out_{ds} = outcome

The variance (σ^2) is calculated as:

$$\sigma^2_d = \sum_{ds} P_{ds} (out_{ds} - \mu)^2 \tag{4}$$

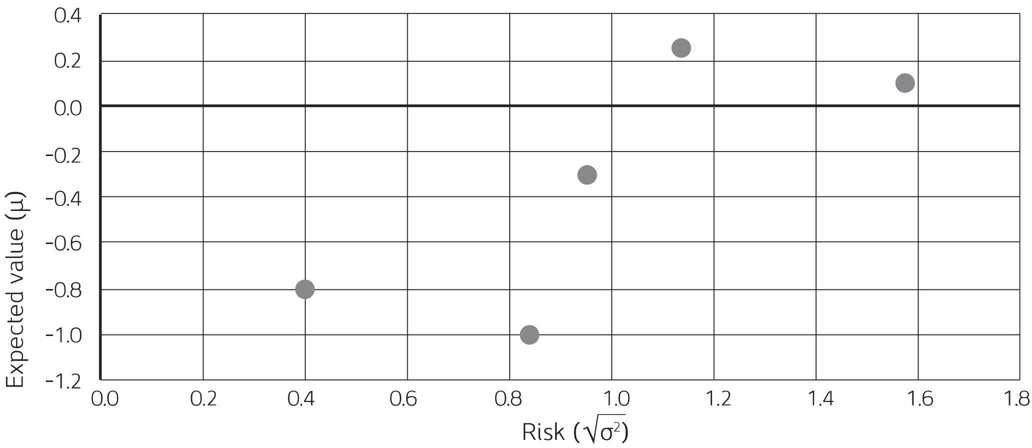
Thus:

$$Risk = \sqrt{\sigma^2} \tag{5}$$

Finally, for the investment portfolio selection, a graph of the expected value (μ) is plotted against Risk ($\sqrt{\sigma^2}$).

From the investment portfolio graph (Figure 3), hydrodesulphurisation, regardless of its high risk, appeared to be the option with the highest return on investment followed by product upgrade. The risk is obviously associated with the uncertainties in fuel prices. An investment of this magnitude will prove futile in the face of a heavy reduction in the cost of fuel. This will make it difficult for VKG to recoup the investment made. Product upgrade was found to be the riskiest option if taken because it is very expensive, and the failure of such a venture could be the final downfall for VKG. Upward vertical integration is the least risky, with little return for the investment and time spent on it. Product discount is the option with the least return on investment.

Figure 3. Investments Portfolio analysis



6. Conclusions

This work focused on three research questions. First, what are the economic implications of sulphur regulations on VKG's business activities? Second, what strategic compliance options are available for VKG? And third, how attractive are these options for VKG sustainability?

The results for the first research question showed that due to the new 0.5% global sulphur emission cap, VKG has found itself in a position where it must make an assessment on the marketability of its 0.8% sulphur content fuel post-2020 if it wants to keep producing and selling marine fuel. This is a situation that is also linked to job creation in the county where it is situated and the economic growth of the host country. Currently, VKG is struggling to keep itself from sinking under the consequences of product demand change as a result of the sulphur emission regulations. Information from interviews shows that the company is still weighing its options on how to go forward in the face of the 0.5% sulphur content regulation. Unfortunately, it does not have the luxury of time before 2020, when the regulation will take effect. Apart from the investment that was made on the refinery and bunker fuel market change research, VKG has not been able to decide what course of investment actions to take. Having been already adversely affected by the downward fuel price trends, it must proceed strategically and cautiously in regard to what investments decision to make. Strategically, because while VKG may still be able to sell its fuel directly to bunker traders, there will also be continued interest in improving air quality along with renewal concerns about air pollution from shipping activities and, follow up regulations might come at any time to interrupt its distribution channel. Indecision will likely prevent a bad investment choice, but on the other hand, any delayed investment could also be risky, in line with conclusions by Rebelo (1991) on the adverse effects of investment indecision. The constant loss of opportunities is counterproductive for any company in any given business environment. VKG also needs to proceed cautiously because nobody is sure about the fuel market or the success of the available abatement technologies for sulphur emissions. The economic feasibility of shale oil is highly dependent on the markets for conventional crude oil.

A continued loss as significant as 2015's will be detrimental to any company of VGK's size and status, especially when combined with the rapid increase in environmental charges. For example, in the past 10 years charges for SO2 emissions have increased by 700%, and waste disposal by 273%. Even though VKG cannot be compared to the big players in maritime fuel markets, such as ExxonMobil, Clipper oil, or Total in terms of manpower, global presence and net worth, the importance of VKG to the economic development of Estonia cannot be downplayed. In the past 10 years, the company has invested close to €900 million in the economy of Estonia and is responsible for over 2,100 jobs, of which, 600 were created within 2011 and 2014. VKG is the largest shale oil producer in Estonia and oil shale covers about 65% of the country's needs for primary energy, which has made Estonia energy independent, cutting almost to zero the importation of energy to Estonia. The oil-shale industry alone contributes between approximately 4–5% (about €300 million) to national GDP every year. In IdaViru County the shale oil industry is responsible for over 6,600 direct and about 13,400 indirect employees which are about 20% of the total regional workforce (Eesti põlevkivitööstuse aastaraamat, 2014). VKG as a company and the oil shale industry are important actors in the growth and prosperity of Estonia. A distortion to this industry will definitely have a grievous consequence on the national economy. Going forward VKG must decide on a sustainable solution for its conformity with the regulations.

Therefore, to address the second question, five investment strategies were projected based on the market environments and VKG's SWOT analysis. These were upward vertical integration, products upgrade, hydrodesulphurisation, product discounts and process innovation. The sulphur emissions are here to stay. VKG must make use of the present market conditions to create for itself a solution that enables it to rise above its challenges. These options are some of the opportunities and strengths that VKG can leverage on.

The third question was answered with the investment portfolio analysis of the five strategic options discussed. The result confirmed that the cost of sulphur emissions regulations compliance is excessively risky and expensive for marine fuel producers, especially VKG. In VKG's case, the transaction costs (cost of compliance) will unavoidably eat away the resources that would have been otherwise used for other growth-induced investments. These costs will generate further social costs like job losses for the region, especially if the company wants to recover its loss. Consequently, a company can only be productive if it can achieve a balance between its transaction costs and its production. Undermining compliance costs by the regulatory bodies when institutions are being set up has grave consequences. While MPEC accepts that the compliance options are expensive (Unctad, 2015), most efforts are concentrated on abatement technologies for ship owners and the port monitoring activities. From NIE theory, the productivity of any institution depends on the cost of transactions, meaning that companies can only thrive if the production processes are without the excessive costs of compliance. The social costs that will ensue are detrimental especially if they result in job losses for a region like Ida-Viru. Industries can only thrive when companies increase their workforce for growth, and any institution that disrupts this process is counterproductive. Larger companies will always have a better edge over smaller ones in the short term due to available disposable resources; however, in the longer term, the effect will become evident through reduced rates of growth. In situations like the sulphur emission regulation, where a regulation is accompanied by high compliance costs, the governing body ought to provide alternative institutions that will reduce the outcome of the transaction costs. In order to reduce social costs and prevent societal waste, the compliance enforcement (allocation of resources and the development of new technologies) depends on the prevailing governance structures.

Another outcome of this work is that VKG as an organisation is sensible and would want to realise a return on any investment that corresponds to the risk involved but VKG could be risk averse. Being risk averse, however, does not mean that it is not open to any form of risk but that when it is presented with different options for investment that seemingly offer similar expected returns, the company would prefer to take the less risky route. Therefore, VKG will likely take on highly risky investments as long as it can be sure that the investments will be rewarded with a higher expected return.

While the conjecture by policymakers that regulations are beneficial is right, the impact of these regulation obligations varies significantly. This study confirmed some of the arguments of the endogenous theory that regulations do not have the same economic impact on large companies as they do for smaller companies. On the basis of size, companies are on different scales. “Smaller” companies like VKG could sometimes lack the capacity to handle the necessary compliance changes that come with regulatory decisions, which is also in line with NIE discussions on transaction costs for institutions. It is noteworthy to mention that the shipping industry incurs such a significant cost for environmental regulations compliance, and so, for sulphur emission regulations like SECA to be rational, there has to be an allowance for level playing among related stakeholders.

The sulphur emissions regulations have been able to yield significant health benefits for the BSR and have reduced the potential acidification damage that sulphur compounds can cause to ecosystems. Clean shipping as a vision was set to make maritime transport greener, and this is presently being achieved through new technologies and changed behaviour on board across all stakeholders in the maritime sector in a concerted and integrated effort of multiple measures. Based on a results presentation and expert interview with Johan Mellqvist (2016), during an EnviSuM (Environmental Impact of Low Emission Shipping: Measurements and Modelling Strategies) partners’ meeting, the preliminary tests conducted on sulphur concentrations in most BSR ports since SECA regulations show a significant reduction in SO2 concentration in the air and a compliance rate of 96.5% in the ports.

However, the underlining fact is that regulation compliance will be related to significant investment decisions for maritime stakeholders, and large uncertainties will always encompass each regulation. The VKG case has confirmed that not all regulations are created equal in terms of their costs or their benefits. For example, market-based or economic-incentive regulations, such as those based on tradable permits are likely to be more cost-effective because they provide incentives for companies to adopt a process that will comply with the regulation, unlike regulations that require technological change or establishing conventional performance standards like the sulphur emissions regulations. Agreed that stimulating innovation in the maritime sector for a cleaner environment is crucial, and that technology development may be able to lead the way out of some persistent environmental problems, but a technical solution to a problem should not set the foundation for the creation of other problems.

This work is limited to a single case. However, it contributes to the body of knowledge in the following ways:

First, it contributes to the on-going discussions on the impact of sulphur emissions regulations on the business performance of maritime stakeholders. It concludes that some maritime companies are struggling under the consequences of change in maritime fuel consumer demand due to the sulphur emission regulations and that the viable compliance options are expensive and risky.

Second, it contributes to one of the EU regulation objectives by showing how the cumulative effect of a beneficial regulation that seeks to "*demonstrate clear added value… full benefits at minimum cost …. With a simple, clear, stable and predictable regulatory framework for businesses, workers and citizens…*" (EU, 2012) can pose a significant threat to the economic well-being of a country. From a policy creation and policy execution point of view, the challenge of regulations like the sulphur emission regulations lies in harmonising the implications of the regulations and its policy instruments as they relate to regulation compliance. It is, therefore, recommended that maritime policymakers and regulatory bodies ensure a continuous cross-link between emissions related regulations and innovation, together with the availability of compliance technical know-how that will consequently cause the creation of policy instruments that will cushion its effect on all stakeholders.

Third, this research discussed the compliance options available for fuel supply companies from the opportunities that are both inherent and external to the case company. This contribution can be extended to similar maritime fuel producing companies. The portfolio analysis framework, in particular, will benefit similar companies in their strategic decision-making process. This type of contribution will improve the innovation capacity of related maritime companies and the integration of new knowledge for the maritime sector.

Further research can be made to assess the economic implications of the MARPOL sulphur regulation on other categories of maritime stakeholders in the BSR, such as ship owners and ports for a comparison of the degree of impact. Further research can also explore the measurement of the effect of SECA regulations on clean shipping regulations for the maritime industry in the BSR –such studies will be crucial to the sustainability of emissions regulations.

References

AirClim. 2011. *Air pollution from ship*. Air Pollution & Climate Secretariat Seas at Risk Bellona Foundation North Sea Foundation Transport & Environment European Environmental Bureau. Retrieved May 21, 2016 from https://www.transportenvironment.org/publications/air-pollution-ships-0

Akash, B. A. 2003. Characterization of shale oil as compared to crude oil and some refined petroleum products. *Energy Sources*, Vol. 25, No. 12, pp. 1171-1182.

Barro, R. J. 1991. Economic growth in a cross-section of countries. *Quarterly Journal of Economics*, Vol. 106, No. 2, pp. 407-443.

Bergqvist, R., Turesson, M. and Weddmark, A. 2015. Sulphur emission control areas and transport strategies - The case of Sweden and the forest industry. *European Transport Research Review*, Vol. 7, No. 2, pp. 1-15.

Blind, K. 2012. The influence of regulations on innovation: A quantitative assessment for OECD countries. *Research Policy*, Vol. 41, No. 2, pp. 391-400.

Bourlès, R., Cette, G., Lopez, J., Mairesse, J. and Nicoletti, G. 2013. Do product market regulations in upstream sectors curb productivity growth? Panel data evidence for OECD countries. *Review of Economics and Statistics*, Vol. 95, No. 5, pp. 1750-1768.

Brynolf, S., Magnusson, M., Fridell, E. and Andersson, K. 2014. Compliance possibilities for the future ECA regulations through the use of abatement technologies or change of fuels. *Transportation Research Part D: Transport and Environment*, Vol. 28, pp. 6-18.

CFA. 2013. Economics fundamental of refining 2013. Canadian fuel association.

Chesbrough, H. 2009. Business Model Innovation: Opportunities and Barriers. *Long Range Planning*, Vol. 43, No. 2, pp. 354-363.

Coase. R. 1998. The new institutional economics. *The American Economic Review*, Vol. 88, No. 2, pp.72-74.

Coase, R. H. 1960. The problem of social cost. In *Classic Papers in Natural Resource Economics*, pp. 87-137. UK: Palgrave Macmillan.

Cray, D. and Mallory, G. R. 1998. *Making sense of managing culture*. London: International Thomson Publishing Press.

Doz Y. and Kosenen, M. 2010. Embedding strategic agility: A leadership agenda for accelerating business model renewal. *Long Range Planning*, Vol. 43, No. 2-3, pp. 370 – 382.

Duke Energy. 2016. Sulphur dioxide scrubber technology. Retrieved June 10, 2016 from https://www.duke-energy.com/environment/air-quality/sulfur-dioxide-scrubbers.asp.

Eesti põlevkivitööstuse aastaraamat. 2014. Eesti Energia, Viru Keemia Grupp, Kiviõli Keemiatööstus, TTÜ Virumaa Kolledži Põlevkivi Kompetentsikeskus. Retrieved November 28, 2016 from http://www.vkg.ee/cms-data/upload/sise-uudised/eesti-polev-kivitoostuse-aastaraamat-2014.pdf.

EfficienSea2. 2016. Report on the available technologies and sensors that can be utilized in the new system and on business model on incentives for monitoring and enforcement. Retrieved August 12, 2016 from http://efficiensea2.org/publications/.

Eggertsson, T. 2013. Quick guide to new institutional economics. *Journal of Comparative Economics*, Vol. 41, No. 1, pp. 1-5.

Eisenhardt, K. M. and Brown, S. L. 1998. Competing on the edge: strategy as structure chaos. *Long Range Planning*, Vol. 31, No. 5, pp. 786-9.

EMSA. 2010. European Maritime safety Agency Annual 2010 Report. Retrieved May 10, 2016 from www.emsa.europa.eu/emsa-documents/download/1421/143/23.html

EU. 2012. *Regulatory Fitnes*. Communication from the commission to the European parliament, the council, the european economic and social committee and the committee of the regions.

Eurostat. 2016. Energy dependency in the EU. Eurostat news release. Retrieved October 20, 2016 from ec.europa.eu/eurostat/documents/.../8.../c92466d9-903e-417c-ad76-4c35678113fd.

Fleisher, C. S. and Bensoussan, B. E. 2003. Strategic and competitive analysis: methods and techniques for analysing business competition. *Upper Saddle River*, NJ: Prentice Hall.

Gillham, B. 2000. Case study research methods. Bloomsbury Publishing.

Guohui, S., and Eppler, M. J. 2008. Making Strategy Work: A Literature Review on the Factors influencing Strategy Implementation 1. *ICA Working Paper*, Vol. 2, pp. 1-46.

Hämäläinen, E., Hilmola, O.P., Prause, G. and Tolli, A. 2016. Forecasting maritime logistics costs – Will the low oil price remain? In A. Serry and L. Lévêque (Eds.). *Le transport maritime à courte distance (Short-Sea Shipping)*, Devport 2016 Conference, pp. 19-34. Le Havre, France: EMS Geodif.

IMO. 2008. Revised MARPOL Annex VI: Regulations for the prevention of air pollution from ships and NOx technical code. London: IMO Marine Environmental Protection Committee (MEPC).

IMO. 2013. Sulphur oxides (SOx)—Regulation 14. Retrieved September 20, 2016 from http://www.imo.org/OurWork/Environment/PollutionPrevention/AirPollution/Pages/Sulphur-oxides-(SOx)- Regulation-14.aspx.

IMO. 2014. Third IMO GHG Study 2014. International Maritime Organisation, London, UK.

IMO. 2015. Guidance on the application of regulation 13 of MARPOL annex VI tier III requirements to dual fuel and gas-fuelled engines. MEPC.1/Circ.854. London.

IMO. 2016. IMO sets 2020 date for ships to comply with low sulphur fuel oil requirement. Press briefing release 28/10/2016. Retrieved November 30, 2016 from http://www.imo.org/en/MediaCentre/PressBriefings/Pages/MEPC-70-2020sulphur.aspx.

Jaffe, A. B., Peterson, S. R., Portney, P. R. and Stavins, R. N. 1995. Environmental regulation and the competitiveness of US manufacturing: what does the evidence tell us? *Journal of Economic Literature*, Vol 33, No. 1, pp. 132-163.

Jiang L., Kronbak J. and Christensen L. P. 2014. The costs and benefits of sulphur reduction measures: Sulphur scrubbers versus marine gas oil. *Transportation Research Part D*, Vol. 28, pp. 19–27.

Kabe, T., Ishihara, A. and Qian, W. 2000. Hydrodesulphurization and hydrodenitrogenation: chemistry and engineering. Wiley-VCH.

Mahoney, J. T. 1992. The choice of organizational form: vertical financial ownership versus other methods of vertical integration. *Strategic Management Journal*, Vol. 13, No. 8, pp. 559-584.

Markowitz, H. M. 1991. Portfolio Selection: Foundations of portfolio theory. *The Journal of Finance*, Vol. 46, No. 2, pp. 469-477.

Martin, R. and Sunley, P. 1998. Slow convergence? The new endogenous growth theory and regional development. *Economic geography*, Vol. 74, No. 3, pp. 201-227.

Mellqvist, J. 2016. SOx compliance monitoring, EnviSuM partner meeting, 25.10.2016, Copenhagen.

Ministry of the Environment. 2015. Põlevkivi kasutamise riiklik arengukava 2016-2030. Retrieved November 28, 2016 from https://www.riigiteataja.ee/aktilisa/3180/3201/6002/RKo_16032016_Lisa.pdf.

Ministry of the Environment. 2016. Eesti Vabariigi maavaravaru 2015. a koondbilanss. Retrieved November 28, 2016 from http://www.envir.ee/sites/default/files/koondbilanss_2015.pdf.

Noble, C. H. 1999. Building the Strategy Implementation Network. *Business Horizons*, pp. 19-27.

Nabli, M. K. and Nugent, J. B. 1989. The new institutional economics and its applicability to development, *World Development*, Vol. 17, No. 9, pp. 1333-1347.

Notteboom, T. 2010. The impact of low sulphur fuel requirements in shipping on the competitiveness of roro shipping in Northern Europe. *WMU Journal of Maritime Affairs*, Vol. 10, No. 1, pp. 63–95.

NSF – North Sea Foundation. 2008. *Clean Shipping: Towards an integrated approach of sustainable shipping.* North Sea Foundation (Utrecht, the Netherlands). Utrecht: Stichting De Noordzee.

Nugraha, F. 2009. Effective implementation of emission control area towards cleaner shipping operations: focusing on sulphur oxides (SOx) emission reduction. *World Maritime University Dissertations*, Paper 186.

OECD. 2005. International standard cost model manual. Measuring and reducing administrative burdens for businesses.

OECD/ITF. 2016. Reducing Sulphur Emissions from Ships: The Impact of International Regulation. Retrieved June 10, 2016 from http://www.itf-oecd.org/reducing-sulphur-emissions-ships-impact-international-regulation.

Olaniyi, E. O. and Reidolf, M. 2015. Organisational Innovation Strategies in the Context of Smart Specialization. *Journal of Security and Sustainability Issues*, Vol. 5, No. 2, pp. 213–227.

Olaniyi, E.O. and Prause, G. K. 2016. Baltic-Russian Innovation Cooperation in the Context of EU Eastern Partnership. In T. Kerikmäe and A. Chochia (Eds.). *Political and Legal Perspectives of the EU Eastern Partnership Policy*, pp. 257-279. Switzerland: Springer International Publishing

Osterwalder, A. and Pigneur, Y. 2009. *Business Model Creation*. Amsterdam, The Netherlands: Modderman Drukwerk.

Panagakos, G. P., Stamatopoulou, E. V. and Psaraftis, H. N. 2014. The possible designation of the Mediterranean Sea as a SECA: A case study. *Transportation Research Part D: Transport and Environment,* Vol. 28, pp. 74-90.

Piercy, N. and Giles, W. 1989. Making SWOT analysis work. *Marketing Intelligence & Planning*, Vol. 7, No. 5/6, pp. 5-7.

Porter, M. E. and Millar, V. E. 1985. How information gives you competitive advantage. *Harvard Business Review*, No. 85415, pp. 149-161.

Prause, G. 2014. Smart Specialization and EU Eastern Innovation Cooperation: A Conceptual Approach. *Baltic Journal of European Studies*, Vol. 4, No. 1, pp. 3-19.

Rebelo, S. 1991. Long-run policy analysis and long-run growth. *Journal of Political Economy*, Vol. 99, No.3, pp. 500-521.

Renda, A., Schrefler, L., Luchetta, G. and Zavatta, R. 2013. Assessing the Costs and Benefits of Regulation. Brüssel: Centre for European Policy Studies. Retrieved June 1, 2014 from http://ec.europa.eu/smart-regulation/impact/commission_guidelines/docs/131210_cba_study_sg_final.pdf.

Repetto, R. 1990. Environmental Productivity and Why It Is So Important. *Challenge*, Vol. 33, No. 5, pp. 33-38.

Shipway, I. 2009. Modern portfolio theory. *Trusts & Trustees*, Vol. 15, No. 2, pp. 66-71.

Siirde, A., Eldermann, M., Rohumaa, P. and Gusca, J. 2013. Analysis of greenhouse gas emissions from Estonian oil shale based energy production processes, life cycle energy analysis perspective. *Oil Shale*, Vol. 30, No. 2S, pp. 268-282.

Sköld, S. 2012. Clean Shipping Project. Available on-line, date viewed May 30, 2016.

Solow, R.M. 1994. Perspectives on growth theory. *The Journal of Economic Perspectives*, Vol. 8, No. 81, pp. 45-54.

Unctad. 2015. Chapter 5: legal issues and regulatory developments. In *Legal Issues and Regulatory Developments Ship-source pollution and protection of the environment*. Retrieved February 25, 2015 from unctad.org/en/PublicationChapters/rmt2015ch5_en.pdf.

Utterback, J. 1994. *Mastering the dynamics of innovation: how companies can seize opportunities in the face of technological change*. University of Illinois at Urbana-Champaign's Academy for Entrepreneurial Leadership Historical Research Reference in Entrepreneurship.

VKG. 2015. Financial statement. 2015 year book. Retrieved May 21, 2016 from http://www.vkg.ee/aastaraamat2015/index-en.html.

Wiśnicki, B. Czermański, E., Droździecki, S., Matczak, M. and Spangenberg, E. 2014. Suplphur Regulation–technology solutions and economic consequences for the Baltic Sea Region shipping market. Gdańsk: Institute of Maritime Transport and Seaborne Trade, University of Gdańsk.

WoodMackenze. 2016. Global marine fuel sulphur cap - challenges of a 2020 implementation. Retrieved November 30, 2016 from https://www.woodmac.com/reports/refining-and-oil-products-global-marine-fuel-sulphur-cap-challenges-of-a-2020-implementation-43374172.

Yin, R. K. 1989. *Case study research: Design and methods*. Revised edition. Applied Social Research Methods Series, 5. Newbury Park (Calif.) [etc.]: Sage Publications

Appendices

Appendix 1. Expectation value of investment options

	Price spread scenarios (expectation value)					
	Probability					
Options	0.35	0.3	0.1	0.1	0.15	Expected value (μ)
Upward vertical integration	-0.35	-0.3	0	0	-0.15	-0.8
Products Upgrade	0.7	0	-0.1	-0.2	-0.3	0.1
Hydrodesulphurization	0.35	0.3	0	-0.1	-0.3	0.25
Product Discount	-0.7	-0.3	0	0	0	-1
Process innovation	-0.35	-0.3	0.1	0.1	0.15	-0.3

Note: Scenarios are "very high," "high," "constant," "low" and "very low". Scenario scale is -2, -1, 0, +1, and +2.

Appendix 2. Risk factor ($\sqrt{\sigma^2}$)f each investment

Options	Price spread scenarios (variance)					Risk (SQRT σ^2)
Upward vertical integration	0.01	0.01	0.06	0.06	0.01	0.40
Products Upgrade	1.26	0.00	0.12	0.44	0.66	1.58
Hydrodesulphurization	0.20	0.17	0.01	0.16	0.76	1.13
Product Discount	0.35	0.00	0.10	0.10	0.15	0.84
Process innovation	0.17	0.15	0.17	0.17	0.25	0.95

Publication 2

Olaniyi, E.; Prause, G.; Boyesen, J. (2018). The Impact of SECA Regulations on Clean Shipping in the BSR. In: Ölçer, A.I., Kitada, M., Dalaklis, D., Ballini, F. (Ed.). *Trends and Challenges in Maritime Energy Management* (309−323). Springer. (WMU Studies in Maritime Affairs; 6). DOI: https://doi.org/10.1007/978-3-319-74576-3.
(ETIS Classification 3.1)

The Impact of SECA Regulations on Clean Shipping in the Baltic Sea Region

Eunice O. Olaniyi, Gunnar Prause, Jan Boyesen

1. Introduction

The shipping industry is responsible for the transport of approximately 90% of world trade and is one of the most environmentally benign forms of transport if the transport of goods on a tonne mile basis is considered (Jiang et al., 2014). Ships are also major producers of pollutants such as carbon oxides (CO_2), sulphur oxides (SOx), ozone-depleting substances (ODS), volatile organic compounds (VOC) and nitrogen oxide (NOx) emissions (Wiśnicki et al., 2014). Although much of the pollution emitted by shipping is deposited over the sea, it does not undermine that fact that it is the largest single source of acidification and eutrophication in many countries in Europe. The output of SOx and NOx by shipping surpasses that of land transport (Panagakos, 2014). Sulphur especially burns in fuels to form SOx, which is one of the pollutants to the environment especially in the formation of acid rain (Notteboom, 2010).

It contributes significantly to the increased levels of health-damaging particulate matter and ozone (Airclim, 2011). Air pollution is the cause of about 50,000 premature deaths every year in Europe, resulting in a social cost of about €58 billion annually. After reacting with air, these emissions are converted to dangerous compounds that cause premature death by poisoning the blood through infiltration from the lungs leading to inflammations and heart and lungs failures after a continuous exposure over a long time (Alcamo et al., 1987).

Additionally, much deep-sea shipping occurs near coastlines, polluting densely populated coastal areas and causing significant health damage (Holmgren et al., 2014).

E. O. Olaniyi (✉) · G. Prause
Department of Business Administration/TSEBA, Tallinn University of Technology, Tallinn, Estonia
e-mail: eunice.olaniyi@ttu.ee

J. Boyesen
Maritime Development Centre of Europe, Copenhagen, Denmark

A.I. Ölçer, et al. (eds.), *Trends and Challenges in Maritime Energy Management,*
WMU Studies in Maritime Affairs 6, https://doi.org/10.1007/978-3-319-74576-3_22

Emissions at ports during manoeuvring and berthing account for only a small fraction of ship emissions. Even though this is the case, it is essential not undermine their harmful health effects on the population living in the coastal area. Emissions during free sailing account for the more significant percentage of the overall ship emissions but have less damaging effects on human health because of the sparse population (Jiang et al., 2014).

Maritime transport is currently far less regulated than land-bound transport. One of the reason is that while land transport is not as international as sea transport, most countries are often logistically, organizationally, and legally involved in shipping and often tend to obstruct the legislative process (Holmgren et al., 2014). Another explanation is that most governments are careful not to discourage export trade by increasing its cost and, finally, popular views assume that, most sea transport occurs on international waters and its pollution does not reach land - an assumption that is far from the truth.

The clean shipping vision was set to make maritime transport greener, and is being achieved through new technologies and changed behaviour on board across all maritime stakeholders in concerted and integrated efforts of multiple measures (Stipa, 2013). The integrated clean shipping approach focuses on three fronts: *Ships* - the ship that is welcome in every port and causes no negative impact on the environment with a zero target emission. *Ports* - highly efficient with excellent environmental services and strong incentives to facilitate and encourage Clean Shipping. *Cargo* - excellent corporate footprint and cargo owners include ecological issues in their decision-making process when contracting carriers (NSF, 2008).

The International Maritime Organisation (IMO) is employing a global clean shipping approach to improving the maritime emissions of SOx and PM from ships, mainly through technical and operational reduction measures (IMO, 2015). The International Convention for the Prevention of Pollution from Ships (MARPOL 73/78) had a three-tier regulatory scheme to reduce NOx and SOx emissions from shipping, Tier I in 1997 and Tier II/III in 2008 (IMO, 2008, 2009) all of which were formed to ensure harmonisation with international law and better enforcement. The underlying legislation for regulating sulphur emissions from ships was Directive 1999/32/EC. This was amended by Directive 2005/33/EC adopted at the MEPC 53rd session in July 2005, which designated the Baltic Sea, the North Sea and the English Channel as sulphur emission control areas (SECAs) and limited the maximum sulphur content of the fuels used by ships operating in these sea areas to 1.5% (IMO, 2008). The Baltic Sea was named as the first SECA from 19 May 2006 followed by the North Sea Area and the English Channel in 2007 (IMO, 2009).

It is noteworthy to point out that SECA is not solely applicable to SOx emissions as this criterion was also amended at the 58th MEPC session in October 2008 on Appendix III of Annex VI. The new standards stated that SOx, NOx, or PM and Noxious Liquid Substances, Sewage, garbage are all restricted in this area from 2010. By 1st July 2010, MARPOL in Annex VI reduced the Sulphur content in marine fuel from 1.5% to 1.0 % (IMO, 2013). This limit was further reduced to 0.1 % from 1 January 2015 (IMO, 2015). Another addition to SECA came through China and the regulation states that from 2nd December 2016 there will be three emission control areas on China Sea - the Pearl River Delta, the Yangtze River Delta and Bohai Sea (North, 2016).

The global sulphur cap was set not to exceed 4.5% by the amended Annex VI law.

This limit was further dropped to 3.5% in 2011, effective from January 2012. Currently, the global limit has reduced to 0.5% from 2020. This was confirmed at the MEPC 70th session in October 2016 (IMO 2016). These will have been twenty-three preparatory years (1997 - 2020) for maritime stakeholders to comply with the strict regulation on global sulphur reduction by 2020.

Strengthened regulations and environmental awareness are of vital importance to stimulate clean shipping, but it has some consequences for shipping business (Panagakos, 2014). Going by Panagakos premise then, the implications of the Sulphur emission Directive, maritime sector stakeholders like the shipping companies will be directly or indirectly linked to the economic decisions that will ensue in their efforts to comply. One of the consequence will be increased freight costs. In other words, the high costs of the clean shipping regulations could cause a modal backshift from sea to the road and could result in more road pollution and congestion, which will be contrary to other land regulations (Hämäläinen, Hilmola, Prause & Tolli 2016). Furthermore, export companies like heavy industrial companies that have the maritime transport at the core of their supply chain activities are worried about how this will affect their profit (AirClim, 2011).

At the end of 2015, European Union (EU) approved, in the frame of the Baltic Sea Region (BSR) Interreg Programme, the "EnviSuM (Environmental Impact of Low Emission Shipping Measurements and Modelling Strategies) Project" aiming to study and assess the technical efficiency and the socio-economic impact of clean shipping solutions in the Baltic Sea Region (BSR). The project seeks to provide tested and analysed results on the efficacy of the different clean shipping solutions and proffer recommendations that will benefit not only the environment and the general health of the BSR populace but also the maritime businesses by promoting their economic growth.

This work as part of the ongoing EnviSuM project studies the economic impacts of Sulphur Emission Control Area (SECA) regulations on maritime stakeholders in the BSR. Based on experts' interviews, focus groups, learning cafe and BSR-wide survey. The objective of this work is to study the various measures taken by stakeholders towards Sulphur emission reduction and maritime stakeholders assessments of the economic impact of SECA regulations on their businesses and BSR. The research questions that will be used to address this issue are: (1) How has the SECA regulation impacted the maritime business activities in BSR?; 2) What are the stakeholders' reactions to these impacts?; and (3) How will SECA impact blue growth and innovation activities in the BSR?

The discussions that are related to SECA compliance in BSR were mostly gotten from expert interviews, learning café and focus groups, while the economic impact of SECA regulation on maritime industries and BSR were from a BSR-wide survey targeted at top management executives in the maritime business. This contribution will improve the integration of new knowledge that will provide new systems for cleaner and more cost-effective shipping for the maritime sector.

This work is organised as follows: Sect. 2 discusses the sulphur emissions regulations, shipping activities on the Baltic Sea and SECA compliance options. Section 3 describes the system of methods used for this research. Part 4 highlights SECA regulations compliance in BSR as well as the economic impact of SECA regulations on maritime businesses and BSR. Section 5 discusses the implications of the results and provide conclusions.

2. Sulphur Emissions Regulations compliant Shipping on Baltic Sea

According to Annex VI of the International Convention for the Prevention of Pollution from Ships (MARPOL 73/78), the Baltic Water means “the Baltic Sea with the Gulf of Bothnia, the Gulf of Finland and the entrance to Baltic Sea bounded by the parallel of the Skaw in the Skagerrak at 57o44’.8 N” (Nugraha, 2009). It measures about 415 000 km^2, and is considered the largest brackish water in the world, the Baltic Sea, despite being shallow (53m mean depth) with a narrow canal that makes ships to find it difficult for ships to navigate, is subject to intense shipping and covers a significant share of the world's seaborne trade (Karl-Heinz et al., 2013). It is one of the most densely plied seas in the world and accommodates up to 15% of the world's cargo freight. Over 2000 ships operate on the Baltic Sea at a time and carry as much as 166 million tonnes of oil. Shipping can be considered essential for all Baltic Sea countries because significant shares of foreign trade are routed through the Baltic Sea Ports. These countries are Finland, Sweden, Denmark, Poland, Russia, Germany, Estonia, Latvia and Lithuania (Helcom, 2012). Shipping activities have been predicted to even increase in the coming years due to the economic growth of the BSR. Russia oil export through Baltic alone has been predicted to reach up to 180 million tonnes by 2020. These activities make the Baltic Sea very susceptible to heavy pollution whose cumulative effect come with substantial negative consequences to all living things.

The SECA regulation mostly affects the costs of ships operations, especially those who operate more or solely in the SECAs. For the benefits of Sulphur regulation to outweigh the cost, the reduction measure chosen by the ship owners is critical (Jiang et al., 2014). Many studies already have discussed the different abatement or compliance methods for the SECA regulations (i.e. Notteboom, 2010; Wiśnicki et al., 2014; Jiang *et al.,* 2014; Nugraha, 2009; Brynolf *et al.*, 2014; Bergqvist *et al.*, 2015; OECD/ITF 2016). Some of the different options available to reduce sulphur emissions in the SECAs are changing the source of fuel from the usual Heavy fuel oil (HFO) to other possible alternative sources of ship fuel like; Marine Gas Oil (MGO), Marine Diesel Oil (MDO), Liquefied Natural Gas (LNG), biogas, biodiesel, ethanol, methanol, coal, nuclear power, wind, solar panels, and hydrogen cells. The other is the use of abatement technologies such as the Scrubbers. The scope of this work will, however, be limited to switching to low sulphur fuel, use of LNG and the installation of the scrubber.

A complete switch to 0.1% low-sulphur content fuel seems like the easiest option and is expected to become the most common solution for shipping lines. However, one of the salient challenges of this option is the difficulty in predicting trends in fuel prices due to the volatility of the market forces (Jiang *et al.*, 2014; Hämäläinen *et al.,* 2016).

Hämäläinen *et al.* (2016) gave examples of several studies that have attempted to forecast fuel prices in their bid to analyse the sulphur directive effects and have recurrently come-short.

The use of LNG has been argued to be the most attractive alternative fuel to meet the sulphur directive. Apart from the political backing, LNG is naturally low in sulphur and therefore meets the new restrictions without any problems during combustion (Jiang *et al.,* 2014). When the gas is in liquid form, it contains more energy and is easier to process in a combustion engine. However, the disadvantage is that while it may be possible to convert existing vessels, it is very costly to convert. It also requires twice as much storage capacity than the usual marine fuel to provide the same amount of energy. Thus, it is most likely that LNG will be used only in new NLG vessels (Brynolf *et al.,* 2014).

The extension of the MARPOL Convention also allows the use of technical equipment that cleans emissions from sulphur, allows the continued use of the cheaper high-sulphur fuel, and still meets the stricter sulphur restrictions. One of such abatement technologies is the installation of the scrubber on existing vessels or new vessels (Bergqvist et al., 2015). There are principally two types of scrubber namely the dry and the wet scrubbers. The wet scrubber is further classified into the open loop, closed loop and the hybrid. The disadvantages with the scrubbers especially the wet scrubbers range from the dilemma of discharging the acidic wash water which requires a marine environment with high salinity and high alkalinity to neutralise to another fact that the scrubber itself occupies a considerable percentage of space on the ship. The cost of installation of the scrubber on a vessel especially on an old vessel is also high (about €2 - €8 million, depending on the age and the size of the ship) and requires about 10 years for before a return of investment (Brynolf et al., 2014).

3. Method

This research employs multiple and cross-sectional methods. The empiric data collection were executed in the frame of the EnviSuM project between September and December 2016.

Maritime stakeholders were identified and divided into five categories from 1 to 5. Each category was also index based on its perceived direct impact from SECA regulations. As shown in Table 1, 3-star signifies high priority, 2-star medium priority and 1-star low priority for data collations. Thus, categories 1, 2 & 3, with 3 and 2 stars were the primary focus for data gathering. The target group consisted of top management level stakeholders (MD/CEOs, Directors, top-level managers) mostly because, experts' opinions and decisions, as well as the knowledge of what activities are being embarked on, were core information needed for the research.

First, to explore the activities of the maritime stakeholders towards SECA regulations compliance, interviews (structured, face-to-face, phone calls and Skype)

Table 1 SECA maritime stakeholders' priority index (Source: Compiled by the authors)

Category	Maritime Stakeholders	Order of Impart
Category 1	Shipping companies, Ship Operators, Shipowners	3 stars
Category 2	Ports	3stars
Category 3	Ship Suppliers (maritime equipment and services)	2 stars
Category 4	Port authority, Non-governmental organisation (NGO) Public sector (Ministry, Municipal, Government agency, education, Research), Police/Customs	1 star
Category 5	Shippers (Logistics service providers, Production and Trading, Real Estates/Facilities managers)	1star

were conducted. This was guided by the exploratory nature of this objective, which was to produce according to Mason 1996, "… a rounded understanding of rich, contextual, and detail data that can also be generalised in some way. Furthermore, Mason pointed out that interview is suitable for a research position that suggests people's knowledge, opinions, understanding, interpretations, experiences and interactions. Each interview lasted between 1 hours to 2 hours. Notes were taken. Also, voice recordings were made. Further follow-up questions were asked for clarification and validations. Descriptive analysis of the interview data was made to provide an account of SECA related activities around BSR using Yin (1989).

Second, a BSR-wide online survey study was conducted with a selected number of maritime experts focusing on the experts' perception and conclusions concerning the financial impact of SECA on their businesses and then on BSR. A pilot of the survey instrument was executed to establish content validity from EnviSuM partners from Germany, Estonia, Finland, Denmark, Norway and Poland. The focus of the pilot was to provide clarity, value, and the importance of the survey items. Sixty respondents, representing a broad cross-section of maritime experts from, Estonia, Denmark, Germany, Finland, Norway, and Poland completed the survey.

Other sources of information were from focus groups and EnviSuM learning cafés organised in maritime fairs and exhibitions where workshops were organised by the EnviSuM project. Letters of invitations were sent to participating companies and confirmations were received beforehand for the organisation of such events.

4. Results

4.1 SECA regulations Compliance in BSR

Results from the experts' interviews and focus group meetings revealed the following:

The Use of Low Sulphur Content Fuel Because of the availability of different types of marine fuel as well as SECA regulation**s**, most shipping companies, in the interim, tend towards the fuel distillates such as MGO and MDO. Further, ultra-low sulphur fuel oil (ULSFO) has been gaining popularity as a cheaper alternative to other distillates since 2015. There is already a 180,000 mt demand, which is expected to grow beyond 300, 000 mt by the end of 2017. Another reason for its rise in demand is the massive investment that is needed for the scrubber or the LNG retrofit.

Some ship operators have, however, expressed their worry over the long-term effect of using this fuel and what effect it would have on ship engines initially designed for HFO. Others are optimistic that its usage can flush out the sludge that accumulates in the fuel tank. There is also concern about the availability of low sulphur fuel with the 0.5% global sulphur cap coming up 2020. Most of the cruise ships use the low sulphur fuel, which seems to be the interim strategy at the present until they are sure about the fuel markets trend.

So far, because of the intense competition, no shipping line has increased its transportation cost. Many of them are waiting for the fuel price go up. In addition, the new global sulphur cap for 2020 seems to be a game changer. Nobody seems to be sure of the full impact of this regulation on fuel price until then. There are anticipations that the sulphur global will be reviewed and push back to 2025.

LNG as an Alternative Fuel The use of LNG as a marine fuel especially attracted the high attention of the shipping industry in the BSR. Some ship-owners stated their preference for the use of alternative fuel path for their sulphur compliance requirements especially the use of LNG. One of the primary reason for this is that the use of LNG ensures the compliance of not only SECA but is also useful for the anticipated NOx emissions regulation. LNG is seen as the total package to emission regulation compliance ranging from SOx, NOx, and PM to CO2 and black carbon. LNG is not a popular option when compared to MGO/MDO/ULSFO and the scrubbers.

The primary reason is the cost implication for retrofitting or new installation, but its demand seems to have soared. For example, by the end of 2014, LNG-fuelled ships in the BSR were only Viking Grace the dual-fuel ferry owned by Viking and two LNG-powered (gas-only engine) cruise ferries of the Fjord Line operator. However, by the end of 2015, there were 24 new builds, and 3 LNG retrofitted ships, and as at 2016, there are over 40 LNG-propelled ships ordered from different shipping lines with their delivery dates up to 2018.

The Use of Scrubber*:* In the BSR, ferries, ro-ro and general cargo (feeder container ships) are the majority of the ships that are equipped with the scrubbers. Even though fuel price has been on the downward since 2014 and the price spread between the HFO and the MGO has dramatically reduced, some ship owners still invest in the scrubber technology.

According to the Baltic Port organisation (BPO), by the end of 2015, 5.4% of the total short sea shipping ships were equipped with scrubbers, which amounts to 73 vessels in the BSR. More so, more ships are already scheduled to be retrofitted before the end of 2017. By the end of 2020, about 200 ships are expected to be retrofitted with the scrubbers. Most ports operators brought up arguments on the ecological safety of the open loop scrubber since its wash water is discharged back into the sea together with an unclear rule as to whether it has been banned or is still being allowed to be used in the BSR.

There was much favour towards the hybrid model because the closed loop scrubber will be useful on the shallow Baltic waters and at the same time its open loop part will be useful while non-SECA. The Dry scrubbers are not popular, and only one ship is equipped with a dry scrubber in the BSR. Tests in Poland showed that using a scrubber needs additionally up to 13 MWh of electricity per day. In the case of an electricity production price on board the ship of around 80 € per MWh, this means that it would need additional costs of €100,000/year.

Compliance Cases from Shipping Companies Three cases presented to highlight the efforts made by the shipping companies regarding their compliance with the SECA regulations as follow:

Case 1: Tallink, Estonia. Tallink has 17 vessels - 2 cargo, 6 Ro/Ro, 9 cruises altogether. Currently, 3 of these vessels are chartered out. At the moment, Tallink strategy is to use MGO while on SECA and HFO in non-SECA. However, one of the latest addition to their fleet because of SECA is the Megastar, which is equipped with dual fuel engines and will be propelled by LNG and built by the Meyer wharf in Turku - Finland. The propulsion is equipped with 5 engines, which run around 6.000h per year. 3 Wärtsilä 12V50DF (11.4 MW/machine) and 2 Wärtsilä 6L50DF (5.7 MW/machine). This means that the engine can be switched automatically from fuel oil to LNG operation at loads below 80% of the full load. In order to switch, the operator's command can be an automatic initiate transfer that takes only about a minute allowing the fuel oil to slowly change to LNG.

Case 2: Viking Line, Finland. Viking line operates 7 vessels. Viking strategy for SECA is to use fleets propelled by LNG. An already existing LNG driven ship is the Viking Grace. The Viking Grace started its service in 2013 and is equipped with 4 Wärtsilä 8L50DF engines (7.7 MW/machine). It sails on the route between Stockholm, Åland and Turku. Viking line has already ordered one more LNG driven ship that would arrive by 2020. There is no mention on any scrubber retrofit.

Case 3: DFDS Seaways Denmark. DFDS owns 53 vessels, 5 are on charter while 1 is laid up. Leveraging on the reduced price spread between oil fuel and gas oil, the most prominent investments in scrubber technology in the BSR is by DFDS Seaways. DFDS has 17 scrubbers' retrofitted ships that cost the company about DKK 568m (Approx. 80m EUR). The company's target is to install scrubbers on 21of its ships by 2017. At the end of the 2015 financial year, the company reported that it had achieved the budgeted return on investment for the scrubber strategy. DFDS is one of the scrubber grant recipients from the EU. It has received DKK 35m (Approx. 5m EUR) on this premise up to date.

Compliance Activities in the BSR Ports This section presents four key SECA compliance activities in the BSR ports: (a) LNG infrastructure; (b) Onshore Power Supply; (c) Incentives for shipping companies; and (d) Compliance Monitoring and Control.

(a) **LNG infrastructure.** The development of LNG bunkering infrastructure within the BSR was initiated by the Baltic Port Organization "LNG in Baltic Sea Ports" and LNG in Baltic Sea Ports II projects for the harmonisation of pre-investment activities of Ports networks to standardise the LNG system. This initiative was because of the EU Directive 2014/94/EU that TEN-T core seaports must be equipped with accessible LNG bunkering points by 2025. So far, there has been a steady increase in the development of LNG bunkering infrastructure within the Baltic ports. There are terminal feeds for vessels with LNG going through bunkering upgrades. Some of them currently use the ship-to-ship, tank truck to ship bunkering. The port of Stockholm was the first port in the BSR to take the LNG initiative, and it was the first port in the world to offer LNG bunkering solutions through a bunkering boat for LNG supply to Viking Grace, a cruise ferry. Other LNG terminal infrastructures are in Świnoujście, Poland, Port of Klaipeda, Lithuanian and Lysekil, Sweden. There are other small-scale LNG terminals in Nynäshamn and Gothenburg Sweden. LNG has a gas bunker station used for Fjord Line in the Port of Hirtshals, Denmark.

(b) **Onshore Power Supply**. Onshore Power Supply (OPS), also known as shore connection, shore-side electricity and cold ironing is a solution that allows the ships to turn off their auxiliary engines to stop the use of fuel. The use of OPS allows a substantial reduction in emissions, noise and vibrations generated by ships berth at ports. This technology is particularly crucial for crews, passengers and residential areas closed to the ports as obtainable in Stockholm, Ystad, and Gdynia and Tallinn. The ports of Gothenburg, Lübeck, Helsinki, Ystad, and Stockholm currently provides OPS. Helsinki introduced shore power in 2012 for Viking Line's ferries. The Port of Ystad has a large OPS system for both 50 Hz and 60 Hz. Stockholm port was planning to have all of its five new quays equipped with the OPS system by the end of 2016, but these are not ready yet.

(c) **Incentives for shipping companies.** Currently, most incentive activities are geared towards ships that use LNG, generate low NOx emissions or use the OPS. The Port of Gothenburg, for example, uses the Environmental ship index (ESI) and the clean shipping index (CSI) for its reward system and award ships fuelled by LNG a 20% discount saving the ships SEK 0.05 per gross tonnage (GT). This will make a vessel like Viking Grace, calling at Stockholm daily to earn a rebate of around SEK 1 million (approx. 105,400 EUR) every year until 2019 when the port plan to stop. Besides, ships with ESI score of 30 points or are categorised as "green" by CSI yardsticks are awarded 10% discount off the port dues according to their GT. Port of Gothenburg, also offers a rebate for the use of OPS. The Port of Rostock offer vessels with ESI of 40 points and above a range of 5% to 10% discounts. In the Port of Riga, a 10% rebate of port charges is given to crude oil tankers with a Green Award Certificate.

(d) **Compliance Monitoring and Control.** Compliance and monitoring are done through inspections and fuel samplings. The standard practices are the inspections of the IAPP6 and IOPP7 certificates, Oil Record Book, bunker delivery notes (BDN), logbooks and records relating to the fuel switchover before entering the SECA and navigational activities. Inspections are made mostly on ships without installed emission abatement equipment. In some countries like Poland, fuel samples are collected and analysed for inspection, but in other countries, samples are only analysed if there were indications of abnormalities noticed or perceived during document inspections. Samples are taken from the service tank, or return pipe or fuel filter and analysed by accredited laboratories. Analysis usually takes between 1 to 7days. Sometimes the inspectors make use of handy equipment that can immediately detect the sulphur content of the fuel used on-board although the results provided by this method are only indicative that usually need further confirmation from laboratory analyses. 6,801 inspections were made in 2015 up until March 2016. Surveillance aircraft are also strategically stationed at the water belt of Helsinki and Denmark to monitor emissions based on optical and sniffer measurement. An optical, ultraviolet spectroscopic sensor analyses reflected solar light that passes through the smoke (also called DOAS, (Differential Optical Absorption Spectroscopy)) to measure the path concentration of SO_2 and NO_x from the ship. Airborne measurement of about 100 ships carried out monthly. The preliminary report from the EnviSuM technical team gave a 96.5% compliance in the BSR ports, which has been consistent (Mellqvist, 2016).

4.2 Impact of SECA Regulations on Maritime Business Activities in BSR

Tallinn University of Technology together with the Maritime Development Centre started an ongoing survey on the impact of SECA regulations on maritime business in BSR from October 2016. The underlying questionnaire included 10 questions assessing the impact of SECA regulation from the view of different maritime stakeholders. The 10 questions covered the overall economic impact of SECA as well as the impact on blue growth, costs, pricing, own company development, innovation, FDI, cargo flows, modal split and branding of BSR as shown in Table 2. Five-point scaling from -2 = very negative to 2 = very positive was used to measure the maritime stakeholder view for all questions. Until now 60 questionnaires from all BSR were collected showing a first trend on how SECA regulations affect or is assumed to impact maritime business activities.

Based on the completed questionnaires, statistical analysis was carried out to in order to find core patterns in the maritime community. The first observation shows that nearly

Table 2 Description of economic impact of SECA regulations

What is the impact of SECA regulations on the maritime businesses and the BSR?
Overall economic impact on BSR
Impact on blue growth in BSR
Impact on your product/service costs
Impact on your pricing
Economic impact on your company development
Impact on innovation of maritime sector in BSR
Impact on the attractiveness of BSR for foreign direct investments (FDI)
Change of cargo flows within Europe
Change in transport modal split within the BSR
Reputation/Branding of BSR

Note: N of data = 60

all Mean (M) results for all the questions were close to zero, except the M for innovation and branding which were around 1. Statistical tests confirmed the significance of this results and also revealed that the overall Ms are not significantly different for the high impact priority groups of maritime stakeholder (i.e. ship owners, ports, maritime suppliers) which suggest that the assessment of SECA impact are relatively homogeneous among the maritime sectors. The interpretation of these first results indicates that 2 years after 0.1% SECA in BSR until now, the impact on economic parameters like costs, pricing, FDI, cargo flows and modal splits are considered negligible by the maritime stakeholders. Significant SECA impacts are, however, attributed to innovation and reputation of BSR.

Additional regression analysis was used to find out which of the remaining nine variables affects the variable "overall economic impact of SECA". The F-test showed a significant fit for the resulting model even though the R-square was 52%. The regression analysis coefficients and the related t-test revealed that variables “blue growth” and “FDI” are statistically significant, both with a positive leading sign. The variable “pricing” appeared to be “nearly significant” with a p-value of 7% but with a negative sign. The Beta-coefficients percentage shows that three variables “blue growth”, “FDI” and “pricing” are accounted for in about 60% of the impact in “overall economic impact of SECA”. The negative sign of the “nearly significant” variable “pricing” suggests that increasing pricing will have a negative impact on the overall perception of SECA.

Finally, the ANOVA analysis of the responses of the ship owners and the Ports concerning the SECA regulation impact on the modal split revealed a significant difference. Whereas the Mean of ship owners on the modal split was slightly positive with a value of about 0.4, the corresponding value for the ports was about -0.4.

5 Implications and Conclusions

SECA regulations have already been in force in BSR for 2 years now and have no doubt enhanced clean shipping in BSR with significant changes seen with vessels that operate on the Baltic Sea as well as the Ports. The EnviSuM project aims to reveal empirically the impact of SECA regulations in BSR and the first measurements, which shows a compliance rate of 96.5% in most BSR ports confirms significant health benefits for the BSR. Furthermore, ongoing expert interviews and survey suggest that the maritime stakeholders in BSR expect a minimal economic impact of SECA regulations on shipping sector, especially on pricing, costs, FDI, cargo flows or modal split. Only innovation, branding and reputation of BSR are expected to improve significantly through SECA regulations. Surprisingly, this assessment does not differ significantly among all the maritime stakeholder groups in BSR. Some of the expert interviews and studies of secondary data also revealed that most of the ship owners took advantage of the low oil price to comply with SECA regulations in BSR by using MGO. By doing so, most of the ship owners try to postpone the expensive abatement investments. Economic implications and unreliability of the fuel price are the primary reason for this investment stalling. Other reasons are fear for the loss of revenue during installations, time spent on retrofitting, further and post-installation and modification activities as well as the constant need for intervention from the manufacturers, especially regarding maintenance.

There were many views that the implementation of SECA should have been better prepared for and many ship owners were confused regarding the expected costs and benefits related to the different abatement and emission control technologies, which has led to sub-optimal solutions. Most ship owners would have preferred to have access to reliable information to help them make decisions. However, with the current situation in the shipping market, where there is excess capacity for demand, there is very little willingness to invest in LNG vessels and the scrubber technology. Although the interesting information from the expert interviews indicated that the trend for the decision on abatement strategy is that ship owners would prefer a scrubber installation for used vessels and LNG installations for new builds, this can be confirmed by the fact that there are only 3 LNG retrofitted vessels running in BSR. However, the BSR can still be considered a bedrock for the implementation of LNG infrastructure, but its specialised infrastructure for bunkering purposes is necessary to allow the growing number of LNG-fuelled ships to operate. It is, therefore, necessary that Ports be involved in LNG bunkering facilities synergies with ship owners and other stakeholders like the LNG suppliers. It was generally accepted that the use of LNG as ship fuel would be more popular in the coming years.

Another interesting matter that kept cropping up was the use of OPS, which has improved the air quality and the noise level in Ports considerably. However, the OPS requires adaptation and suitable equipment (e.g. frequency converters) not only in the Ports but also on board the ships, this is another inclined investment action, which also requires the cooperation of both the Ports and ship owners.

A thought-provoking question that emerged from the different interactions is that since MGO and other compliant fuel are distillates; what are the necessary actions needed to prevent the residual fuel from becoming industrial waste? The scrubber technology seems to provide a much-needed technology push effect for European technology but how many ship owners can afford the costs?

Prior to the strengthened requirements for sulphur reductions, there was fear that the SECA regulations would hurt the maritime industry. However, there has been lesser effects than was initially anticipated especially with the ship owners and the Ports. There are probably several reasons for this. First is that there has been a substantial drop in oil prices, which has absorbed a lot of the feared cost, increased. Since fuel costs are the primary cost component for the ship owners, this has led to substantial savings. It will, therefore, be interesting to see what will happen if the oil prices go up again. Another reason for the low impact might also be an overcapacity witnessed in the shipping market. Some ship owners have closed down routes, changed routes and some have changed to larger vessels to adapt to SECA and reduce negative economic impacts. Most ship owners have used the over-capacity opportunity to slow steam, achieving significant financial savings. It seems like this will continue for many years to come.

The SECA research in BSR will be providing a very useful case study especially when the global sulphur cap comes into full effect in 2020. Although a cause-effect situation might be difficult to extrapolate without a higher population size, this work contributes to the body of knowledge in the following ways: It postulates the economic consequences and the market potential for abatement technologies beneficial for knowledge integration in Maritime in BSR and Europe. It also provides an excellent prospect to use the BSR SECA as a test bed and demonstration platform for solutions that are larger and can be used globally. Furthermore, since parameters like fuel prices and market demand are also critical parameters to capture a fuller impact of the different SECA compliance options, further research is needed to measure the full impact of the SECA regulations especially towards the creation of “Investment Decision Tool" accessible to all Maritime stakeholders.

Acknowledgement The authors thank the European Regional Development Fund sponsors who has supported the EnviSuM project

References

AirClim (2011). Air pollution from ship. Air Pollution & Climate Secretariat Seas at Risk Bellona Foundation North Sea Foundation Transport & Environment European Environmental Bureau. https://www.transportenvironment.org/publications/air-pollution-ships-0.

Alcamo, J., Amann, M., Hettelingh, J.P., Holmberg, M., Hordijk, L., Kämäri, J., Kauppi, L., Kauppi, P., Kornai, G., & Mäkelä, (1987). Acidification in Europe: a simulation model for evaluating control strategies. *Ambio*, 232-245.

Bergqvist R, Turesson M, Weddmark A (2015). Sulphur emission control areas and transport strategies - The case of Sweden and the forest industry. European Transport Research Review 7(2).

Brynolf S, Magnusson M, Fridell E, Andersson K (2014). Compliance possibilities for the future ECA regulations through the use of abatement technologies or change of fuels. *Transportation Research Part D: Transport and Environment, 28, 6-18*.

Hämäläinen E, Hilmola OP, Prause G, Tolli A. (2016). Forecasting maritime logistics costs – Will the low oil price remain? In: A. Serry, L. Lévêque. (Eds.). *Le transport maritime à courte distance (Short-Sea Shipping): Devport 2016 Conference (Le Havre, France).* (pp.19-34) Le Havre, France: EMS Geodif.

Helcom, (2012). Maritime Activities in the Baltic Sea. Baltic Sea Environment Proceedings No.123. Accessed December 20, 2016 from https://www.google.ee/search?q=helocme+report+&ie=utf.

Holmgren J, Nikopoulou Z, Ramstedt L, Woxenius, J (2014). Modelling modal choice effects of regulation on low-sulphur marine fuels in Northern Europe. Transportation Research Part D: Transport and Environment, 28, 62-73.

IMO. (2008) Revised MARPOL Annex VI: *Regulations for the prevention of air pollution from ships and NOx technical code London*: IMO Marine Environmental Protection Committee (MEPC).

IMO. (2009). Prevention of air pollution from ships Second IMO GHG Study 2009 Update of the 2000 IMO GHG Study Final report covering Phase 1 and Phase 2: noted by Secretariat (MEPC 59/INF.10).

IMO. (2013). Sulphur oxides (SOx)—Regulation 14. Accessed 2016-09-20. http://www.imo.org/OurWork/Environment/PollutionPrevention/AirPollution/Pages/Sulphur-oxides-(SOx)- Regulation-14.aspx.

IMO. (2015). *Guidance on the application of regulation 13 of MARPOL annex VI tier III requirements to dual fuel and gas-fuelled engines.* MEPC.1/Circ.854. London

IMO. (2016). IMO sets 2020 date for ships to comply with low sulphur fuel oil requirement. Press briefing release 28/10/2016. http://www.imo.org/en/MediaCentre/PressBriefings/Pages/MEPC-70-2020sulphur.aspx Accessed 30/11/2016.

Jiang L, Kronbak J, Christensen LP (2014). The costs and benefits of sulphur reduction measures: Sulphur scrubbers versus marine gas oil. *Transportation Research Part D,* 28:19–27.

Karl-Heinz B, Möller M, Wenske C (2013). Baltic maritime transport, its structure, competitive situation and economic weight in Pan-Baltic Manual of Best Practices on clean shipping and port operations. Eds. Breitzmann, K & Hytti, M. UBC Environment and Sustainable Development Secretariat, Vanha Suurtori 7, FIN-20500 Turku, Finland.

Mason, J. (1996). Qualitative researching. London: London: SAGE.

Mellqvist, J. (2016). SOx compliance monitoring, EnviSuM partner meeting, 26.10.2016, Copenhagen.

North (2016). China: Emission Control Areas. http://www.nepia.com/news/industry-news/china-emission-control-areas-starupdatestar/. Retrieved on 22.12.2016.

Notteboom, T (2010). The impact of low sulphur fuel requirements in shipping on the competitiveness of roro shipping in Northern Europe. *WMU Journal of Maritime Affairs,* 10(1):63–95.

NSF - North Sea Foundation (2008). Clean Shipping: Towards an integrated approach of *sustainable shipping*. North Sea Foundation (Utrecht, the Netherlands).

Nugraha, F. (2009). Effective implementation of emission control area towards cleaner shipping operations: focusing on Sulphur oxides (SOx) emission reduction. *World Maritime University dissertations, 186.*

OECD/ITF (2016.) Reducing Sulphur Emissions from Ships: The Impact of International Regulation. http://www.itf-oecd.org/reducing-sulphur-emissions-ships-impact-international-regulation. Retrieved on June 10, 2016.

Panagakos G P, Stamatopoulou E. V., Psaraftis H.N. (2014). The possible designation of the Mediterranean Sea as a SECA: A case study. *Transportation Research Part D: Transport and Environment*, 28, 74-90.

Stipa T (2013). Clean shipping current. In K. Breitzmann, & M. Hytti (Eds.), *Pan-Baltic Manual of Best Practices on clean shipping and port operations*. Turku, Finland. UBC Environment and Sustainable Development Secretariat, Vanha Suurtori 7, FIN-20500.

Wiśnicki, B., Czermański, E., Droździecki, S., Matczak, M. and Spangenberg, E. (2014). Sulphur Regulation–technology solutions and economic consequences for the Baltic Sea Region shipping market. In: Ernest Czermański (Eds.) Institute of maritime transport and seaborne trade. University of Gdańsk.

Yin, R. K., (1989). Case study research: Design and methods, revised edition. Applied Social Research Methods Series, 5.

Publication 3

Olaniyi, E. O. (2017). Towards EU 2020: An Outlook of SECA Regulations Implementation in the BSR. *Baltic Journal of European Studies*, 7(2), 182-207. **(ETIS Classification 1.1)**

DE GRUYTER
OPEN

Towards EU 2020: An Outlook of SECA Regulations Implementation in the BSR

Eunice Omolola Olaniyi

Department of Business Administration,
Tallinn University of Technology
Akadeemia tee 3,
Tallinn 12618, Estonia
E-mail: eunice.olaniyi@ttu.ee

Abstract: *The clean shipping concept emerged in a bid to make maritime transportation green and environmentally friendly. This mandate is being accomplished through improved conducts, actions and technology in the maritime industry. One of such measures was the creation of the Sulphur Emission Control Areas (SECA) in 2005 and 2012 to reduce the rate of sulphur emissions from shipping. Sustainable growth—an EU 2020 priority—is strategically linked to the SECA regulation in that it promotes resource efficiency, greener environment and a competitive economy.*

Thus, the International Maritime Organisation (IMO) and, as adopted by the European Parliament (EP), SECA regulation stipulated that from 2015 all ships in SECA are under the obligation to use low sulphur marine fuel that must not exceed 0.1% (IMO, 2011). This regulation has incited rigorous arguments on the economic disadvantage it would subject affected maritime stakeholders who are made to comply with stringent regulation their counterparts in non-SECA are not subjected to.

Two years of 0.1% sulphur regulations have witnessed many changes in the maritime industry and most of the first responses were realised with vessels that ply along the Baltic Sea. This work presents an account of European maritime industry's approaches towards SECA regulations and the stakeholders' thoughts on the economic impact of SECA. This contribution brings a clearer picture to the status quo as well as highlighting a needed future focus.

doi: 10.1515/bjes-2017-0016 Baltic Journal of European Studies
Tallinn University of Technology (ISSN 2228-0588), Vol. 7, No. 2 (23)

Keywords: *clean shipping, emission reduction, EnviSuM project, EU 2020, institutionalism, SECA*

1. Introduction

Shipping is considered environmentally friendly because the cargo conveyed on a tonne mile basis appears insignificant when measured and compared to the mass and space of water (Jiang, Kronbak & Christensen, 2014). However, despite this, ships are the major source of pollutants such as carbon oxides (CO_2), sulphur oxides (SOx), ozone depleting substances (ODS), volatile organic compounds (VOC) and (nitrogen oxide (NOx) emissions (Wiśnicki *et al.*, 2014). Even though most of the emissions from the ships are deposited into the deep sea, these emissions are still responsible for acidification and eutrophication, and especially for the negative impact on the environment (Airclim, 2011; Sheba, 2014). After a prolonged exposure, they form poisonous compounds that infiltrate the lungs and poison the blood causing premature death from inflammation, heart and lungs failure (Alcamo *et al.*, 1987; Corbett & Farrell, 2002; Cullinane & Bergqvist, 2014). While shipping is compared to other modes of transportation, it appeared better in terms of an amount of CO_2 emissions (Holmgren *et al.*, 2014), however, the production of sulphur oxides (SOx) and nitrogen oxides (NOx) emissions from shipping activities is greater in comparison to land transportation (Panagakos, 2014).

The priority of clean shipping is to make maritime transport greener (Stipa, 2013). Integrated clean shipping strategy zooms on three areas. The *ship* that can be received in all ports with near to nil target emissions, *ports* that are competent and equipped with environmentally-friendly facilities and at the same time can offer encouraging incentives to expedite clean shipping, and lastly, cargo with appropriate corporate footprint and owners that embrace environmentally conscious decisions (NSF, 2008). These efforts are synchronised with the Europe 2020 objective of sustainable growth (Prause, 2014a). According to EU (2010), they include the following:

- ‘Smart growth’ or creating an economy-based knowledge and innovation;
- ‘Sustainable progress’ or encouraging a resourceful, competent, greener and more competitive economy;
- ‘Inclusive growth’ or nurturing a high-employment economy that will deliver social and territorial cohesion.

Green growth, social sustainability and energy efficiency are the core to achieving growth sustainability (Prause & Hunke, 2014). Many efforts are seen in the development and expansion of greener initiatives around Europe. Examples are in the public transport system, reductions in fossil and fuel consumption, waste management, district heating, climate change awareness, reduction of greenhouse gas emissions by 20–30% and green infrastructure initiatives (Hunke & Prause, 2013; Prause, 2014b; Nabielek, Hamers & Evers, 2016). There is a high focus especially on the creation of about 20% of the EU energy demands from renewables and increased energy productivity by 20% before 2020 (EU, 2012).

As a result, international legislation on shipping was strengthened and shipping is no longer allowed as usual. Particularly, this policy focuses on a reduction of sulphur in ship fuels, which is expressed in terms of % m/m (mass). Thus in May 2005, the Sulphur Emission Control Area (SECA) was created to curtail airborne emissions from ships. In that, ships trading in designated emission control areas will have to use on-board fuel oil with a sulphur content of no more than 0.1% m/m from 1 January 2015 (IMO, 2015). The SECA area embodies about 0.3% of the world's waters (Notteboom, 2010).

Panagakos (2014) emphasised the importance of fortified regulations and environmental awareness for the stimulation of clean shipping and at the same time warned about the magnitude of the costs for the maritime industry. If Panagakos' deductions are true, the repercussions of the SECA regulations on the maritime sector stakeholders can be linked directly or indirectly to the investment decisions that will ensue in the compliance actions. Normally, the affected companies respond to regulations by changing their strategies for the innovation process and activities such as research and development, expansion, equipment upgrade (Olaniyi & Viirmäe, 2016). In their studies, Hämäläinen (2015) and Hämäläinen, Hilmola & Tolli (2016), showed concerns on the implication of the SECA regulation that it could lead to a modal backshift from sea to the road causing more road pollution and congestion, thereby conflicting with other land regulations. Other concerns were for reduced revenue for export companies whose supply chain is mainly marine based (AirClim, 2011; Hämäläinen *et al.*, 2016).

In 2015, the EU officially approved EnviSuM—Environmental Impact of Low emission Shipping Measurements and Modelling Strategies project—to research and evaluate the technical efficiency and the socio-economic impact of clean shipping solutions in the BSR in the framework of the BSR Interreg Programme. The EnviSuM plans to deliver verified results on the effectiveness of the various clean shipping solutions and offer beneficial references for the environment and health of the BSR population. It also plans to promote economic development in the maritime sector. Thus, this study is a part of the current EnviSuM project studies on the economic consequences of the Sulphur Emission Control Area (SECA) regulations on maritime stakeholders in the BSR. The aim of this work is to study the BSR maritime compliance activities concerning reduction of sulphur emission. It also studies collective stakeholders' assessments on how the SECA regulations have affected or will affect their businesses and the BSR. The research questions addressing this subject are: (1) How has the SECA regulation influenced the maritime sector in the BSR? (2) How has the innovation that stemmed from the SECA regulations compliance influence blue growth and clean shipping activities in the BSR? and (3) What are the stakeholders' reactions to these impacts?

Innovation, in this study, is 'incremental innovation'—improving already existing products by making them better, faster, and cheaper; 'process and business model innovation'—implementation of a new/improved products and services that occur through the cross-sectorial blend of technologies, design and business simulations consisting of unique incidents that lead to beneficial change as described by Olaniyi and Prause (2016).

The first and the second question will be answered by using the qualitative analysis of interviews and focus group sessions, while the third question will be tackled by using a survey analysis. This contribution is aimed at improving the integration of new knowledge that will provide new systems for cleaner and more cost-effective shipping for the maritime sector.

The structure of the work is as follows: Section II discusses the theoretical framework. Section III describes the methodology. Section IV highlights the various SECA directive compliance activities observed in the BSR as well as its economic influence on maritime businesses environment and the BSR. Section V discusses the implications of the results and Section VI concludes.

2. Theoretical framework

2.1 Institutionalism and its influence on industrial behavioural pattern

Organisations are subjected to and dependent on environmental influences (often referred to as institutional forces) and one of such influences are regulations (Furusten, 2013). Regulations force organisations to conform in order to meet the criteria for corporate citizenship (Gardberg & Fombrun, 2006). Institutional theory (mostly used for the adaptation of organisational practices) postulates that organisational structures are not spontaneous nor driven only by competition or wanting to be effective but are mostly influenced by the rules, norms and demand of their environment and stakeholders (Meyer & Rowan, 1977; DiMaggio & Powell, 1983; Dacin, Goodstein & Scott, 2002). Institutional theory gained popularity because it was able to explain the complex assessment of why organisations change their character and influence progressively (Dacin *et al*., 2002), and provides an explanation for the parallelism that is common between them and their environments which emphasise that organisations are structural reflections of socially created realities (Meyer & Rowan, 1977).

The core of the institutional viewpoint is that normative pressures, whether external or internal, usually influence organisations. Even more so, when organisations are within the same environment they are sometimes obliged to practice similar activities (Peters, 2000). This mostly happens when organisations are trying to conform to constitutional rules in their bid to be legitimate and successful in the environment they find themselves. Sometimes, members of a particular industry do not have choices that can be modified through their membership but have to accept predetermined choices (also called norms) that cannot be changed by their association. This gives an explanation concerning the predictive nature of organisations (Martin & Frost, 1996), in which conformity ensures legitimacy and institutional initiatives produce safety nets and opportunities that cushion and reduce organisational risks (Gardberg & Fombrun, 2006).

A “norm” is a rule created by a group of people in a particular environment with some degree of binding authority over the same set of people (Meyer, 2008). These changes are mostly about organisations responding to the challenges of the existence of the institutions governed by their environment (Dacin *et al*., 2002). In some cases, conformity comes as result of a direct mandate from the state (DiMaggio & Powell, 1983). Legitimacy activities can facilitate the opportunity for an organisation to distinguish itself and construct local advantages (Kostova & Roth, 2002). An example of tthis is an environmental regulation like the

SECA regulation. While there are common rules across boards, organisational conformity to the institutional atmosphere give room for positive appraisal and increases survival chances (Zucker, 1987).

In most modern organisation theories, organisations try to differentiate themselves with their structures. However, structural change in organisations is not so much driven by the mentioned factors as they are by institutionalism, which leads to homogeneity (DiMaggio & Powell, 1983). Institutional theory proposed a correlated description for homogeneity in organisations known as 'institutional isomorphism' (Lieberman & Asaba, 2006), as a coercing process that forces a specific unit of population to bear resemblance to other units that are in the same regular conditions which make them competitive or normative (DiMaggio & Powell, 1983). As such, organisational features are modified towards a growing compatibility with the norm. Sometimes these practices evolve over time due to shared knowledge ('mimetic isomorphism'), on the other hand, sometimes it is due to some social realities that are enforced by the law, stakeholders or public opinions thus becoming legitimate and institutionalised ('coercive isomorphism') (Meyer & Rowan, 1977; DiMaggio & Powell, 1983; Dacin *et al*., 2002). In some other cases, organisations respond to what they perceive as suitable and appropriate for the environment where they are ('normative isomorphism') (DiMaggio & Powell, 1983).

To study the influence of the institutional environment on the organisation in another methodical way, Kostova and Roth (2002) introduced the institutional profile theory and called them issue-specific pillars. These are regulatory, cognitive, and normative institutions, which are usually influenced by different motivation or isomorphism. Defining the three pillars, Kostova and Roth explained that the regulatory pillar mirrors the existing regulations and rules in a national environment and stimulates a particular set of attitudes. The cognitive pillar reflects the stereotypes used in a given country while normative pillars show their values and beliefs. Affirming Zucker's (1987) summation that in an institutionalised context, organisations are pressured to become increasingly similar due to environmental control and that some of the indicators of 'institutional environment' reflect pressures that are external to the organisation, such as the laws and regulations created by the states or professional authorities.

One the other hand, this particular part of the neoclassical paradigm of the institutional theory also focuses on the study of how regulations as an institutional structure can cause organisations to respond differently to the same set of simulations (Reynolds, 1981). In compliance, while organisations are expected to respond in a certain way to meet regulatory demands, there is no guarantee that the whole system will do so in similar actions to achieve legitimacy. Even though the existence of common legal conditions affects many aspects of an organisational activity and decisions, most imitations seen in organisational structures are because of the fact that there are no other set choices to select from (DiMaggio & Powell, 1983). Hence, the selection is usually subject to the evaluation of individual organisational interests and perceived benefit (Reynolds, 1981).

When the SECA directive was introduced, maritime stakeholders and related organisations had to comply in order to be legal to run shipping businesses in the SECAs. They had few compliance options to choose from and a lot of them had to carefully make their choice based on perceived benefit, acceptable risk and costs of investments. In new institutional economics, transaction costs (compliance costs) are expensive with the tendency to interfere with effective productivity (Olaniyi & Viirmäe, 2017). Thus, compliance choices are strategic for most companies.

2.2 Sulphur emissions regulations and shipping on the Baltic Sea

To ensure synchronisation with other international law as well as for improved implementation, the Directive 1999/32/EC was enacted to regulate sulphur emissions from ships and was amended by Directive 2005/33/EC in Annex VI of the International Convention for the Prevention of Pollution from Ships (MARPOL 73/78). The law restricts the sulphur content of the marine fuel used in the designated sea areas to 1.5% m/m, further to 1.0% by 1 July 2010 and later to 0.1% w/w by 1 January 2015 (IMO, 2008; 2009; 2013). The Baltic Sea Region (BSR) was the first water designated as SECA in 2006 and in 2007, the North Sea Area and the English Channel (Nugraha, 2009). In December 2016, China also designated three emission control areas in its states. These are the Pearl River Delta, the Yangtze River Delta, and the Bohai Sea in China waters (North, 2016). Recently, in the MEPC 70th meeting, the global sulphur cap in non-SECA of 3.5% was reduced to 0.5%, effective from January 2020 (IMO, 2016).

In MARPOL 73/78, the BSR is described as "the Baltic water with the Gulf of Bothnia, the Gulf of Finland and the entrance to Baltic Sea bounded by the parallel of the Skaw in the Skagerrak at 57^{o}44'.8 N". This is approximately about 415,000 km^2 and shallow. It is known as the major brackish water in the world, measuring 53m in depth and having a narrow canal that makes navigation challenging for cruising ships (Helcom, 2012). Because a significant share of the world's marine cargo freight takes place on it, it is subjected to rigorous shipping activities (Breitzmann, Möller & Wenske, 2013) making it the most heavily plied seas in the world up to about 15% (Daduna, Hunke & Prause, 2012). All these activities make the Baltic Sea vulnerable to substantial pollution whose aggregate effect will be harmful (Breitzmann *et al*., 2013). Substantial foreign trade freights are routed through the Baltic Sea ports of Finland, Sweden, Denmark, Poland, Russia, Germany, Estonia, Latvia and Lithuania and as a result of steady growth witnessed in the economic sector of the BSR, escalated trade freights on it are foreseeable in the future (Helcom, 2012; Daduna & Prause, 2016).

The SECA regulations, as other regulations, typically are expected to increase the costs of shipping operations, especially for ships that ply SECAs regularly. There are concerns that the SECAs might alter the competitiveness of European industry in global markets and international trade or even disrupt the level playing field of globally operating industries (Korhonen *et al*., 2015), and the delivery of economic growth (COMPASS, 2010). Already, there was the anticipation of about 25–35% increase per tonne freight (Notteboom, 2010). The 2020 global sulphur cap of 0.5% is also speculated to increase the costs of container ship to about 4–13%. COMPASS (2010) hypothesised that global sulphur cap could result in an increase in the overall price of fuel by 2020. This speculation could lead to some industries relocating for "better" business conditions. For instance, Hämäläinen *et al*. (2016) stated that companies like the paper machine and mill in Finland might be facing closure due to the SECA directive, because of cost challenges and may have to relocate the bulk paper production closer to the markets in Central Europe. However, OECD/ITF (2016) refuted the impact of the sulphur emission regulation on global trade flows and reported that it has been negligible.

A lot of authors already have extensively evaluated the different options for the SECA regulations compliance (i.e. Notteboom, 2010; Wiśnicki *et al*., 2014; Jiang *et al*., 2014; Nugraha, 2009; Brynolf *et al*., 2014; Bergqvist, Turesson & Weddmark, 2015; OECD/ITF 2016), which will be explained briefly in the next paragraphs.

The easiest option to reduce sulphur emission is to change the use of the usual marine heavy fuel oil (HFO) to cleaner and lighter distillates that emit little waste after combustion such as the Marine Gas Oil (MGO) and Marine Diesel Oil MDO (Farrell *et al*., 2002; Brynolf *et al*., 2014; Wiśnicki *et al*., 2014). Fuel switching option is subject to the unpredictable trends in fuel prices because of the volatility prevalent in the fuel market (Jiang *et al*., 2014; Hämäläinen *et al*., 2016).The second option is the use of alternative fuel such as liquefied natural gas (LNG), biogas, biodiesel, ethanol, methanol, coal, nuclear power, wind, solar panels, and hydrogen cells. The use of LNG is arguably the most politically supported option. Natural gas has long been widely used in land industry for heating and transportation purposes. It is naturally low in sulphur and satisfies the new sulphur regulation requirements (Jiang *et al.*, 2014). The discussions on LNG are popular because ship engines that operate on it emit almost zero SO_2. Not only this, the emissions of NOx and PM are also drastically reduced by 80% or more (AirClim, 2011). It is more convenient for vessels trading between fixed ports where LNG fuel is available to use LNG as marine fuel than for large ships that need deep sea shipping (Wiśnicki *et al*., 2014). Bergqvist *et al.* (2015) explained that keeping LNG in liquid form requires the gas to be below its boiling point, which is 163° C kept under pressure and requires large tanks installed either above the deck or inside the ship. As expected, the tanks will take about three times or more space than other fuel tanks. This is one of the disadvantages of using LNG. It is rather expensive to convert old vessels to LNG, so most LNG-powered vessels are newly built (Bergqvist *et al*., 2015).

Another popular option is the use of the scrubber, an abatement technology that removes sulphur deposit from the ship exhaust and permits the use of the cheaper HFO (Concawe, 2013). There are two types of scrubber—the dry and the wet scrubbers. The wet scrubber is categorised into three types: the open loop, the closed loop and the hybrid system scrubbers. One of the drawbacks common with the use of the scrubbers, mostly the wet scrubbers is how or where the acidic wash water is discharged. Another is that the discharged sludge must be kept in storage on board until the ships berths giving the ship extra weight while cruising (Jiang *et al.*, 2014). The cost of the retrofit is around 2–4 million euros, subject to the age and the size of the ship. A scrubber has a lifespan of 10–15 years (Brynolf *et al*., 2014) and 3–5 years of payback period (Atari & Prause, 2017). The scrubber can be installed on both new and old ships (Bergqvist *et al*., 2015).

A special measure to reduce ship emissions in the ports is the use of onshore power supply (OPS), a land-based power grid connection when vessels berth in ports. This is a corresponding EU directive that enforces shore-side electricity supply infrastructure to be installed in all TEN-T Core network ports and other ports by 31 December 2025 (Directive 2014/94/EU). Usually, scrubbers are fitted on the main engines, at berth ships usually shut off the main engine and leave the auxiliary engines running to generate electricity. When the onshore power is used, there is a reduction in the emissions from ships. With various ports installation facilities coming up, ship-owners are being encouraged to adapt their ships to using onshore power when berthed (OECD/ITF, 2016). This option has become a necessity for ships who have a great need for electricity at berth (Ecofys, 2015; OECD/ITF, 2016).

3. Methodology

3.1 Instruments and materials

All data collection activities took place between May 2016 and May 2017. The first and second research questions were answered by examining previous studies and published reports on SECA. Furthermore, face-to-face structured and semi-structured experts' interviews were made across the BSR. Where face-to-face interviews were impossible, phone calls and Skype videos were made. The interview lasted between 1 and 2 hours. 39 interviews were made. Other study instruments were the BSR maritime experts' focus group meetings in the frame of EnviSuM learning café.

The third research question was investigated through a survey study. The survey was conducted to assess BSR maritime experts' perceptions on the economic effect of SECA regulations. A pilot survey was first conducted according to Easterby, Thorpe & Jackson (2012) to create content validity, clarity and suitability. EnviSuM partners from Germany, Estonia, Finland, Denmark, Norway and Poland were part of this activity. 509 surveys were sent out through a collective effort from all EnviSuM partners across the BSR, collecting 122 respondents, representing a cross-section of maritime experts at the management level. The low responses from the survey were triangulated with previous results from interviews and focus group meetings according to Leary (2009).

3.2 Sample

Top management executives were targeted because they make most of the economic and investment decisions. The stakeholders were divided into 5 categories and catalogued according to how directly impacted they are from SECA regulations. Table 1 depicts this categorisation where a 3-star level indicates high priority, 2 stars indicate medium priority and a 1-star level means low priority. Using this, categories 1, 2 and 3 consisting of Shipping companies/ Ship operators/Ship owners, Ports and Ship Suppliers became the major focus of this data analysis.

Table 1. SECA Maritime Stakeholders Priority Index

Category	Maritime Stakeholders	Order of Impact
Category 1	Shipping companies/Ship operators/Ship owners	3 stars
Category 2	Ports	3 stars
Category 3	Ship Suppliers (maritime equipment and services)	2 stars
Category 4	Port authority, Non-governmental organisation (NGO) Public sector (Ministry, Municipal, Government agency, Education, Research), Police/customs	1 star
Category 5	Shippers (Logistics service providers, Production and Trading, Real Estates/Facilities managers)	1 star

3.3 Measurement and analysis

Analysis of this research encompasses 2 studies:

Study 1: The analysis was based on interviews, the focus group meetings and document reviews. A descriptive analysis of the interview data according to Yin (1989) was used to highlight SECA related activities and their core patterns in the maritime community in the BSR.

Study 2: The analysis was based on the survey. Statistical software was used to analyse and interpret the perceived impact of SECA regulations on maritime business activities in the BSR. The first part of the analysis was conducted to acquire data on the stakeholders' general perception of SECA. It included maritime sector-specific questions on their SECA related activities, SECA implementation benefits, gaps, and maritime stakeholders' future expectations. In the second part, the survey analysis included a 10-factor questionnaire to measure the economic impact of SECA regulation from the viewpoint of the maritime stakeholders. The question, as elucidated in Table 2, covered the economic impact of SECA on blue growth, costs, pricing, own company development, innovation, FDI, cargo flows, modal split and branding of the BSR.

A 5-point summative rating scales from -2 to +2, the degree to which the impact is very negative to very positive, was used to evaluate each factor. The mean score of the answers obtained regarding the impact of SECA regulations indicates the degree to which the questionnaire relates to the underlying overall perspectives. Kerlinger (1986) discussed some of the weaknesses of the rating scales and one of them is their measurements, as they are perceived to be "too easy" to construct for them to be impactful. This issue was addressed through the pilot survey and interviews with various EnviSuM partners from the different maritime sector where the survey was designed to allow open comments to each question. This technique is similar to what Fowler (1995, p. 131) called "the field pre-test with observation". Item-specific comments were tracked and analysed and wordings were improved as needed.

Table 2. Factor dimension of the economic impact of SECA regulations

What is the impact of SECA regulations on the maritime businesses and the BSR?
Overall economic impact on the BSR
Impact on blue growth in the BSR
Impact on your product/service costs
Impact on your pricing
Economic impact on your company development
Impact on innovation of maritime sector in the BSR
Impact on attractiveness of the BSR for foreign direct investment (FDI)
Change of cargo flows within Europe
Change on transport modal split within the BSR
Reputation/branding of the BSR

Note: n of data = 122

4. Results

4.1 Study 1: SECA regulations compliance activities

The results from the experts' interviews, focus group meetings, and reports reviews revealed the following:

4.1.1 Compliance activities by ship owners

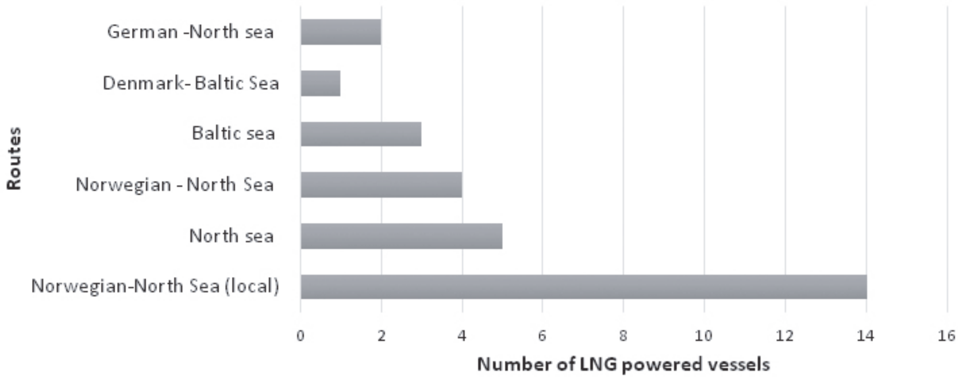
The use of low sulphur content fuel: Because of the uncertainties that surround the fuel price and SECA regulations, most ship owners at the moment are favourably disposed towards the use of fuel distillates such as MGO and MDO.

Fortunately, a new fuel type called the ultra-low sulphur fuel oil (ULSFO), a hybrid fuel of different refinery streams with a higher viscosity and lower volatility to the MGO has been developed and is gaining popularity as a cheaper source of marine fuel since 2014. This is a major innovation stemming from the need for a cheaper alternative from the heavy investment that is needed for the scrubber and the LNG options. By the end of 2016, there was approximate 200,000mt Amsterdam–Rotterdam–Antwerp monthly supply that is projected to increase above 350,000mt/month by the end of 2017 as reported by Platt in October 2016. This will mean that the demand for marine gas oil, which is currently about 320,000mt per month, will have an approximately 50-50 ratio (if not lower) with the ULSFO. Already there are nine different types of ULSFO available in the markets worldwide, as reported by the Baltic Ports Organisations (BPO) in 2016. However, some ship owners have shown their concern over the unknown effect of using the ULSFO over time on ship engines originally designed for HFO. Lastly, all respondents agreed that the 2020 global sulphur cap is a major “game changer” and there are different speculations on its full impact on fuel demand, which are beyond the scope of this study.

LNG as an alternative fuel: There was a strong promotion of LNG as a marine fuel across Europe and many ship owners would prefer to use it. The use of LNG is not only useful for the compliance of SOx and PM but it also ensures the compliance of the anticipated NOx emissions regulation. Ferries are the largest group of vessels fuelled by LNG. There are 18 ferries powered by the LNG engine, 14 of which are small car/passenger ferries. Others are 4 general cargo ships, 2 ro-ro ships, and 3 gas carriers. From discussions with BPO, there are no containers ships or bulk carries fuelled by LNG. However, because of how expensive it is to retrofit or to install in a newly built ship, out of the 28 ships operating short sea shipping in the European SECA, there are only 3 LNG powered vessels operating in the BSR as shown in Figure 1.

The use of the scrubber: The scrubbers are mostly installed on ferries, ro-ro and general cargo (feeder container) ships. However, the rate at which the fuel price has plummeted in the past three years has somewhat decreased the investment in the scrubber technology, although a few investment cases are still seen. By the end of 2016, 83 ships were equipped with the scrubbers in the European SECA. As shown in Table 3, there are 41 ro-ro and 28 ro-pax vessels retrofitted with the scrubbers. Other retrofitted vessels are: 5 bulk carriers, 5 containers, 3 general cargo ships and 1 tanker. The average age for a scrubber retrofit is 9.5 years. By the end of 2017, more ships are still expected to be scrubber retrofitted with the scrubber. Going by BPO extrapolations, there should be around 200 scrubber-retrofitted vessels by 2020.

Figure 1. The number of LNG-powered vessels on European SECA



Source: Compiled by the author from multiple sources

From an interview at the Maritime University of Szczecin, Poland, running a scrubber on board ships requires additional 13 MWh electricity per day. This means 80 euros per MWh will mean a 100,000 euros per year additional running costs, notwithstanding the maintenance and extra running fuel costs.

Table 3. Scrubber retrofits in European SECA (ro-ro and ro-pax)

Shipping lines	Ro/Ro	Ro/Pax
DFDS	15	6
Finnlines	11	4
Transfennica	6	-
KESS	4	-
Royal Wagenborg	2	-
P&O Ferries	1	-
TransAtlantic	1	-
Condor Ferries	1	1
Brittany Ferries	-	6
Color Line	-	4
Scandlines	-	4
Stena Line	-	2
TT-Line	-	1
Total	**41**	**28**

Source: Compiled by the author from multiple sources

Now there are ongoing debates on how safe using the open loop scrubber is to the environment since the exhaust wash water is discharged directly into the seawater and some are calling for its ban in the BSR. Although there are no clear rules on how this should be handled, the hybrid scrubber innovation is widely accepted to solve this dilemma. This way, ship owners can use the closed loop scrubber when on the shallow waters of the BSR and change to the open loop during deep sailing.

4.1.2 Compliance strategy cases from shipping lines

Tallink, Estonia: Tallink has 17 vessels—2 cargo, 6 ro-ro, 9 cruises of which 3 are chartered out. The shipping line uses the MGO. In February 2017, Tallink launched a new ship—*The Megastar*. *The Megastar* is a five-engine vessel powered by both the LNG and the MGO

Viking Line, Finland: Viking Line runs 7 vessels. For SECA compliance, the Viking is focusing on LNG-powered vessels. Viking's first LNG-powered ship, *The Viking Grace*, started operations in 2013 and was the first LNG-powered ship in Europe. Like Tallink, Viking has no scrubber-retrofitted ship.

DFDS Seaways Denmark: DFDS is one of the biggest shipping lines in Europe and has 53 vessels with 5 on a charter. DFDS leverages on the reduction in fuel price and price spread between HFOs and the other distillate oil by investing in the scrubber. Currently, the company has 21 scrubber-retrofitted vessels comprising of 15 ro-ro and 6 ro-pax ships (see Fig. 3).

4.1.3 Compliance and monitoring activities in the ports

LNG infrastructures in the ports: The projects of the Baltic Port Organisation, LNG in Baltic Sea Ports and LNG in Baltic Sea Ports II started fostering the development of LNG bunkering in the BSR with the aim of synchronising investment in ports' networks in order to regulate the LNG. This was after the introduction of the EU Directive 2014/94/EU on LNG bunkering infrastructure, spurring a steady growth of the LNG bunkering facilities within the BSR ports. Some ports with limited or no LNG infrastructures offer the boat-boat and truck-ship bunkering. Ports with some sort of LNG bunkering facilities/terminals are the port of Stockholm, Gothenburg, Nynäshamn, Lysekil (Sweden), Świnoujście (Poland), Klaipeda (Lithuania), Pori (Finland) and Hirtshals (Denmark). The Swedish Maritime is arguably at the forefront of clean shipping activities in the EU.

Onshore power supply (OPS): Leaving the auxiliary engine running at the ports has been a major source of noise and emission pollution at the port. The use of OPS ensures significant health benefits for the ship crews as well as for people living around the ports because as soon as the ships stop using the fuel-powered engines, the noise from ship vibrations and the emissions from fuel combustion stop. The ports of Gothenburg, Stockholm, Lübeck, Helsinki and Ystad are currently equipped with the OPS.

Compliance monitoring and control: Ports and coastal states are directly responsible for vessels compliance inspections in relation to their nation as well as international law (OECD/ITF, 2016). Compliance monitoring is done through inspections of ships' records especially those of ships without installed emission abatement equipment and fuel samplings. Sniffing devices are strategically stationed at the Great Belt Bridge of Denmark. There are also surveillance aircrafts that measure emissions around the ports. These devices are optical ultraviolet spectroscopic sensors that analyse the concentrated path of SO_2 and NO_2 from ships. Emissions from at least a 100 ships are monitored every month. The OECD reported that in 2015, according to figures by EMSA, about 2.8% (427) of the inspected ships (15,247) were found to have defaulted. Nevertheless, by the second half of the year, the non-complaint rate became very low compared to what it was earlier in that year. The Danish shipping (formerly known as Danish Shipowners' Association), confirmed that the non-compliance rate has reduced drastically and that since 2015, only 19 shipping companies have been reported to default. Two of which were recently reported by the Danish EPA (Environmental Protection Agency) in September 2017. Additionally, from an expert interview with Prof Mellqvist, an EnviSuM partner from Chalmers University based on about 4,000 tests they conducted in the middle of the BSR Sea between 2016 and 2017 there was about 95% emissions compliance rate and about 85% compliance around the borders.

4.2 Study 2: Evaluation of the impact of SECA regulations on maritime business activities in the BSR

The results from Study 2 are based on the analysis of the administered BSR-wide survey responses.

4.2.1 Stakeholders' familiarity with the SECA regulation

The procedures used for this study are according to business statistics elucidated by Aczel and Sounderpandian (2002). The stakeholders' responses are expressed in percentages of the overall responses (n = 122).

All the respondents answered that they were very familiar with the SECA regulation and about 67% responded that their employees are fully aware of the SECA regulation and have conducted SECA-related training for their staff. Of the stakeholders, 91.7% monitor and evaluate their clean shipping emission parameters regularly and, surprisingly, while most admitted that this is because it was obligatory, they also admitted to doing so because they care about their ecological footprint (82%), they wish to benchmark against their competitors (64%) and 54.5% feel that doing so would benefit their company. More than half (about 60%) indicated their interest in the use of an investment decision tool for SECA-related investments.

When asked about how satisfied they were with the preparation and introduction of SECA regulations in the BSR, 63% agreed that they were satisfied with the SECA preparations but pointed out that there were some loopholes, such as information gap, underdeveloped services, underdeveloped and unclear rules for sanctions, monitoring and controlling activities. Most respondents feel most strongly about unclear rules for monitoring and sanctions (45.7%), followed by underdeveloped services and infrastructure (37.1%). Furthermore, the stakeholders believe that future discussions on SECA should be centred mostly on a "BSR-wide availability of SECA-related services and infrastructure", "use of low sulphur fuel", "technology improved information collaboration" and "the use of LNG". The "scrubber solution" was considered as one of the least important topics by 74.3% of the respondents.

4.2.2 Economic impact of SECA regulation—the stakeholders' perspectives

The mean and standard deviation of the scores on the "economic impact of SECA regulations" data exhibit that nearly all mean (M) for all the variables were close to zero, except for *innovation* (*M=1.106*) and *branding* (*M= 0.812*), suggesting that the evaluation of the SECA impact is comparatively similar among the stakeholders. It also indicates that at two years implementation of SECA, its effect on fiscal measurements such as *costs*, *pricing*, *FDI*, *cargo flows* and *modal splits* are perceived as insignificant by the stakeholders. Nevertheless, much impact is expected to be from *innovation* and *branding of the BSR.*

In order to find out which of the nine variables have a significant impact on the variable "overall economic impact of SECA", additional regression analysis according to Mendenhall & Sincich (1989) was used. The F-test indicated a substantial fit for the subsequent model even though the R-squared was 58%. From the regression analysis coefficients and the related t-test, factors like *blue growth*, c*argo flows* and *branding* were statistically substantial with a positive leading sign *of r = 0.56, 0.33* and *0.32*, respectively. Their *ß*-coefficient percentages also showed that they accounted for about 56% of the "overall economic impact of SECA". This implies that *blue growth*, c*argo flows* and the *BSR branding/reputation* are the most important factors linked to the "overall impact of SECA" and are in parallel with SECA growth. In other words, to improve the general perception on SECA among the stakeholders, emphasis should be on to how to improve stakeholders' opinion on *overall*, *blue growth* and *branding*. *Pricing* showed as being "nearly significant" having a *p-value of 8%* but with a negative sign. This negative sign could indicate that an increase in pricing will negatively affect the "overall perception of SECA".

Finally, 1-factor ANOVA was used to test the existence of the differences in the responses from Denmark (DE) and Estonia (EE), because both countries have the highest number of responses. A review of the results showed significant differences in four responses: *overall effect*, *development*, *blue growth* and *FDI* with probability error of $p < .05$. *Overall impact* and *development* have a much lower probability error of $p < .01$. The Danish are six times more positive (*mean = 0.8*) about the *overall impact* of SECA regulations when compared to the Estonians (*mean = 0.125*) suggesting a more liberal reception towards SECA regulation and better acceptance from Denmark. Estonians show a neutral disposition towards *development* and are less positive towards *blue growth* when compared with their Danish counterparts who are positive on both variables. Again, when it comes to the flow of *FDI*, the Estonians showed a negative stance while the Danish believe SECA will improve and attract foreign direct investments into the BSR.

5. Discussions and implications

The various SECA compliance activities witnessed in the BSR confirm that institutions indeed do have great influence on the sets of actions and behavioural pattern witnessed in the maritime industry and accomplished via new technologies and improved behaviour across all stakeholders in the maritime industry in a combined and cohesive effort of several actions. The principal logic of institutionalism, in this case, shows how institutions influence their members to act in response to the basic elements of the institutional structure although mostly are company-specific strategies.

The first part of this study answered the first question and the results showed major modifications in the way the shipping industry is being operated in the BSR. It also displayed the efforts made by the ports to ensure compliance since SECA regulations came into force in the BSR. Even though the SECA regulations make it compulsory for ship owners to use low sulphur fuel, the costs of bunkering have not gone up. In fact, the reverse is the case with ship owners making meaningful savings from the fuel costs, although it might be difficult to predict how long this might last. Furthermore, there have been major overhauling made in the way most shipping line works. Some have changed, reduced or increased their number of routes, while some have replaced their smaller vessels with bigger ones. These strategies made to reduce the economic impact of the SECA regulations could have led to the current overcapacity seen in the shipping industry.

The second question revealed the various innovative actions taken in order to mitigate or reduce the impact of compliance such as the hybrid marine fuel, surveillance drones for monitoring and compliance checks. The scrubber technology especially could be a major source for the obviously needed technology push-effect in the EU but it constitutes huge investment costs and risks for the ship owners. The intensified OPS infrastructures growth in the ports (although not borne out of SECA compliant need), have greatly improved the noise and air quality around the ports. Even at this, the OPS entails an adaptation for appropriate gears like the frequency converters in the ports and on the ships. This is will be additional costs requiring full teamwork for all concerns.

The third question answered from the survey analysis showed that the stakeholders do not really have negative impressions about SECA, neither have they experienced significant instability in their business as a result of its compliance. Unexpectedly, this evaluation was unanimous among the stakeholders. Yet, most respondents agreed that policymakers should have given them more time to prepare for the SECA implement especially when the investment costs and risks are quite high. They insisted that the preparation time would have prevented the dilemma they faced when deciding compliance options and at the same time would have reduced the financial wastage on the limited options available from the onset. An inference from this could be that most of them, especially the ship owners, would have wanted to have links to a reliable source that would ensure their decisions yield better results and make them better advantaged. Interestingly, the results also indicated that the ship owners are not averse to the use of the scrubber but would rather have a scrubber retrofit with an old vessel but install an LNG on their new vessels. This can be attributed to the high costs of LNG retrofit.

6. Conclusions

The purpose of this article was to study the various measures taken in the maritime industry in BSR towards sulphur emission reduction and assess the stakeholders' perception of the economic impact of SECA regulations. All the activities observed are worthwhile contributions to clean shipping and blue growth in the BSR. At the creation of SECA, there were concerns that the regulations would have negative impact on the general maritime sector in BSR. Some of these fears were mostly on the modal shift from the sea to the road, increased costs of sea transportation that will to cascade down to the cost of goods, especially agricultural produce. However, from the reports and results of this study, the effect has not been as intense as was originally anticipated, particularly on ship owners and the ports.

This conclusion highlights the contribution of this work to the body of knowledge. First, it illuminates how various stakeholders have contributed to clean shipping, blue growth and the EU 2020 objectives in the BSR. Second, it serves as a background study for the 2020 global sulphur cap implementation. Third, showcasing the achievements in the BSR maritime industry will put the BSR in a good light that can be used as an accelerator for larger solutions explored worldwide.

A limitation of this study is that it left out fuel prices, an important parameter to capture the impact of the SECA compliance based on its timeline factor. An interesting further research direction could be to capture fuel costs and its historical time series to create an "Investment Decision Tool" accessible to all maritime stakeholders.

Eunice Omolola Olaniyi studied International Business at the University of Salford, Manchester, UK. She is currently an EnviSuM Project Manager and works in the Tallinn University of Technology partner's office in Tallinn, Estonia where she is also a PhD candidate. The EnviSuM project (Environmental Impact of Low Emission Shipping: Measurements and Modelling Strategies) is funded by the European Union and studies the technical efficiency and socio-economic impacts of clean shipping solutions in view of the IMO emission regulations that entered into force in January 2015.

References

Abrahamson, E. (1991), 'Managerial fads and fashions: The diffusion and rejection of innovations,' *Academy of Management Review*, vol. 16, no. 3, pp. 586–612. https://doi.org/10.2307/258919

Aczel, A.D. & Sounderpandian, J. (2002), *Complete Business Statistics*, vol. 1, New York: McGraw-Hill/Irwin.

AirClim (2011), *Air Pollution from Ships*, Air Pollution & Climate Secretariat, Seas at Risk, Bellona Foundation, North Sea Foundation, Transport & Environment & European Environmental Bureau. Retrieved from https://www.transportenvironment.org/publications/air-pollution-ships-0 [accessed 9 Sep 2016]

Alcamo, J.; Amann, M.; Hettelingh, J. P.; Holmberg, M.; Hordijk, L.; Kämäri, J.; Kauppi, L.; Kauppi, P.; Kornai, G. & Mäkelä, A. (1987), 'Acidification in Europe: a simulation model for evaluating control strategies,' *Ambio*, vol. 16, no. 5, pp. 232–245.

Atari, S. & Prause, G. (2017, *forthcoming*), 'Risk assessment of emission abatement technologies for clean shipping,' in *Proceedings of the 17th International Conference "Reliability and Statistics in Transportation and Communication"* (RelSTat2017 Conference), Riga.

Bergqvist, R.; Turesson, M. & Weddmark, A. (2015), 'Sulphur emission control areas and transport strategies—the case of Sweden and the forest industry,' *European Transport Research Review*, vol. 7, no. 2, pp. 1–15. https://doi.org/10.1007/s12544-015-0161-9

Breitzmann, K. H.; Möller, M. & Wenske, C. (2013), 'Baltic maritime transport, its structure, competitive situation and economic weight,' in K. Breitzmann & M.Hytti (eds.) *Pan-Baltic Manual of Best Practices on Clean Shipping and Port Operations*, Turku: UBC Environment and Sustainable Development Secretariat.

Brynolf, S.; Magnusson, M.; Fridell, E. & Andersson, K. (2014), 'Compliance possibilities for the future ECA regulations through the use of abatement technologies or change of fuels,' *Transportation Research Part D: Transport and Environment*, vol. 28, pp. 6–18. https://doi.org/10.1016/j.trd.2013.12.001

Cofala, J.; Amann, M.; Heyes, C.; Wagner, F.; Klimont, Z.; Posch, M. & Stavrakaki, A. (2007), *Analysis of policy measures to reduce ship emissions in the context of the revision of the national emissions ceilings directive*, Final Report, IIASA Contract 06-107, Laxenburg: International Institute for Applied Systems Analysis.

COMPASS (2010), *The COMPetitiveness of EuropeAn Short sea freight Shipping compared with road and rail transport*, Final Report, European Commission DG Environment Transport & Mobility Leuven, 18 August 2010.

Concawe (2006), *Techno-economic analysis of the impact of the reduction of sulphur content of residual marine fuels in Europe*, Concawe Report 2/06, Brussels.

—— (2013), *Oil refining in the EU in 2020, with perspectives to 2030. The oil companies' European association for Environment, Health and Safety in refining and distribution*, Concawe Report 1/13R, Brussels.

Corbett, J. (2007), 'Mortality from ship emissions: A global assessment,' *Environmental Science and Technology*, vol. 41, no. 24, pp. 8512–8518. https://doi.org/10.1021/es071686z

Corbett, J. J. & Farrell, A. (2002), 'Mitigating air pollution impacts of passenger ferries,' *Transportation Research Part D: Transport and Environment*, vol. 7, no. 3, pp. 197–211. https://doi.org/10.1016/S1361-9209(01)00019-0

Cullinane, K. R. & Bergqvist, R. (2014), 'Emission control areas and their impact on maritime transport,' *Transportation Research Part D*, vol. 28, pp. 1–5. https://doi.org/10.1016/j.trd.2013.12.004

Dacin, M. T.; Goodstein, J. & Scott, W. R. (2002), 'Institutional theory and institutional change: Introduction to the special research forum,' *Academy of Management Journal*, vol. 45, no. 1, pp. 45–56. https://doi.org/10.5465/AMJ.2002.6283388

Daduna, J.; Hunke, K. & Prause, G. (2012), 'Analysis of short sea shipping-based logistics corridors in the Baltic Sea region,' *Journal of Shipping and Ocean Engineering*, vol. 2, no. 5, pp. 304–319.

Daduna, J. & Prause, G. (2016), 'The Baltic Sea as a maritime highway in international multimodal transport,' in *Proceedings of the International Conference on Operations Research OR 2015: Optimal Decisions and Big Data", 1–4 September 2015, Vienna (X−X)*, Berlin: Springer-Verlag.

DiMaggio, P. & Powell, W. (1983), 'The iron cage revisited: Institutional isomorphism and collective rationality in organizational fields,' *American Sociological Review*, vol. 48, no. 2, pp. 147–160. https://doi.org/10.2307/2095101

Easterby-Smith, M.; Thorpe, R. & Jackson, P. (2012), *Management Research*, 4th ed., Thousand Oaks & London: SAGE Publications.

Ecofys (2015), *Potential for shore side electricity in Europe*, Ecofys Final Report, Commissioned by European Commision DG Clima, Utrecht, Netherlands.

EU (2010), *EUROPE 2020: A European Strategy for Smart, Sustainable and Inclusive Growth*. Retrieved from http://ec.europa.eu/eu2020/EuropeENversion.pdf [accessed 20 May 2017]

—— (2012), *Europe 2020: Europe's growth strategy: Growing to a sustainable and job-rich future*. Retrieved from http://ec.europa.eu/europe2020/pdf/europe_2020_explained.pdf [accessed 20 May 2017]

Fowler, F. J. Jr (1995), *Improving Survey Questions: Design and Evaluation*, Thousand Oaks: SAGE Publications.

Furusten, S. (2013), *Institutional Theory and Organizational Change*, Cheltenham: Edward Elgar Publishing. https://doi.org/10.4337/9781782547099

Gardberg, N. A. & Fombrun, C. J. (2006), 'Corporate citizenship: Creating intangible assets across institutional environments,' *Academy of Management Review*, vol. 31, no. 2, pp. 329–346. https://doi.org/10.5465/AMR.2006.20208684

Gros, D. & Roth, F. (2012), *The Europe 2020 Strategy: Can it maintain the EU's competitiveness in the world?* Brussels: Centre for European Policy Studies (CEPS).

Hämäläinen, E. (2015), 'Estimated impacts of the sulphur directive on the Nordic industry,' *European Transport Research Review*, vol. 7, no. 8. https://doi.org/10.1007/s12544-015-0158-4

Hämäläinen, E.; Hilmola, O. P. & Tolli, A. (2016), 'North European export industry and the shadows of sulphur directive,' *Transport and Telecommunication Journal*, vol. 17, no. 1, pp. 9–17.

Helcom (2012), *Maritime Activities in the Baltic Sea*, Baltic Sea Environment Proceedings, no. 123. Retrieved from https://www.google.ee/search?q=helocme+report+&ie=utf. [accessed 20 Dec 2016]

Holmgren, J.; Nikopoulou, Z.; Ramstedt, L. & Woxenius, J. (2014), 'Modelling modal choice effects of regulation on low-sulphur marine fuels in Northern Europe,' *Transportation Research Part D: Transport and Environment*, vol. 28, pp. 62–73. https://doi.org/10.1016/j.trd.2013.12.009

Hunke, K. & Prause, G. (2013), 'Management of green corridor performance,' *Transport and Telecommunication*, vol. 14, no. 4, pp. 292−299. https://doi.org/10.2478/ttj-2013-0025

IMO (2008), Revised MARPOL Annex VI: Regulations for the prevention of air pollution from ships and NOx technical code, London: IMO Marine Environmental Protection Committee (MEPC).

—— (2009), *Prevention of air pollution from ships*, Second IMO GHG Study 2009. Update of the 2000 IMO GHG Study Final report covering Phase 1 and Phase 2: noted by Secretariat (MEPC 59/INF.10), London: IMO Marine Environmental Protection Committee (MEPC).

—— (2013), Sulphur oxides (SOx)—Regulation 14. Retrieved from http://www.imo.org/OurWork/Environment/PollutionPrevention/AirPollution/Pages/Sulphur-oxides-(SOx)- Regulation-14.aspx [accessed 20 Sep 2016]

—— (2015), Guidance on the application of regulation 13 of MARPOL annex VI tier III requirements to dual fuel and gas-fuelled engines. MEPC.1/Circ.854, London: IMO Marine Environmental Protection Committee (MEPC).

—— (2016), 'IMO sets 2020 date for ships to comply with low sulphur fuel oil requirement, Press briefing release, 28 October 2016. Retrieved from http://www.imo.org/en/MediaCentre/PressBriefings/Pages/MEPC-70-2020sulphur.aspx [accessed 30 Nov 2016]

Jiang, L.; Kronbak, J. & Christensen, L. P. (2014), 'The costs and benefits of sulphur reduction measures: Sulphur scrubbers versus marine gas oil,' *Transportation Research Part D*, vol. 28, pp. 19–27. https://doi.org/10.1016/j.trd.2013.12.005

Kerlinger, F. (1986), *Foundations of Behavioral Research*, 3rd ed., New York: CBS College Publishing.

Korhonen, J.; Pätäri, S.; Toppinen, A. & Tuppura, A. (2015), 'The role of environmental regulation in the future competitiveness of the pulp and paper industry: the case of the sulphur emissions directive in Northern Europe,' *Journal of Cleaner Production*, vol. 108, pp. 864–872. https://doi.org/10.1016/j.jclepro.2015.06.003

Kostova, T. & Roth, K. (2002), 'Adoption of an organizational practice by subsidiaries of multinational corporations: Institutional and relational effects,' *Academy of Management Journal*, vol. 45, no. 1, pp. 215–233. https://doi.org/10.2307/3069293

Leary, Z. (2009), *The Essential Guide to Doing Your Research Project*, Los Angeles & London: SAGE Publications.

Lieberman, M. B. & Asaba, S. (2006), 'Why do firms imitate each other?' *Academy of Management Review*, vol. 31, no. 2, pp. 366–385. https://doi.org/10.5465/AMR.2006.20208686

Martin, J. & Frost, P. (1996), 'Organizational culture war games: a struggle for intellectual dominance,' in S. R. Clegg, C. Hardy & W. R. Nord (eds.) *Handbook of Organization Studies*, London: SAGE Publications.

Martin, R. & Sunley, P. (1998), 'Slow convergence? The new endogenous growth theory and regional development,' *Economic Geography*, vol. 74, no. 3, pp. 201–227. https://doi.org/10.2307/144374

Mellqvist, J. (2016), *SOx Compliance Monitoring*, EnviSuM Partner Meeting, 26 October 2016, Copenhagen.

Mendenhall, W. & Sincich, T. (1989), *A Second Course in Business Statistics: Regression Analysis*, Basingstoke: Macmillan Publishing.

Meyer, J. W. (2008), 'Reflections on institutional theories of organizations,' *The Sage Handbook of Organizational Institutionalism*, London & Thousand Oaks: SAGE Publications, pp. 790–811. https://doi.org/10.4135/9781849200387.n35

Meyer, J. W. & Rowan, B. (1977), 'Institutionalized organizations: Formal structure as myth and ceremony,' *American Journal of Sociology*, vol. 83, no. 2, pp. 340–363. https://doi.org/10.1086/226550

Nabielek, K.; Hamers, D. & Evers, D. (2016), 'Smart, green and inclusive urban growth: visualising recent developments in European cities,' In *REAL CORP 2016–SMART ME UP! How to become and how to stay a Smart City, and does this improve quality of life?* Proceedings of 21st International Conference on Urban Planning, Regional Development and Information Society, CORP: Competence Center of Urban and Regional Planning, pp. 953–957.

North (2016), *China: Emission Control Areas.* Retrieved from http://www.nepia.com/news/industry-news/china-emission-control-areas-starupdatestar/. [accessed 22 Dec 2016]

Notteboom, T. (2010), 'The impact of low sulphur fuel requirements in shipping on the competitiveness of roro shipping in Northern Europe,' *WMU Journal of Maritime Affairs*, vol. 10, no. 1, pp. 63–95. https://doi.org/10.1007/s13437-010-0001-7

NSF (2008), *Clean Shipping: Towards an integrated approach of sustainable shipping*, Utrecht: North Sea Foundation.

Nugraha, F. 2009. *Effective implementation of emission control area towards cleaner shipping operations: focusing on sulphur oxides (SOx) emission reduction,* World Maritime University Dissertations, 186.

OECD/ITF (2016), *Reducing Sulphur Emissions from Ships: The Impact of International Regulation.* Retrieved from http://www.itf-oecd.org/reducing-sulphur-emissions-ships-impact-international-regulation [accessed 10 Jun 2016]

Olaniyi, E. O. & Prause, G. K. (2016), 'Baltic-Russian innovation cooperation in the context of EU Eastern Partnership,' in T. Kerikmäe & A. Chochia (eds.) *Political and Legal Perspectives of the EU Eastern Partnership Policy*, Cham: Springer International Publishing, pp. 257–279.

Olaniyi, E. O. & Viirmäe, M. (2016), 'The economic impact of environmental regulations on a maritime fuel production company,' *Research in Economics and Business: Central and Eastern Europe*, vol. 8, no. 2, pp. 58–84.

Panagakos, G. P.; Stamatopoulou, E. V. & Psaraftis, H. N. (2014), 'The possible designation of the Mediterranean Sea as a SECA: A case study,' *Transportation Research Part D: Transport and Environment*, vol. 28, pp. 74–90. https://doi.org/10.1016/j.trd.2013.12.010

Peters, B. G. (2000), *Institutional Theory: Problems and Prospects*, Political Science Series, Dissertation of Department of Political Science, Institute for Advanced Studies (IHS).

Prause, G. (2014a), 'Smart specialization and EU eastern innovation cooperation: a conceptual approach,' *Baltic Journal of European Studies*, vol. 4, no. 1, pp. 3−19. https://doi.org/10.2478/bjes-2014-0001

—— (2014b), 'Sustainable development of logistics clusters in green transport corridors,' *Journal of Security and Sustainability Issues*, vol. 4, no. 1, pp. 59−68. https://doi.org/10.9770/jssi.2014.4.1(5)

Prause, G. & Hunke, K. (2014), 'Sustainable entrepreneurship along green corridors,' *Journal of Entrepreneurship and Sustainability Issues*, vol. 1, no. 3, pp. 124−133. https://doi.org/10.9770/jssi.2014.1.3(1)

Reynolds, L. (1981), 'Foundations of an institutional theory of regulation,' *Journal of Economic Issues*, vol. 15, no. 3, pp. 641–656. https://doi.org/10.1080/00213624.1981.11503881

SHEBA (2014), *Sustainable Shipping and Environment of the Baltic Sea Region*. Retrieved from http://www.bonusprojects.org/bonusprojects/the_projects/sustainable_ecosystem_projects/sheba [accessed 30 Jun 16]

Stipa, T. (2013), 'Clean shipping current,' in K. Breitzmann & M. Hytti (eds.) *Pan-Baltic Manual of Best Practices on Clean Shipping and Port Operations*, Turku: UBC Environment and Sustainable Development Secretariat.

Tolbert, P. S. & Zucker, L. G. (1983), 'Institutional sources of change in the formal structure of organizations: The diffusion of civil service reform, 1880–1935,' *Administrative Science Quarterly*, pp. 22–39. https://doi.org/10.2307/2392383

Wiśnicki, B.; Czermański, E.; Droździecki, S.; Matczak, M. & Spangenberg, E. (2014), *Sulphur Regulation–technology solutions and economic consequences for the Baltic Sea Region shipping market*, Gdansk: Institute of Maritime Transport and Seaborne Trade, University of Gdańsk.

Zucker, L. G. (1987), 'Institutional theories of organization,' *Annual Review of Sociology*, vol. 13, no. 1, pp. 443–464. https://doi.org/10.1146/annurev.so.13.080187.002303

Publication 4

Olaniyi, E. O.; Gerber, P.; Prause, G. (2018). Strategic Energy Partnership in Shipping. In: Kabashkin I., Yatskiv I., Prentkovskis O. (eds) *Reliability and Statistics in Transportation and Communication*. Lecture Notes in Networks and Systems, Vol 36. pp 102-111. Springer, Cham.

(ETIS Classification 3.1)

Strategic Energy Partnership in Shipping

Eunice O. Olaniyi[1(✉)], Patrick Gerber[2], and Gunnar Prause[1]

[1] Tallinn School of Business and Governance,
Tallinn University of Technology University, Tallinn, Estonia
{eunice.olaniyi,gunnar.prause}@ttu.ee
[2] EP Consulting OÜ, Jaama 12-4 11621, Tallinn, Estonia
info@epconsulting.ee

Abstract. The International Maritime Organisation (IMO) is employing a global clean shipping approach to reduce shipping emissions and to improve the Maritime's carbon footprint. One of the measures was the establishment of Sulphur Emission Control Area (SECA) in special parts of the world including Baltic Sea Region (BSR). Since 2015, ships are allowed only to use fuel with a maximal Sulphur content of 0.1% forcing ship owners to use special bunker fuel like LNG or to invest in expensive abatement technologies like the scrubbers. These are more expensive than the usual heavy fuel oil (HFO). Predictions are that oil prices may increase in which case ship-owners who have started using the LNG or the scrubber's technologies will enjoy a competitive advantage over others due to the higher margins that can further increase with additional investments into energy efficiency.

In the context of SECA, this paper tackles the research objective of how strategic energy partnerships can be adapted by the maritime sector. The research focused on the adaptation of the scrubber technology for the Maritime Energy Contracting model (MEC) using the Energy Service Contracting concept. Since the authors currently participate in the EnviSuM project, which assesses the technical efficiency and the socio-economic impact of clean shipping solutions of the SECA regulations in BSR, the research was empirically validated by expert interviews, survey results and case studies.

Results illustrated how the MEC model can be a market mechanism for the delivery of emission reduction in the maritime sector.

Keywords: Business model · Emission reduction · EnviSuM project
SECA regulation · Maritime Energy Contract

1 Introduction

The perception of maritime transport is generally seen as one of the most environmentally friendly especially when measured by weight. The conclusion is based on the premise that ships move large volumes of goods, making its emissions low when distributed per unit weight. Although much of the pollution emitted by international shipping is deposited over the sea, it is the largest single source of acidifying and atrophying fallout on land in many countries in Europe [12]. Emissions from shipping in the form

I. Kabashkin et al. (eds.), *Reliability and Statistics in Transportation and Communication*, Lecture Notes in Networks and Systems 36,
https://doi.org/10.1007/978-3-319-74454-4_10

of sulphur oxides, SOx, nitrogen oxides, NOx, carbon dioxide, COx and particulate matter (PM) are significantly detrimental to the environment [2]. Furthermore, these emissions can travel long distances and Sulphur dioxide emissions especially cause acid rain and generate fine dust known as particulate matter, which is dangerous for human health as they cause respiratory and cardiovascular diseases and reduce life expectancy up to two years [11]. This is why IMO engaged a global clean shipping approach to improve the Maritime's carbon footprint, emissions of Sulphur Oxides (SOx) and particulate matter from ships by technical and operational reduction measures. One of the measures to achieve these objectives was the establishment of Sulphur Emission Control Area (SECA) in special parts of the world including Baltic Sea Region (BSR). Since 2015, ships in the BSR are only allowed to use fuel with a maximal sulphur content of 0.1% (1,000 parts per million – ppm. In addition, in 2016, the global SOx for bunker fuel was reduced to 0.5% (5,000 ppm) from 2020 [9]. This ensures that all ships globally must pay attention to the sulphur content of the fuel they use.

It has been two years of 0.1% sulphur emission regulation in selected parts of the Sulphur Emission Control Area (SECA), most speculations on the negative effect of the regulation have been wrong due to the fuel price crash and low freight rates [14]. Reliance and demand for abatement technologies such as the scrubber technology have decreased drastically because of the low costs of bunkering. Ship owners are not willing to make the risk of the investments associated with the scrubber technology. With the 2020 sulphur global, cap in view, traditional fuel companies might no longer be able to cope with the decreasing demand for HFO because their major product will no longer be marketable. Due to sulphur emission directives, maritime stakeholders have been forced to look for innovative ways of adhering to the stipulation of emission reductions from ships [21]. They are faced with 2 types of challenges that are long and short-term solutions. The long term effect is borne on strategic solutions that carry along every aspect of the shipping industry while the short term only requires meeting the SECA regulations at the stipulated time of January 2015 and 2020. There is the need for a new-market based model implementation for energy efficiency and supply especially one that is also suitable for the ship emission directive.

Already in previous work [15, 17], authors proposed activities for sulphur emissions regulation compliance that are both conventional and traditional. They suggested that companies need to use the strategic fit between their internal characteristics (strengths and weaknesses) and their external environment (opportunities and threats).

This study proposes a business model consideration for high Sulphur bunker oil producers using an Energy Saving Contract (ESC) model commonly practised by the energy saving company (ESCO) for adaptation into the maritime sector – mostly the shipping companies and medium sized fuel company using the scrubber technology. With the high uncertainties attached to the fuel prices, high edged strategies must be about great insight, experimental and evolutionary undertaking as much as the traditional skills of planning and uncompromising performance. The new model pools two goals: to ensure the compliance of the Sulphur emission directive and to lower the transaction costs that emanate from the compliance measure. The core objectives of this work are summarised as follows: To adapt the Energy Service Contract model into a suitable model for maritime industry and to demonstrate its implementation. The questions the author seek to answer are what are features of the ESC that can be modified into the maritime sector? What are the constructs to be considered in the contract? All empiric activities were executed in the frame of the “EnviSuM” project in 2016. This article is arranged in the following way: the next talks about business models, its importance and how it is the ECS can be adapted into the marine time sector. The next section discusses the MEC contract and its intricacies while the last section gives the conclusion.

2 Literature Review

2.1 Emission Abatement Technologies

The introduction of 0.1% Sulphur content regulation in SECA in 2015 requires that ship owners consider the use of bunker oil also called HFO (heavy fuel oil). To achieve the desired level of Sulphur emission, low Sulphur distillate oils such as MGO (marine gas oil) or MDO (Marine Diesel Oil) which are cleaner and more expensive with a Sulphur content of 0.1% have become the popular option [14]. Another effective way to fulfil the SECA regulation is the use of alternative source of fuel such as the Liquefied Natural Gas (LNG), methanol, and other biofuels that ensures that the ship emits very little waste after of combustion. The LNG is mostly accepted as a promising energy source for shipping because LNG ensure the compliance of the anticipated NOx emissions regulation. However, even though it is less costly when compared to distillates and HFO, the costs of distributing it to ports and ships is very high and also depends on the distance of the port from the LNG import terminals [2].

In their efforts to reduce compliance costs, the European Commission has also given support for the promotion of new technologies [9]. An example is the scrubber technology, an abatement method that maintains the Sulphur level in the exhaust fume from the ship [21] so that the ship owner is able to use the HFO and still be SECA complaint. The scrubbers are said to reduce the SO2 emission by at least 99% alongside with the PM emission. There are two major types of scrubber technology - the dry scrubber and the wet scrubber. The wet scrubber is further classified as the open loop, the closed loop and the hybrid scrubber.

The cost of scrubber installation on ships varies depending on technology and the state of the ship and ranges from 2 to 4 million € for a ship [2]. To install the scrubber on a ship there is a need for the additional stabilising fortifications because of its weight and because it has to be kept in an elevated position, all of which are additional costs [11]. Another cost related to the scrubber installation is the opportunity cost of off hiring days (4–8 weeks) during which the ship owner loses revenue. In addition, operating the scrubbers increases the rate the engine consumes fuel and is estimated to increase to about 3% or more [7]. It is more expensive to install the scrubber system on an old vessel rather than on a new vessel, and the closed system scrubber is more expensive than the open system scrubber [21]. All these factors pose a great challenge and discouragement to ship owners when considering the use of scrubber as an abatement solution for sulphur emissions.

The scrubber has a lifespan of 15 years and a payback period of 3–5 years [1]. Ross, et al. explained that the payback period of an investment determines the time required to regain the capital expended for such investment [18]. The payback period is calculated by summing up the discounted cash inflows of a number of periods in order to get the net present value (NPV) of the investment. The minimum number of periods necessary to reach an NPV greater than zero is called the payback time. If the payback period of an asset is greater than its lifespan, it means the increased purchase price will not be regained.

The calculation of the spread between the MGO and the HFO is another important factor that is used to evaluate a scrubber investment. The MGO usually has a higher price value when compared to the HFO and the difference between them is referred to as the spread value [12]. The higher the cost of the MGO the higher the spread and the higher the ship owner savings will be if HFO is used [13]. The decrease in HFO demand could also mean a drastic increase of the spread in 2020 due to reduced HFO price as speculated by [1].

2.2 Energy Service Contracting

According to Chesbrough, technology by itself has no single objective value, the economic value of a technology will remain dormant until it is commercialised in some way through a business model [6]. In some instances, companies need to use business model to expand their perspectives in order to capture value from a new technology.

This work uses the common energy contracting models popular for the energy efficiency and supply. Energy Contracting (also called ESCO) is defined as an inclusive energy service model that is used to achieve energy efficiency in a bid to optimised cycle cost [5]. The popular basic ESCO business model either provide the needed energy – Energy Supply Contracting (ESC) or ensures energy savings – Energy Performance Contracting (EPC) to the end users [20]. The ESCO takes on the responsibility of the overall delivery of the needed energy from planning, installations, distribution, operations and maintenance as well as buying of needed fuel [3].

The authors will be relating to the Energy supply contracting which focuses on energy supply. A standard ESC is measured towards supply to reduce costs of operation [5]. ESC delivers energy solutions to the need of a customer who is not interest or not knowledgeable on the technical solutions especially when it comes to maintenance. Thus, energy is provided at a reduced price [3]. Usually, the initial capital investment is free for the customers and contract period of 10–20% energy savings can run up to 10 to 15 years. Financing an ESC is a matching process that is customised for individual customers to fit their needs. Fees and other elements are tailored or adjusted for occasions such as increased risks or length of contract [8]. When the initial installation is huge or has a larger scale of risk then the customer might be asked to make an upfront investment although when this happens, such upfront costs are limited to secondary items such as parts and usually referred to as “in-house” elements [3].

3 Method

As described by Siggelkow, a case study provides a grounded real-life scenario for the audience persuasion [19]. This work is a case study that highlights how the energy contract can be adapted to the maritime business activity. With many energy servicing companies in the market, the approach to this concept started with a literature review to understand energy contracting and its success factors. For this research, interviews with ESCO practitioners with building retrofit experience were made to identify salient factors to contract and to probe their opinions on the execution of the MEC projects/contracts. The interviews were recorded and transcribed. Holistic coding was used and was based on theoretical constructions to arrange the data. In vivo coding was used to better understand the things "through the eyes of the ESC practitioners" and process coding to describe and explore the actions [10]. Osterwalder's nine-point decomposition of a business model [16] was used to change the fuel company's traditional business and to the new MEC business model.

4 Results

4.1 Maritime Energy Contracting Case

Producing SECA complaint fuels require high investments, so also is the investment costs for abatement technologies. Current figures indicate a decrease in scrubber installations due to low bunkering prices and low freight rates. Most ship owners do not have the financial means to embark on such huge investments nor are willing to take on the associated risks, they would rather buy the low sulphur fuel even though its price is significantly higher than the HFO commonly used for marine bunkering. If this trend continues, some traditional fuel companies will not be able to cope with the decreasing demand for HFO because their major product will no longer be competitive in the market. In order to diminish this additional business risk, the implementation of a new business model is required for high Sulphur bunker oil producers.

A radical and promising new business model for maritime fuel producers is a change from being just fuel producers towards becoming an energy service company. In this regard, the Energy Supply Contract (ESC) concept is transferred to the maritime sector to create what the authors referred to as Maritime Energy Contracting (MEC). The contextual idea is to supply the HFO to contracted ships, pre-finance the project, and run the scrubber installation in order to protect the SECA compliance. The major motivation is to lower the transaction (compliance) costs from SECA regulation compliance of both shipping company and the fuel company. The new business model of the fuel company will become "energy solutions" using the scrubber installations on ships. The fuel company implements the energy service package at its own expenses according to the project specific requirements set by the customer. For its own profit, it will receive payment for the energy (fuel) delivered, depending on the actual consumption of the ship together with the flat rate costs for service & maintenance as well as the quality assurance. The cost savings of the construction will be shared between the fuel producer and the ship owner in the course of the contract lifetime. MEC guarantees energy costs savings so that the payback from the cost savings from the supplied energy throughout the contract period will cover the investment costs and the cost of risks made by the fuel producing company.

The components for the implementation of maritime energy package outcome will be as follows: Detailed planning (Project development, rough planning, agreement, contract, Scrubber installation and start up pre-financing, operation and maintenance, troubleshooting, optimisation and user motivation. Other activities are fuel supply, scrubber monitoring and controlling, quality assurance and other benefit through outsourcing of function i.e. price guaranty and outsourcing of commercial and technical risks.

4.2 Contract, Pricing and Contract Conditions

The typical duration of energy service contract for buildings is 10 years because stationary objects like buildings do not need shorter agreements and are similar to district heat contract durations. In case of ships, this situation changes drastically, as ships are mobile assets and are easily moved around the world to other jurisdictional areas. It is therefore recommended to have periods of 3 to maximum 5 years contract with each contract customer based and adjusted periodically. Using the Energy Supply Contracting as a prototype, the Marine Energy Contracting will consist of two price components. The needed energy (fuel) supply part and the asset financing including the additional services for the agreed service time. Both components are related to formulas where the influencing factors were considered and have adjusted prices consequently. The formulas are typically updated every month. Thus, using a typical ESC [4] and from conducted interviews, the following contract calculations and assumptions are made for MEC:

Energy Supply Calculated as:

$$\mathrm{AP_{HFO}}\,[€/\mathrm{mt}] = \mathrm{AP_{0HFO}}\,[€/\mathrm{mt}] + \mathrm{FS}\,[€/\mathrm{mt}] - \mathrm{FS_0}\,[€/\mathrm{mt}], \tag{1}$$

where: $\mathrm{AP_{HFO}}$ – Working price during contract time per metric tonne of fuel (€/mt); $\mathrm{AP_{0\_HFO}}$ – Baseline price according to official statistics in the certain period €/mt; FS – Price for fuel supply per metric tonne €/mt; $\mathrm{FS_0}$ – Fuel supply baseline in a particular period (i.e. 01-06/2017) €/mt.

Non-Energy (Assets) Calculated as:

$$\mathrm{LP}\,[€/a] = \mathrm{LP_0}\,[€/a] \times (0.5 + 0.3 + \frac{I}{I_0} + 0.2 \times \frac{L}{L_0}), \tag{2}$$

where: LP – New price during contract time per annum [€/a]; $\mathrm{LP_0}$ – Base price according to official statistics in certain [€/a]; I_0: – Current price index for consumer goods taken as the baseline (i.e. the consumer index of common goods of the year 2015 is set as 100); I – Current price index for consumer goods comparable to the I_0 (e.g., September

2017 = 103); L – Average salary index at a certain time during the contract time; L_0 – Average salary index for setting as starting point for the contract.

This equation takes in the original costs for the non-energy related part plus inflation legalisation (e.g. higher material costs) and changes in the personnel salary. In the proposed formula, 50% of the yearly price is fixed, whereas 30% are depending on the development of general inflation (consumer good index) with 20% depending on the development of salary costs, which have a strong influence on the provided services (maintenance, monitoring) during the contract time.

Contract Terms and Conditions

I. Owner of the scrubber asset during the contractual period is the fuel company.

II. Definitions:

- Maritime Energy Contracting Price: offered comprehensive competitive technical solutions and prices regarding the functional description of the energy services. It includes the fuel price, scrubber costs and adjustment costs.
- Scrubber costs: the capital cost of the scrubber installation spread into an amortisation over the years.
- Energy price: covering the consumption of HFO at current price level. This includes consumption related only to marginal costs defined exclusively in the service contract. It will also include the risk of price surge or decline.
- Adjustments: An additional margin for running the scrubber comprising of all operational costs for the scrubber usage such as administration, maintenance, personnel, insurance and management together with entrepreneurial risk, including a profit margin. *Adjustments open a negotiation space with the contractual customer.

III. The interests' rate is determined by the market (best available offer) and will stay stable over the contractual period to avoid sudden changes within the agreement.

IV. The contractual fuel company will supply a list of "partner network" where the ship owner can bunker fuel on events where ship is not within the jurisdictions of contractual fuel company. The contractual fuel company will work out rebates or compensation with affiliated partner company.

V. In the event where energy (fuel) is gotten from another supplier other than the partner network. To protect the purpose of selling own HFO, the amounts, which had been taken out of the "partner network", have to be compensated by the ship owner. The ship owner will give access to the bunkering book or float sensor for bunker measurements to confirm compliance or deviation.

VI. The non-energy related part remains stable over the contractual period, except in the event of the aforementioned influencing factors.

VII. At the end of the contractual time, directions on continuance have these option:

- The scrubber asset is taken into the ship owner's asset list.
- A new tender is organised for the operation of the scrubber, including all services like maintenance, monitoring, optimisation, etc. and handing the ownership of the asset over to the new partner.

VIII. In the case of sudden end of contract, the following procedure will come into effect: For the starting point of the contract, the financial value of the scrubber asset (scrubber plus installation) is defined and in case of a sudden end of the contract, the shipping company will pay a financial compensation. The amount of compensation is calculated by the linear depreciation over the full contract time. Example: If for a total contracted period of 36 months, the defined value of the scrubber asset is 3.6 M €. If the ship owner after 16 months decides to end the contract and to take over the scrubbers themselves, the ship owner will pay a compensation as follows: 36 months full contract time minus 16 months of contract, which equals a remaining 20 months. For each month, the compensation is 100.000 €. Therefore, for a 20 month deviation period the sum 2.000.000 € will be paid as compensation.

IX. Other issues arising.

- Border of property: It is very important to define the borders of property, as this will have a significant impact on the responsibility. The Scrubber and connected parts will be in the responsibility of the fuel company (for the contracted period) but all other components like engines, etc. will remain in the responsibility of the ship owner.
- Space for scrubber and retrofit is given free of charge: The extra space for the scrubber and the time for the retrofit have to be free of charge to remove the complexity involved in the calculation of the non-energy related part.
- Quality of supply: The quality of the Scrubber efficiency (percentage of SOx reduction) will be defined, monitored and guaranteed.
- Additional energy consumption is business of the ship owner: The additional energy consumption with the scrubber will be added to the total costs of the scrubber in the contract calculations.

The MEC model can be described as a focal concept for strategy that creates unprecedented opportunities in the maritime sector because it is actionable and offers feasible fresh way to innovation in an uncertain, fast-moving and unpredictable environment such as the maritime sector.

The cooperative structure will ensure the following:

Environmental benefits (SOx emissions reduction). (2) Money savings on initial investment costs (scrubber installation), utility costs and maintenance cost that is taken up by the fuel company i.e. reduction in investment risks, technical risks, market risks, and performance risks, leaving only “zero risks” to the ship owner. (3) Jobs and career creation. (4) Reduced operational costs through using the much cheaper HFO, thus, the shipping company can concentrate on its core function, which is transportation, and do away with the hassle of energy efficiency through the MEC third party contracting. (5) Free technology and expertise support for the ship owner. (6) A scalable investment for the fuel company. (7) Promises to have a higher margin for the fuel production company compared to the traditional HFO supply approach. (8) Customer fitted model i.e. customised contracts with the ship owners.

So far, even though the BSR has witnessed commendable compliance activities, the success level is far from satisfactory, especially as it relates to the heavy and risky investments the maritime stakeholders are subjected to. Another challenge is the uncertainties that surround the use of the each compliance method. Unfortunately, the reduced fuel prices have made many investments meaningless and wasteful. With the upcoming 2020 global restrictions, the energy consumption will increase as the demand level for the low fuel oil. The maritime industry may yet experience another game changer, which might force an increment in the price of the fuel. However, beyond that, there might be a shortage in the low sulphur fuel supply.

5 Conclusion

The authors put forward the MEC model as a market mechanism for the delivery of emission reduction in the maritime sector by using the scrubber technology to cushion the economic effect of the SECA regulations and illustrated modified features of the ESC model and construct to be considered in the Maritime Energy Contract model. Unlike the usual conventional strategies, business model concepts accentuate analysis and strategies embedded in experimentation as projected by the authors. With appropriate state enabling policies, the energy contracting model – a proven and resilient structure can boost the maritime industry by shifting the focus of the scrubber technology towards selling “energy solutions”, and jump-start a viable private-sector that targets the maritime stakeholders. In this light, the scrubber technology can provide a much-needed technology-push-effect for the European technology. The main disruptive advantages are based on the shift from CAPEX to OPEX (no direct investment for ship owners is needed) and the establishment of new services, with additional value in the maritime sector.

The work is limited to the use of only HFO/MGO and not to other sources of fuel like the LNG. The LNG approach can be an interesting angle for further research. Also, due to the scope of this work, the authors were unable to show other contracts that will involve the “partnering network” such as the scrubber manufacturer, other fuel company, maintenance and/or a financing house. This can also be a consideration for future research.

References

1. Atari, S., Prause, G.: Risk assessment of emission abatement technologies for clean shipping. In: 17th International Multi-Conference ‘‘Reliability and Statistics in Transportation and Communication’’ Riga (2017, forthcoming)
2. Bergqvist, R., Turesson, M., Weddmark, A.: Sulphur emission control areas and transport strategies – The case of Sweden and the forest industry. Eur. Transp. Res. Rev. **7**(2) (2015)
3. Bertoldi, P., Rezessy, S., Vine, E.: Energy service companies in European countries: current status and a strategy to foster their development. Energy Policy **34**(14), 1818–1832 (2006)
4. BFEE Homepage on Energy Contracting. http://bfeeonline.de/bfee/informationsangebote/publikationen/sonstige_publikationen/vfw_mustervertrag_waermelieferung_2012.pdf. Accessed 10 May 2017
5. Bleyl, J.W.: Conservation First! The New Integrated Energy-Contracting Model to Combine Energy Efficiency and Renewable Supply in Large Buildings and Industry. ECEEE summer Studies, Paper ID, 485 (2011)

6. Chesbrough, H.: Business model innovation: opportunities and barriers. Long Range Plann. **43**(2), 354–363 (2011)
7. EMSA Homepage: European Maritime safety Agency Annual 2010 Report. http://www.emsa.europa.eu/emsa-documents/download/1421/143/23.html. Accessed 10 May 2016
8. Goldman, C.A., Hopper, N.C., Osborn, J.G.: Review of US ESCO industry market trends: an empirical analysis of project data. Energy policy **33**(3), 387–405 (2005)
9. IMO Home page: IMO sets 2020 date for ships to comply with low sulphur fuel oil requirement. Press briefing release 28/10/2016. http://www.imo.org/en/MediaCentre/PressBriefings/Pages/MEPC-70-2020sulphur.aspx. Accessed 30 Nov 2016
10. Miles, M.B., Huberman, A.M., Saldana, J.: Qualitative data analysis: A sourcebook. Beverly Hills, Thousand Oaks (1984)
11. Notteboom, T.: The impact of low sulphur fuel requirements in shipping on the competitiveness of roro shipping in Northern Europe. WMU J. Marit. Aff. **10**(1), 63–95 (2010)
12. Nugraha, F.: Effective implementation of emission control area towards cleaner shipping operations: focusing on sulphur oxides (SOx) emission reduction. World Maritime University Dissertations (2009)
13. OECD/ITF Home page on Reducing Sulphur Emissions from Ships: The Impact of International Regulation. http://www.itf-oecd.org/reducing-sulphur-emissions-ships-impact-international-regulation. Accessed 10 June 2016
14. Olaniyi, E., Prause, G., Boyesen, J.: Economic impact of SECA regulations on clean shipping in the BSR- first empiric results from EnviSuM project. In: 2017 International Conference on Maritime Energy Management Proceedings. World Maritime University, Malmo, Sweden (2017)
15. Olaniyi, E.O., Viirmäe, M.: The economic impact of environmental regulations on a maritime fuel production company. Res. Econ. Bus. Central Eastern Europe **8**(2), 58–84 (2016)
16. Osterwalder, A.: The Business Model Ontology-a proposition in a design science approach. University of Lausanne (Doctoral Thesis) (2004)
17. Prause, G., Olaniyi, E.O.: The impact of environmental regulations on the regional development in Eastern Estonia. In: Muravska, T. (ed.) New Challenges of Economic and Business Development Conference, Riga, 2017, Riga. Latvian State University (2017)
18. Ross, S.A., Westerfield, R., Jaffe, J.F., Roberts, G.S.: Corporate Finance, vol. 7. McGraw-Hill/Irwin, New York (2002)
19. Siggelkow, N.: Persuasion with case studies. Acad. Manag. J. **50**(1), 20–24 (2007)
20. Sorrell, S.: The economics of energy service contracts. Energy Policy **35**(1), 507–521 (2007)
21. Wiśnicki, B., Czermański, E., Droździecki, S., Matczak, M., Spangenberg, E.: Sulphur Regulation–technology solutions and economic consequences for the BSR. Shipping market Institute of Maritime Transport and Seaborne Trade, University of Gdansk (2004)

Publication 5

Olaniyi, E. O.; Atari, S. & Prause, G. (2018). Maritime Energy Contracting for clean shipping, *Transport and Telecommunication Journal*, Volume 19, Issue 1, Pages 31–44, ISSN (Online) 1407-6179, DOI: https://doi.org/10.2478/ttj-2018-0004.
(ETIS Classification 1.1)

Transport and Telecommunication, 2018, volume 19, no. 1, 31–44
Transport and Telecommunication Institute, Lomonosova 1, Riga, LV-1019, Latvia
DOI 10.2478/ttj-2018-0004

MARITIME ENERGY CONTRACTING FOR CLEAN SHIPPING

***Eunice O. Olaniyi*[1]*, Sina Atari*[2]*, Gunnar Prause*[3]**

[1, 2, 3] *Tallinn School of Business & Governance, Tallinn University of Technology University*
Tallinn, Estonia, Akadeemia tee 5 19086
[1] *eunice.olaniyi@ttu.ee,* [2] *sina.atari@ttu.ee,* [3] *gunnar.prause@ttu.ee*

To reduce the Sulphur emission from shipping and ensure clean shipping, a number of Sulphur Emission Control Areas (SECA) were enforced in special areas around the globe. From 2015, in SECA, ship owners are not allowed to use fuel with more than 0.1% Sulphur content. One of the major concerns for the SECA regulation is that maritime stakeholders have had to take into consideration the costs as well as the tolerable risks of their compliance investment options. Besides that, low freight rates have increased the competition and had caused financial pressure on ship owners so that lower capital reserves and low credibility levels limit the manoeuvring space for investment activities.

The indications from BSR after 2015 showed that the low fuel price has eased the economic effects of the SECA regulation and as a result, most ship owners have delayed their investment decisions. Even though the postponement of emission abatement techniques seems to have reduced the compliance expenses for SECA, they, however, did not improve the position of shipowners relative to their competitors. Consequently, new policy instruments to stimulate innovation, to raise competitiveness and to comply with the new environmental regulations are needed. It would have been easier to hedge fuel price volatility and offer maritime logistics services for a lower price, but to be able to ensure sustainable results in long-term, maritime stakeholders must be ready to device astute strategies that can propel them to unparalleled advantage.

This research first appraised the investment risks and payback period associated with the scrubber using different capital budgeting methods. It further illustrated the Maritime Energy Contracting (MEC) model as a market mechanism for the delivery of a cost-effective emission reduction using the scrubber technology as well as an instrument to realise a competitive advantage for ship operators. The results are empirically validated by case studies from BSR.

Keywords: Investment appraisal, VaR, Scrubber, SECA, Energy Contracting, Business model

1. Introduction

The motivation for environmental regulations is mostly related to improving health and quality of life (Lindstad *et al*., 2015). Shipping activities are responsible for up to 15% of the world's anthropogenic pollution of sulphur oxides (SOx), nitrogen oxide (NOx) emissions and some other harmful elements. These emissions are dangerous to human health and can travel long distances (Abadie *et al*., 2017). SOx emissions specifically cause acid rain and generate particulate matter (PM), which is the root-cause of respiratory and cardiovascular diseases (Notteboom, 2010). This why maritime transportation showing efforts to reduce the impact of health-damaging emissions and ensure cost efficiency in the activities that can curtail it (Lindstad and Eskeland, 2016). Stricter emissions and bunkering fuel requirement regulations by IMO on sulphur emissions was enacted in the MARPOL, Annex 2 where Sulphur emissions from ships are not allowed beyond 0.1% since 2015 (IMO, 2016). SECA regions are about 0.3% of the world's water surface and consist of the North Sea, the English Channel (plus the coastal waters around USA and Canada) and the Baltic Sea region (BSR) (Notteboom, 2010). The sulphur restrictions on another dimension involve a global standard that currently allows 3.5% sulphur content from fuel and ship emissions outside SECA and has stipulated that from 2020, only 0.5% of sulphur emissions will be allowed on all water surfaces worldwide (IMO, 2016). Other sulphur related regulations are the Chinese regulation for coastal waters (published in December 2015 and came into effect in 2016) (North, 2016) and the EU directive 2005/33/EC.

The first two years of the SECA regulation have shown that predictions on the negative implications of the regulation are wrong and the low fuel cost and freight rates have played a huge role in ensuring this (Olaniyi, 2017). Consequently, dependence and pursuit of abatement technologies have declined. Nevertheless, the incoming 2020 global sulphur cap seems to have escalated the urgency of solutions for compliance and clean shipping globally. Stakeholders are now frantic about the options available and economic optimisation of their decisions (Atari and Prause, 2018), although there are speculations that, pushing the 2020 regulation to 2025 will save the maritime industry between $30 billion and $50 billion annually (Platts, 2016). There are also studies that insisted that applying a costly global approach to coastal emission areas might bring more negative result than positive especially in terms of fuel efficiency and increasing CO2 emissions concerns (Lindstad *et al*., 2015). Their argument is that a continual use of HFO at high sea will ensure the cooling effect of global shipping in a 20 years' perspective and further ensure the 100-year CO2 equivalent emissions at 35–40% of CO2 emissions, which can reduce the speculated annual cost of sulphur regulation from 10 billion to 4–5 billion USD. Even at this, the truth is that the sulphur regulations have come to stay and the global limit take-off may not be reviewed forward (Abadie *et al*., 2017). Maritime stakeholders must now look for innovative ways of obeying the sulphur regulations in the face of possible excess fuel demand that cannot be met by the industry (Wiśnicki *et al*., 2014) and at the same time ensure reduction of their compliance costs.

Olaniyi and Viirmae (2016) explained that the compliance costs for SECA regulation are expensive and have the possibility of interfering with the production, turnover and profits of the companies involved. With the high unpredictability nature of fuel prices, compliance strategies must involve experimental and revolutionary ingenuity on the part of the stakeholders. In this regard, this study pools two objectives, first, it presented a case study of the Maritime Energy Contract (MEC) business model, a market mechanism for the delivery of emission reduction the scrubber technology that cushions the economic effect of the SECA regulations. Second, because the scrubber technology is an integral element in the MEC model, the study calculated the investment risks and payback period involved in the scrubber technology to validate the scrubber investments and to fill the investments risk appraisal gap for ship owners.

Both quantitative and qualitative data approaches were used to collect data from April 2016 to May 2017 in the frame of “EnviSuM” - Environmental Impact of Low Emission Shipping: Measurements and Modelling Strategies project. Through the study of different cases, the authors seek to answer these research questions. What are the risks involved in scrubber retrofit? How profitable is the scrubber investment for the ship owners? What are the cost and the benefits of the MEC model for the ship owners? Results show that the estimated payback period of the scrubber installation on the ship is short because the use of bunker fuel together with a corresponding abatement solution such as the scrubber will positively influence the payback period as well as reduce the risks involved. The MEC model is a stimulus that can be used for value creation and the realisation of competitive advantage in the maritime industry for a new entrepreneurial process.

Work is arranged in the following way: the next section is the literature review on maritime and SECA Compliance, the Value-at-Risk (VaR) in Investment Appraisal and Energy Service Contracting (ESC). The third section presents the method of data gathering and analysis of results. The next section highlighted the results and the last section is the conclusion.

2. Literature Review

2.1. Maritime and SECA Compliance

There are different approaches to satisfy the SECA requirement. The popular choices for ship owners are fuel switching from heavy fuel oil (HFO) to marine gasoline oil (MGO), the installation of LNG engine followed by the use of the LNG fuel and installation of the scrubber into the exhaust of the ship to remove the sulphur from the emission (Acciaro, 2014; Daduna and Prause, 2017). All these approaches have their pros and cons and different ship owners have built their SECA regulation compliance strategy around one or more of them. Most of their decisions are borne from the contemplation between the capital expenditures and the OPEX of the compliance investments (GU and Wallace, 2017). Mostly, the factors that influence the various compliance methods ship owners make include: (a) fuel prices (b) the area in which the ship usually operates and the regulation it is accountable to (c) the number of days at sea and (d) vessel’s lifespan (Abadie *et al*., 2017).

Fuel cost and ultimately fuel consumption is an integral part of shipping because it makes up to about 50 - 60% of voyage operational cost (Stopford, 2009). Now, the supply and demand of fuel appear to be balanced around the world, but regional surpluses and shortages are projected to occur towards and after 2020 (CE Delft, 2017). Another factor that affects the operational costs of a vessel as stated by Gu and Wallace (2017) is sailing pattern of a vessel e.g. routes, vessel speed and type of vessels. That was why at the onset of SECA, some ships have been replaced by bigger vessels to slow steam, also some routes were also increased or reduced (Olaniyi, 2017; Gu and Wallace, 2017).

Most compliant fuels are in fact blends of several refinery fractions. At the refinery, crude oil is refined to different fractions of oil that are used for bunkering such as Marine Gas Oil (MGO), Marine Diesel oil (MDO) and the Heavy Fuel Oil (HFO) (Brynolf *et al*., 2014). The MGO and MDO are distillates and more expensive but are SECA compliant. The HFO, on the other hand, is the lower fraction, a residual oil that was the preferred bunkering fuel until SECA (Acciaro, 2014). Even though through hydrodesulphurisation (partial hydrogenation of the fuel to remove sulphur), HFO can be refined to meet the new requirement, it is a very expensive refinery process and only the mega fuel producers are able to take such investment risk (CE Delft, 2017). The price of bunker fuel fluctuates as a response to supply and demand and are usually determined by factors like short-term expectations from forecasts, production estimation from the oil-producing countries, stock levels, seasonality, accidents, weather and sometimes war (Bergqvist *et al*., 2015; Hämäläinen *et al*., 2016).

Another option for SECA compliance is using Liquefied Natural Gas (LNG), to curtail the ship emissions during combustions. The LNG is widely accepted because it also fulfils other regulations such as the CO2 and the NOx and is the cheapest of the fuels (Bas *et al*., 2017). However, there are many challenges that prevent a faster development of the LNG fuel such as the availability of the infrastructure for its bunkering, the need to store the fuel and distribute at a particular temperature that requires special storage and costly retrofit and LNG-fuelled ships (Brynolf *et al*., 2014). All the issues increase the costs of distribution depending on the distance from ports to the LNG import terminals (Bas *et al*., 2017). Although reports are showing that the LNG infrastructure is developing fast worldwide, for example, according to CE Delft (2017) LNG projects are already increasing in North America and most part of Asia like China, South Korea, Japan, and Singapore. Yet, the LNG is not finding a wider use outside shipping. All these setbacks are said to be related to the regulatory framework, the economic capacity and sustainability, technical practicality and the public-social responsiveness (Bas *et al*., 2017; Notteboom, 2014).

A third option, scrubber technology, is an option that allows the use of the HFO by “scrubbing” out the sulphur emission from the exhaust of the ship up to 98% (Abadie *et al*., 2017). With an installed scrubber, the vessel can still run with HFO and remain SECA complaint. Costs of the scrubber installation depend on the ship size, engine size, and an additional cost of fuel for energy, chemicals and waste disposal (Lindstad *et al.*, 2015). The age of the ship is used to determine if an investment in scrubber retrofit is right or wrong (Abadie *et al*., 2017).

The scrubber technology has two major technologies, which is the dry (popular for industrial use), and the wet scrubber technologies (Wiśnicki, 2014). The wet scrubber has been developed into the open loop, (uses only seawater), closed loop (uses the reaction of caustic soda and fresh water) and hybrid (combined both the opened and the closed technology) (Abadie *et al.*, 2017). The open loop has been demonstrated to be cheaper and smaller making it more desirable because it takes less space for installation but has sparked several debates on the ecological implication of using a device that flushes chemical back into the sea. Running a closed loop scrubber is the most expensive because of the broad treatment of the closed loop circulating water (Lindstad *et al.*, 2015).

The actual costs of the scrubber i.e. its operating costs and maintenance costs depend largely on the ship’s size, engine capacity, broiler type and the scrubber technology itself (Bergqvist, *et al*., 2015, Jiang *et al*., 2014; Abadie *et al*., 2017) and ranges from 3 to 6 million € for a ship. Because of its weight, when installing the scrubber, extra fortifications are made to stabilize the ship and ensure the scrubber is in an upright position (Brynolf *et al.*, 2014). Apart from the space, the scrubber itself takes up, extra space is further needed for the accessories like the pumps, tanks, engines and a piping system for the wash water (Bergqvist *et al.*, 2015). It takes between 4-8 weeks for the installation process. Operating the scrubbers increases the fuel consumption rate of the engine at 1-5% (EMSA, 2010). These are some of the contributing factors that discourage ship owners from choosing the scrubber installation option.

According to Atari and Prause (2018), the scrubber lifespan is about 15 years and a payback period (called a breakeven point) of 2 to 5 years. The payback period calculation is one of the methods used to evaluate the worth of the scrubber investment to ensure the payback period is not greater than the scrubber's lifespan (Bergqvist, *et al.*, 2015). This calculation prevents a situation whereby it is impossible to recover the purchase cost after discounting the cash flow (Ross, *et al.*, 2002).

The price difference between MGO (which is a higher) and HFO is called the spread value and this spread is used to assess the economic efficiency of abatement technologies including scrubber investment (Jiang *et al.*, 2014). A higher spread encourages the scrubber installation on the ship. Thus, in the scrubber installation, the cost of the MGO is directly proportional to the ship owner’s savings (OECD/ITF, 2016). Olaniyi *et al.* (2018a, 2018b) projected a high reduction in HFO demand by 2020, along with increased demand for distillates fuels and other hybrid fuel like the ULSFO (Ultra-light Sulphur fuel oil). Another angle of this projection according to WoodMacKenzie (2016) is that the decrease in HFO demand from the 2020 cap could push an increase in the spread from 2020. These predictions are also supported by the International bunker fuel association 2018 report, which has more or less projected the scrubber forward as a more rewarding option from an investment angle.

Many studies have proposed different approaches to making the choice for compliance ranging from the multi-criteria approach (Ren and Lützen, 2015), stochastic programming (Schinas and Stefanakos, 2012), cost-benefit analysis (Jiang *et al*., 2014) and costs function of emission abatement alternatives (Lindstad *et al*., 2015). For the newly built ship, it is most common to make a comparison between the investment annuity and the anticipated fuel cost savings (CE Delft, 2017). While the popular methods, especially for retrofits, is the evaluation of the payback time, Patricksson and Erikstad (2017) put forward sets of reconfiguration possibilities for ship owners whose ships are already running on a low Sulphur fuel with no traffic outside of SECA. They insisted that when a ship is already using SECA compliant fuel and plies within SECA there is no need for an abatement technology installed on the ship. However, they did not do a comparative analysis of the fuel usage on yearly bases nor compare the costs to the abatement costs for such ships. All studies point to one fact, which is that there is still a need for a better way to determine the best choice for regulatory compliance.

2.2. Value-at-Risk (VaR) in Investment Appraisal

To explore the market orientation of the SECA regulation, the authors' estimated and appraised the investment risk associated with the scrubber technology. Aforementioned, investments in scrubber technology are expensive and highly risky for ship owners because the efficiency of a scrubber investment depends on the price spread between MGO and HFO. High price spreads yield short payback periods whereas decreasing price spreads increases payback time and are linked so to higher risks.

Classical instruments for financial investment are studies in the area of capital budgeting and the most important concept represents the Net Present Value (NPV) which can be calculated by using the parameters of the investment (Herbst, 1998):

$$\mathrm{NPV} = \sum_{t=1}^{n} \frac{CF_t}{(1+r)^t} - Outlay, \tag{1}$$

or CF_0 yields:

$$\mathrm{NPV} = \sum_{t=0}^{n} \frac{CF_t}{(1+r)^t}\ , \tag{2}$$

where:

CF_t: cash flow during period (t),
Outlay: investment expenditures at period zero,
n: the normal lifetime of n periods of a scrubber (usually 15 years),
r: the annual average interest rate of the investment.

The cash flow of period (t):

$$CF_t = V_t \cdot spread_t \cdot (100\% - e\%) - add\_cost, \tag{3}$$

where:

V_t: annual fuel consumption,
$spread_t$: HFO-MGO spread over a period (t),
e%: additional scrubber energy consumption,
add_cost_t: additional cost.

An investment is assumed to be favourable if the expected NPV is greater than 0. Based on the NPV approach, the determination of the payback period of an investment is possible by looking for the shortest period n* so that NPV (n*) > 0 (Hull and White, 1998). In both constructions, the NPV as well as the payback period revealed that the results of the investment appraisal depend on the price spread between MGO and HFO during the considered time so there is an associated risk with a scrubber investment, which has to be investigated more detailed.

An appropriate instrument for the control the risk of decisions and investments is through a value-at-risk (VaR) analysis where the VaR shows the capital or percentage of capital loss that should be expected over a particular period with a guaranteed probability or word confidence level (Angelidis and Skiadopoulos, 2008). It describes what loss a particular market volatility will encounter at a certain probability (Linsmeier and Pearson, 2000). Thus, it shows the likelihood and rate at which a loss might occur in any real investment. Using Dowd (2007), the investment in scrubber will be determined by the price spread between the HFO and MGO along with the spread distribution quantiles analysis from a historical figure. In other words, if the spread means is higher than 500 t€, then a 10% VaR of spread in a span of 2 years connotes a 0.1 probability that a scrubber investment of 5 000 000 €, for example, would increase to a higher value by 500,000 € for that 2 years. The NPV of Net fuel cost savings will determine all investment value associated with the scrubber. The study recognizes that the VaR of scrubber investments will help shipowners assess their investments risk level for example; the VaR will be comparable to the loss of the scrubber investment. This is at the 100s of X percentile level of the normal distribution (Jorion, 2006). In concept, it relates to how the stakeholders look for ways to ensure return on their investment and proportionate to the level of the risks involved (Baker and Haslem, 1974).

2.3. Energy Service Contracting

It is not possible to separate policy from the economic significance of compliance because policy framework determines the economic outcome of any industry (Sys *et al*., 2016) which makes the investment appraisal and associated risks imperative. As explained by Horbach *et al.* (2012), regulation is a part of the determinants and drivers of environmental innovation - regulatory push/pull effect. Usually it occurs not as the first introduction of a product cut but as a market or technology - diffusion as seen by the scrubber technology where manufacturing companies are adopting a technology used by chemical companies for the ship to expand their perspectives and capture value that would lead to a visible lessening of regulatory burdens (McGrath, 2010). The economic performance of such technology determines the sustainability of the regulation (Plouffe *et al*., 2011).

The production of SECA complaint fuels involves high risks and investments, the same goes for the costs for abatement technologies. Statistics indicate a decrease in scrubber installations due to low bunkering prices, and low freight rates (Olaniyi, 2017). It is clear that ship owners are unwilling to take a risk that ties down funds that they would otherwise prefer to run their ship. Apart from the unreliable fuel costs and supply, a continuation of this development will likely diminish the impact of a strong stimulus and determinant for innovation and technological push and further lead to the market failure of the scrubber technology (Horbach *et al*., 2012). Chesbrough (2010) explained that until the monetary value of a technology is available as a form of the commodity in any form, its usefulness would remain dormant.

Energy contracting models (EC) commonly used for energy efficiency and supply in the housing sector and stationary and complex buildings like hospitals (Sorrell, 2007). The adoption of energy contracting models in the maritime sector using the scrubber technology to optimise the scrubber technology is quite new and has been discussed by Olaniyi, Gerber and Prause (2018). This study is particularly positioned to submit a solution to the current negative reactions and criticism regarding the economic implication of the scrubber installation and operational costs among other implications such as the technology itself, ecological and environmental factors of using the technology (Lindstad *et al*., 2015; Abadie *et al*., 2017).

EC is a comprehensive energy service model commonly used to optimized energy cycle cost in the housing (Bleyl, 2011) mostly used in Germany, Austria, France, Netherlands, Belgium (Goldman *et al*., 2005). The common models of energy contract are the Energy Supply Contracting (ESC) that delivers basic needed energy and used in services that are short in capital investments and the Energy Performance Contracting (EPC) that ensures energy savings (Sorrell, 2007). Already some other sectors are adopting this model as seen in water treatment and supply, wastewater disposal, industrial gases supply, service management in telecommunications and security (Bleyl, 2011). Concentrating on the ESC for this study, the energy provider becomes responsible for both the installation of the technology as well as the delivery of the needed energy at a reduced price and the same time reduces the costs of operation for both the provider and the recipient company (Bertoldi *et al*., 2006). The ESC model is a customized process for singular customers where the total costs are determined by the associated risks or terms of the contract (Goldman *et al*., 2005).

3. Methodology

The study is established through empirical data from expert interviews, focus group meetings and case studies carried out in the frame of EnviSuM - Environmental Impact of Low Emission Shipping: Measurements and Modelling Strategies project sponsored by the EU regional development fund carried out between April 2016 and May 2017. Data were used to first evaluate the cost constructions of different abatement technologies including the scrubber technology. Through the data gathered, the tendencies and enthusiasms of the ship owners regarding scrubber investments were also determined. From the case studies involving the proposed model and investments calculations, constructs of real synopsis were projected for readers' conviction as described by Siggelkow (2007). Two case studies were presented.

The first case involved the statistical evaluation of historical fuel price data from 2013 and 2017 and fuel price predictions between 2017 and post 2020 to determine the distribution of the spread between HFO and MGO within these years. The analysis carried out, comprised correlation analysis, the empiric probability distribution of the spread value between HFO and MGO of the last four years and statistical test theory. The observed probability distribution of the spread was used as input data for a Value-at-Risk analysis for the scrubber investments. Each spread was associated with the NPV of a scrubber investment.

The second case described the intricacies involved in the adaptation of the energy contract into the maritime industry. Since there are already several energy servicing companies, a desktop research was first carried out to learn energy contracting and related success determinants. Five ESCO practitioners with retrofit experience of at least 10 years were interviewed. The interviews were made to pinpoint significant features of energy contract and to examine their deportment on the on a successful MEC project or contract. The interview analysis is presented as a description for a model contract based on thematic categorisation by Miles *et al.* (1984) and Kvale (2008). The analysis of the overall cost of the MEC model was then made using current real-life figures.

4. Results and Discussions

The application of VaR approach requires the determination of an underlying probability distribution. In the case of the scrubber installation, the risks depend on the price spread of the fuel so that a statistical evaluation of historical fuel price data from 2013 and 2017 and the spread between HFO and MGO within these years is done. Based on this analysis, the empiric probability distribution of the spread value between HFO and MGO of the last four years has been tested by statistical test theory.

4.1. Risks Analysis of Scrubber Investments

The historical time series from 2013 of the fuel prices of MGO and HFO in US$ reveals a high correlation with each other with a positive Pearson coefficient. The spread between MGO and HFO depicts a graph which is shown in Figure 1.

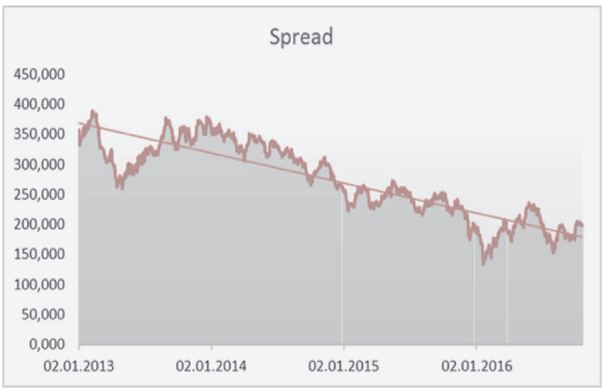


Figure 1. The spread of the HFO and MGO (USD) from 2013 (Computed by Authors)

The histogram of the spread values from 2013 based on 962 values led to an empiric distribution of the spread that has been analysed with the Kolmogorov–Smirnov test as well as with the Shapiro-Wilk test. The results proved that the spread between HFO and MGO is normally distributed with a mean of about 273.5 USD and a standard deviation of about 63.4 USD as shown in Figure 2.

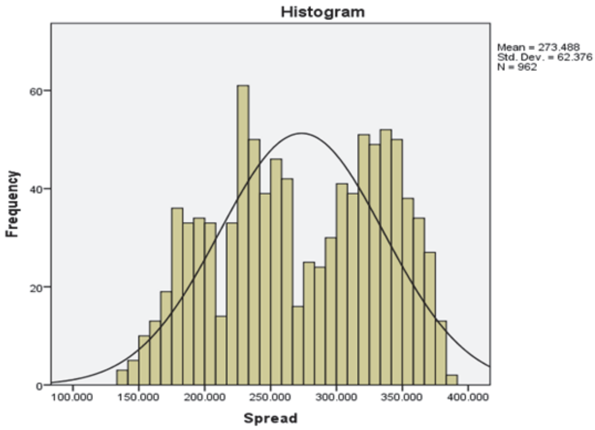


Figure 2. Distribution of HFO/MGO spread (USD) (Computed by Authors)

With the statistical results of the empirical data, it is now possible to conduct a VaR analysis for a scrubber installation on a ship. The property of the spread to be normal distributed allows calculating the quantile which can be used assess the risks of the spread during the investment period. The VaR with definite confidence level α is calculated as $Prob\ (x \leq -VaR\alpha) = 1 - \alpha$. If the distribution is bounded below by –L with probability density function (x) the model yields (Hendricks, 1997):

$$\int_{-L}^{-VaR\alpha} f(x)dx = 1 - \alpha. \qquad (4)$$

In order to make the following calculations compatible with Euro calculations the lower 10%, 5% and 1% quantiles of the underlying distribution of the spread are expressed in Euro and correspond to spread values of 155.4 €, 145.53 € and 127.26 €. The applications of these results are studied and empirically validated with the case of a RoPax ferry as follows:

The RoPax Ferry Case

The RoPax ferry enjoys an engine power of 48 MW and a maximal speed of 27 knots that plies Tallinn and Helsinki. From experts' interviews, it was gathered that for this particular ship, a suitable scrubber system would require a power of 15 MW. Calculations were made for suitable open loop scrubber that will cost about 4,984,000 million € with additional installation costs of 0.7 million €. The off hiring days that involves activities such as the scrubber installation, piping, testing, and commissioning will take about thirty days, annual maintenance costs of about 21 t€ p.a. and material costs of around 300€/ton fuel (for chemicals and waste treatment of scrubber residual) were all added and calculated.

Case RoPax ferry has a daily fuel usage of 60t HFO that amounts a yearly volume of 60t x 360 days = 21 600 tons. The HFO – MGO spread within 962 days of oil price data were used to calculate the VaR in the lower 10%, 5% and 1% quantiles of the linked distribution of the spread. In concept, the VaR analysis usually focuses on the left side of the probability distributions. Subsequently, the discounted value method is used to analyse the resultant value of the quantile so that fuel costs saving of n = 15 (discounted value over the 15 years of scrubber lifespan) and r =11% is set as a risk-free value. The results are as follows (Table 1):

Table 1. Quantiles and Present Value (PV) Of Spread Distributions Earnings during Project Lifetime

Historical Data	Days	Annual Savings from difference in Costs of Fuel / Euro	Fuel Spread(Euro)	PV (Euro) in 15 years
10% days	96.2	3 356 640.00	155.4	19,768,031.74
5% days	48.1	3 143 448.00	145.53	18,512,494.59
1% days	9.62	2 748 816.00	127.26	16,188,415.18

Source: Calculations by Authors

Results show that a lower 5% quantile of the spread distribution will lead to a cost of bunker fuel up to 3,143,448 million € per year. The savings that will be made from using the HFO and the scrubber for the ferry with a probability of 95% will yield at least 18 million € within the 15 years scrubber lifespan as against if the ship was using MGO. Furthermore, from the figures, a spread decreased to 127.26 € will yield a lower saving because the lower 1% quantile of the spread distribution was used. If the trend of a higher spread distribution continues to be normal then the saving will increase.

The authors recognised that the NPV used in this study is dependent on two factors: first, the fuel spread and second the HFO price, i.e. NPV = NPV (Spread, HFO) as a function. Accordingly, a linear regression was used to calculate the NPV on the bases of the spread. The R square fit of 93% confirmed a high model fit. This result is on the assumptions that for the scrubber investment not to be risky, the spread distribution must remain normal with the same statistical parameters for the future years.

The Long-Term Fuel Price Scenario

Using a real-life future forecast from the International Bunker Fuel Association report, the authors constructed two different scenarios of savings using the scrubber.

First, from 2019, there is a likelihood of a sharp drop in demand of HFO as bunker fuel together with the expectation of an MGO price recovery up until 2023, when the spread is expected to close up again. Using this forecast, a very high MGO-HFO spread from the 2019-2013 forecasts will be 340 € that will produce a shorter payback period time as presented in Table 2:

Table 2. Scrubber Payback Period from 2019 (Forecasted Oil Price)

HFO	MGO	Earnings from Installation of Scrubber (€)	Scrubber price (€)	Payback Period
526	866	6 060 056	5 684 000	Less than a year

Source: Calculations by authors

Second, according to the same report, in 2024 the fuel price is expected to decrease and the MGO-HFO spread will reduce to 157.25 € which will be approximately around 11% of the VaR quantile. Using the same parameters and calculations, the total savings from using the scrubber technology will be 3,444,767.80 million € per year, a 9% lower value from the from VaR results from the historical fuel price data (Table 3). This also validates the VaR model.

Table 3. Quantiles Value of Spread Distributions with 2024 (Forecasted fuel price)

Forecasted Data	Days	Annual Savings from difference in Costs of Fuel (€)	Fuel Spread (€)
11% days	105	3 444 767.80	157.25

Source: Calculations by authors

The valuation and integration of the NPV and discounted cash flow of the MGO as against the HFO established and validated the Scrubber options as viable investment prospect that is able to yield high returns for the investors. The evolved VaR used with the real-life scenario further helped to demonstrate the high or low-risk time or risk value of the scrubber investment for a particular duration. Forasmuch, as the assumption that the scrubber costs and services remain constant and that the MGO-HFO spread is evenly distributed this model can serve as a classical instrument to measure the value-at-risk of the scrubber investments.

4.2. Maritime Energy Contracting (MEC)

From the investment and risks analysis, the authors confirmed that the scrubber investments have a lot of potentials to be a profitable venture for the ship owners, however, existing empirical data (Olaniyi, 2017) shows a low number of scrubber installations because of the decline in the price of fuel. This has put a lot of pressure on fuel producers who must step up to produce the demanded volumes and types of needed fuel. Unfortunately, a critical challenge for the traditional fuel producers is to cope with the lack of existing production capacity so that they are forced to upgrade their refining process to meet up with their major markets. Olaniyi and Viirmae (2016) highlighted the high investments sums for fuel producers which are needed to produce low sulphur oil. The access to appropriate credits seems to be complicated for the majority of fuel producers due to low oil price and unclear developments in maritime fuel markets.

Even after having recognized the analysis of scrubber investments together with the related risk assessments, the majority of ship owners who are unwilling or even not able to make the financial commitment for scrubber installations which coincidences with the situation of the fuel producers whose product may no longer be marketable. In the end, to reduce the investment risks for ship owners and to ensure business continuity for fuel producers a new business model is thus proffered.

MEC is a revolutionary and feasible new business model for maritime fuel producers that can afford them the opportunity to metamorphose from the everyday fuel producing to energy producing and servicing. This will involve using the concept of the ESC for their energy (fuel) delivery. In theory, it involves fuel producers going into contract with ship owners by pre-financing the scrubber installation, accepting the responsibility of regular maintenance and at the same time supply HFO. In the end, the fuel producers supply energy solutions to ship owners through scrubber installation. All energy service packages are provided at the full expense of the fuel producers in accord to the contract specifications. In return, the fuel company is paid in full for the fuel supplied along with marginal costs of the scrubber costs for servicing and maintaining the scrubber. They guaranty the quality assurance for the use of the scrubber as well. Both companies share the cost savings described previously. The contract will secure energy costs savings that ensure that the reimbursement from the delivered energy during the contract period will comprise of the investment and risk costs already provided by the fuel producers.

Needless say that for the eradication of sulphur emission in shipping, the challenging issue borders on the execution of the compliance objective of the SECA regulation. The BSR has seen admirable compliance actions but because it is related to expensive and risky venture, its achievement is still not 100 percent. This has plagued it with many uncertainties especially as it has to do with the compliance options. Sadly, the low fuel cost has seemingly rendered most of the first investments somewhat pointless. However, with the 2020 global sulphur cap in view, fuel usage will certainly increase along with demand for low sulphur fuel. The maritime sector will likely witness a drastic change in its markets. This change might increase a likelihood of fuel cost or result to a scarcity in low Sulphur fuel supply.

MEC pools two goals: it lowers SECA compliance costs for the ship owners and fuel producers' and ensure SECA compliance. Elements of the MEC implementation consist of a project design (development, planning, contract scrubber installation, fuel supply, maintenance, maximisation, user incentive, quality monitoring and controlling, price bond and risk and technical contracting).

The Long-Term Fuel Price Scenario

In housing, the ESC contracts usually take up to 10 years. This is because buildings are immobile assets so they could be subjected to longer contracts. However, with ships, the conditions are different. First, they are not stationary assets, more so they move from different zone and region to another, which sometimes involves different countries. Under these conditions, circumstances are likely to change significantly, it is therefore suggested to limit the contract duration within 3 to 5 years, adjustable at intervals as well as client specific.

MEC pricing will subsist on two pricing element. (1) The cost of energy (fuel) supply. (2) Financing of the scrubber as an asset that includes supplementary services within the procured contract period also called the adjustment. Each element reviewed periodically (i.e. monthly, bi-monthly, quarterly or yearly) to accommodate arising impelling or unavoidable issues. Thus:

Energy Supply:

$$AP_{HFO}\,[€/mt] = AP_{0HFO}\,[€/mt] + FS\,[€/mt] - FS_0\,[€/mt] \quad (5)$$

where:

- AP_{HFO}: Current fuel price at contract time/metric tonne of fuel (€/mt)
- AP_{0_HFO}: Baseline price from official statistics at the period €/mt
- FS: Price for fuel supply per metric tonne €/mt
- FS_0: Baseline price for fuel supply in a particular period (i.e. 01-06/2017) €/

Non-Energy (Adjustment):

$$LP\,[€/a] = LP_0\,[€/a] \times \left(0.5 + (0.3 + \frac{I}{I_0}) + (0.2 \times \frac{L}{L_0})\right), \quad (6)$$

where:

LP: New fuel price at contract time per annum €/a,
LP_0: Baseline fuel price from official statistics at the period €/a,
I_0: Current price index for consumer goods taken as the baseline,
I: Current price index for consumer goods proportionate to I_0,
L: Average salary index at the contract period,
L_0: Average salary index for setting as starting point for the contract.

The adjustment calculation takes into account the cost of the asset, inflation and modifications in the employee's salary. In principle, every year 50 % of the price is stable, where 30% is dependent on prevailing inflation (consumer good index). The remaining 20% will depend on salary costs build-up, which will affect the provided services like maintenance and monitoring during the contract period.

Along these lines, the cost of MEC will be as follows:

$$\boldsymbol{MEC\ Price} = Energy\ supply\ +\ Scrubber\ costs\ \ +Adjustments \tag{7}$$

In the sequel, the MEC model will be empirically validated with the same RoPax ferry case like in the VaR approach.

MEC Validation

Using already discussed RoPax ferry ship, the baseline cost is set as the price of fuel (MGO) the cruise was using as at 6th Oct 2017 at 585.08€/t. The annual cost for MGO will be the cost of MGO per tonne multiplied by the daily MGO consumption and multiplied by the number of operating days i.e. 585.08€/mt x 60mt/day x 360 days = 12, 637,796.30 € per year. The cost of HFO is 347.27 €/mt which yields an amount of 7,500,969.99 million €.

To calculate an adjustment for November 2017, the adjustment costs are based on the current Estonian consumer goods index at 01.01.2017 (TE, 2017a), the average salary index at 01.01.2017 (TE, 2017b) and a fictive fuel price of 450€/mt from 01.01.2017. Totalling 2,062, 592.24 €/a ≈ 28 % of HFO price/mt.

The annual scrubber costs will be the sum of the 10% additional scrubber fuel/annual (p.a.), 2% additional scrubber service p.a., 15 years depreciation of scrubber p.a. and interest costs p.a. Totalling 897, 881.00 €/a ≈ 12% of HFO price/mt. Thus, the cost savings and sharing is calculated below and is depicted in Figure 3:

$$MEC\ Price/tonne = (347.27\ \ +\ 41.67\ +\ 97.24) = 486.2€/mt$$
$$Cost\ saving\ for\ Shipowner\ = 585.08 - 486.2\ =\ 98.9€/mt$$

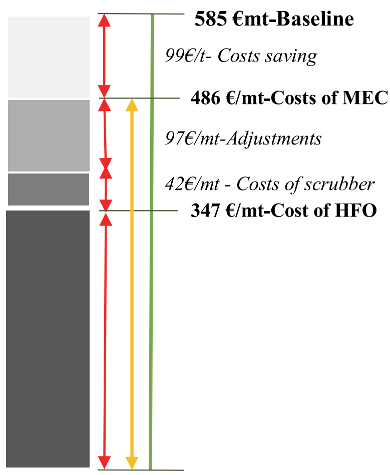


Figure 3. Cost savings in MEC model (Authors' calculations)

By considering the results of the case study it turns out that the shipowner will get the fuel for 99€ per ton cheaper compared to the MGO price whereas the fuel production company will enjoy an additional adjustment of 97€ per ton which generates additional revenues for the fuel company. Another major benefit for the ship-owner is the exchange of the CAPEX to the OPEX that signifies an indirect investment for them. The fuel producer changed his business model from a pure production company towards a service company, which offers now scrubber related services including financing. In comparison to the huge production plant investment for the fuel producing company, the new investments sums for the scrubber installations are smaller and better to handle.

In addition to the financial agreements, a MEC for maritime industry must include other contract conditions in order to become successful. Expert interviews revealed already a list of core points that must be part of MEC agreement between the shipowner and the fuel producer:

- The scrubber as the asset of the fuel producer throughout the agreed contract term.
- Descriptions of financial terms i.e. *Maritime Energy Contracting Price, Scrubber costs, Energy price, Adjustments.*
- Prevailing Interests' rates.
- Provisions for rebates or compensations.
- Terms for penalty and reimbursement for defaults.
- Terms for non-energy elements during the contract period.
- Guidelines for planned or unexpected termination.
- Other matter arising such as *the border of property, Space for scrubber and retrofit, Quality of supply, Additional energy consumption.*

In this regard, using the scrubber option for the MEC concept is a pivotal concept that can be targeted to yield distinctive prospects in the maritime sector because it is practicable and offers a fresh perspective to innovation in an unreliable environment such as the maritime sector. The alliance arrangement will guarantee the following:

(a) SOx emissions reduction.
(b) Scrubber installation costs savings.
(c) Risk transfer to fuel producer such as investment risks, technical risks, market risks, and performance risks, leaving only ‘‘zero risks" to the ship owners.
(d) Jobs creation.
(e) Lowered operational costs for the ship owner that allows the shipowner to focus on shipping activities, which is transportation (this helps them to remove energy efficiency issue from day to day operations).
(f) Free technology and expert support for the ship owners.
(g) Promises a higher margin for both companies.
(h) Customised contracts.

The MEC concept bears many advantages for fuel producers as well as for ship owners because it allows fuel producers to continue producing their traditional product whereas the shipowner gains a competitive advantage due to lower energy costs in shipping which generates additional margin in the transport competition. Yet, the MEC concept leaves open the question of whether the central desulphurisation in fuel producer's plant is more favourable to the decentralised desulphurisation through the scrubber on a ship from an ecological or economical viewpoint. The financial advantage of the scrubber approach is its scalability, which takes into account the credibility situation in the maritime sector.

5. Conclusion

Compliance with SECA regulation is related to investment decisions for shop owners as well as for maritime fuel producers. In the case of a scrubber installation, the Value-at-Risk model is able to demonstrate the risks associated with the scrubber including changes in payback time. Through the scrubber technology, a navigation can be set to mitigate or reduce the economic effect of the SECA regulation on ship owners or maritime fuel producers who do not have the capacity or the will to invest in refinery upgrade.

The research further discussed the concept of a Maritime Energy Contract as a dynamic market instrument to deliver emission reduction and to generate competitive advantages for the shipowner and the fuel company. Authors recognised the MEC as a decentralised method of the SECA regulation compliance for the fuel producers who eventually may have to find a way to make refinery upgrade investment in the long term, but would need to be proactive on the short term while they wait for the appropriate time to commit to a much higher investment.

With applicable political support, the ESC model which has been tried over a long period and in different countries can enhance the maritime sector by refocusing the attention of the maritime stakeholders to using the scrubber technology as providing ‘‘energy solutions’’. This way, a sustainable private sector in the maritime sector will emerge and score a much-desired technology-push-effect for the EU.

The limitation of the study borders around using only HFO/MGO spread scenario without including other sources of fuels, which can be an interesting angle for further research. There can be a comparative study on the VaR for the LNG, methanol, ethanol, CNG and other types of fuel or air purification technologies used to provide a holistic solution bank for the maritime sector.

Acknowledgements

This work is linked to the EnviSuM – Environmental Impact of Low Emission Shipping: Measurements and Modelling Strategies project sponsored by the European Regional Development Fund.

References

1. Abadie, L. M., Goicoechea, N. and Galarraga, I. (2017) Adapting the shipping sector to stricter emissions regulations: Fuel switching or installing a scrubber? *Transportation Research Part D: Transport and Environment*, 57, pp.237-250.
2. Acciaro, M. (2014). Real options analysis for environmental compliance: LNG and emission control areas. *Transportation Research Part D: Transport and Environment*, 28, pp.41-50.
3. Angelidis, T. and Skiadopoulos, G. (2008) Measuring the market risk of freight rates: A value-at-risk approach. *International Journal of Theoretical and Applied Finance*, 11(05), pp.447-469. 4.
4. Atari, S. and Prause, G. (2018) Risk assessment of emission abatement technologies for clean shipping. In: Kabashkin, I., Yatskiv, I., Prentkovskis, O. (Ed.). *Reliability and Statistics in Transportation and Communication*.17th International Multi-Conference "Reliability and Statistics in Transportation and Communication" (RelSTat2017) Riga. October 18-21, 2017. Berlin: Springer. (Lecture Notes in Networks and Systems.
5. Baker, H.K. and Haslem, J.A. (1974) The impact of investor socioeconomic characteristics on risk and return preferences. *Journal of Business Research*, 2(4), pp. 469-476.
6. Bas, G., De Boo, K., Vaes-Van de Hulsbeek, A. M. and Nikolic, I. (2017) MarPEM: An agent based model to explore the effects of policy instruments on the transition of the maritime fuel system away from HFO. *Transportation Research Part D: Transport and Environment*, 55, 162-174.
7. Basak, S. and Shapiro, A. (2001) Value-at-risk-based risk management: optimal policies and asset prices. *The review of financial studies,* 14(2), pp.371-405.
8. Bergqvist, R., Turesson, M. and Weddmark, A. (2015) Sulphur emission control areas and transport strategies-the case of Sweden and the forest industry. *European Transport Research Review*, 7(2), pp.10.
9. Bertoldi, P., Rezessy, S. and Vine, E. (2006) Energy service companies in European countries: Current status and a strategy to foster their development. *Energy Policy,* 34(14), pp.1818-1832.
10. Bleyl, J. W. (2011). Conservation first! The new integrated energy-contracting model to combine energy efficiency and renewable supply in large buildings and industry. *ECEEE summer Studies, Paper ID*, *485*.
11. Boons, F. and Lüdeke-Freund, F. (2013) Business models for sustainable innovation: state-of-the-art and steps towards a research agenda. *Journal of Cleaner Production,* 45, pp.9-19.
12. CE Delft (2017) *Assessment of Fuel Oil Availability.* Final report Delft, July 2016 www.cedelft.eu/publicatie/assessment_of_fuel_oil_availability/1858. Access 05/10/2017
13. Chesbrough, H. (2010) Business model innovation: opportunities and barriers. *Long range planning*, 43(2), pp.354-363.
14. Daduna, J.R. and Prause, G. (2017) The Baltic Sea as a Maritime Highway in International Multimodal Transport. *In Operations Research Proceedings* 2015, Springer, pp.189-194.
15. Dowd, K. (2007) *Measuring market risk*. John Wiley & Sons.
16. EMSA (2010) *European Maritime safety Agency Annual 2010* Report. Retrieved May 10, 2016 from www.emsa.europa.eu/emsa-documents/download/1421/143/23.html.

17. Goldman, C.A., Hopper, N.C. and Osborn, J.G. (2005) Review of US ESCO industry market trends: an empirical analysis of project data. *Energy policy*, 33(3), pp.387-405.
18. Gu, Y. and Wallace, S. W. (2017) Scrubber: A potentially overestimated compliance method for the Emission Control Areas: The importance of involving a ship's sailing pattern in the evaluation. *Transportation Research Part D: Transport and Environment*, 55, pp.51-66.
19. Hämäläinen, E., Hilmola, O.P., Prause, G. and Tolli, A. (2016) Forecasting maritime logistics costs – Will the low oil price remain? In A. Serry and L. Lévêque (Eds.). *Le transport maritime à courte distance (Short-Sea Shipping)*, Devport 2016 Conference, pp. 19-34. Le Havre, France: EMS Geodif.
20. Hendricks, D. (1997). Evaluation of value-at-risk models using historical data. *Economic Policy Review*, *2*(1).
21. Herbst, A.F. (2003) *Capital asset investment: strategy, tactics and tools*. John Wiley & Sons.
22. Horbach, J., Rammer, C. and Rennings, K. (2012) Determinants of eco-innovations by type of environmental impact—the role of regulatory push/pull, technology push and market pull. *Ecological economics*, 78, pp.112-122.
23. IMO (2015) *Guidance on the application of regulation 13 of MARPOL annex VI Tier III requirements to dual fuel and gas-fuelled engines.* MEPC.1/Circ.854. London. http://www.imo.org/en/MediaCentre/PressBriefings/Pages/MEPC-70-2020sulphur.aspx. Accessed 2016/11/30.
24. IMO (2016) *IMO sets 2020 date for ships to comply with low sulphur fuel oil requirement*. Press briefing release 28/10/2016. http://www.imo.org/en/MediaCentre/PressBriefings/Pages/MEPC-70-2020sulphur.aspx Accessed 30/11/2016.
25. Jiang, L., Kronbak, J. and Christensen, L.P. (2014) The costs and benefits of sulphur reduction measures: Sulphur scrubbers versus marine gas oil. *Transportation Research Part D: Transport and Environment*, 28, pp.19-27.
26. Jorion, P. (2006) *Value at Risk: The New Benchmark for Managing Financial Risk*, 3rd Edition, McGraw-Hill.
27. Kvale, S. (2008) *Doing interviews*. Book 2 of The SAGE qualitative research kit.
28. Lindstad, H. E. and Eskeland, G. S. (2016) Environmental regulations in shipping: Policies leaning towards globalization of scrubbers deserve scrutiny. *Transportation Research Part D: Transport and Environment*, *47*, pp. 67-76.
29. Lindstad, H., Sandaas, I. and Strømman, A. H. (2015) Assessment of cost as a function of abatement options in maritime emission control areas. *Transportation Research Part D: Transport and Environment*, 38, pp.41-48.
30. Linsmeier, T. J. and Pearson, N. D. (2000) Value at risk. *Financial Analysts Journal*, 56(2), pp.47-67.
31. McGrath, R.G. (2010) Business models: A discovery driven approach. *Long range planning*, 43(2), pp.247-261.
32. Miles, M.B., Huberman, A.M. and Saldana, J. (1984) *Qualitative data analysis:* A sourcebook. Beverly Hills.
33. North (2016) *China: Emission Control Areas.* Retrieved from http://www.nepia.com/news/industry-news/china-emission-control-areas-starupdatestar/. Accessed 22.12.2016.
34. Notteboom, T. (2010) The impact of low sulphur fuel requirements in shipping on the competitiveness of roro shipping in Northern Europe. *WMU Journal of Maritime Affairs* 10(1), pp.63–95.
35. Nugraha, F. (2009) Effective implementation of emission control area towards cleaner shipping operations: focusing on sulphur oxides (SOx) emission reduction (2009).World Maritime University Dissertations. 186.
36. OECD/ITF (2016) *Reducing Sulphur Emissions from Ships: The Impact of International Regulation.* http://www.itf-oecd.org/reducing-sulphur-emissions-ships-impact-international-regulation. Accessed 10/06/2016.
37. Olaniyi, E., Gerber, P. and Prause (2018) Strategic Energy Partnership in Shipping. Risk assessment of emission abatement technologies for clean shipping. In: Kabashkin, I., Yatskiv, I., Prentkovskis, O. (Ed.). *Reliability and Statistics in Transportation and Communication*.17th International Multi-Conference "Reliability and Statistics in Transportation and Communication" (RelSTat2017) Riga. October 18-21, 2017. Berlin: Springer.
38. Olaniyi, E., Prause, G. and Boyesen, J. (2018) The impact of SECA regulations on clean shipping in the BSR: First empiric results from EnviSuM project. In: Ölçer, A.I., Kitada, M., Dalaklis, D., Ballini, F. (Ed.). *Trends and Challenges in Maritime Energy Management*. 2017 International

Conference on Maritime Energy Management, Malmo, Sweden, 24-25 January 2017. Springer. (WMU Studies in Maritime Affairs.
39. Olaniyi, E. O. (2017) Towards EU 2020: An Outlook of SECA Regulations Implementation in the BSR. *Baltic Journal of European Studies*, 7(2), pp.182-207.
40. Olaniyi, E.O. and Viirmäe, M. (2016) The Economic Impact of Environmental Regulations on a Maritime Fuel Production Company. *Research in Economics and Business: Central and Eastern Europe*, 8(2) pp.58-84.
41. Osterwalder, A. and Pigneur, Y. (2009) *Business Model Creation.* Modderman Drukwerk: Amsterdam.
42. Panagakos, G.P., Stamatopoulou, E.V. and Psaraftis, H.N. (2014) The possible designation of the Mediterranean Sea as a SECA: A case study. *Transportation Research Part D: Transport and Environment*, 28, pp.74-90.
43. Patricksson, Ø. and Erikstad, S.O. (2017) A two-stage optimization approach for sulphur emission regulation compliance. *Maritime Policy & Management*, 44(1), pp.94-111.
44. Platts (2016) *The IMO's 2020 Global Sulfur Cap: What A 2020 Sulfur-Constrained World Means for Shipping Lines, Refineries and Bunker Suppliers*. https://www.platts.com/IM.Platts.../SR-IMO-2020-Global-sulfur-cap-102016.pdf. Accessed 12/12/2016
45. Plouffe, S., Lanoie, P., Berneman, C. and Vernier, M. F. (2011) Economic benefits tied to eco-design. *Journal of Cleaner Production*, 19(6), pp. 573-579.
46. Prause, G. and Olaniyi E.O. (2017) The impact of environmental regulations on the regional development in Eastern Estonia. *New Challenges of Economic and Business Development* - 2017: Riga, May 18th – 20th, 2017. Ed. Muravska, T. Riga: Latvian State University
47. Ren, J. and Lützen, M. (2015) Fuzzy multi-criteria decision-making method for technology selection for emissions reduction from shipping under uncertainties. *Transportation Research Part D: Transport and Environment*, *40*, pp. 43-60.
48. Ross, S.A., Westerfield, R., Jaffe, J.F. and Roberts, G.S. (2002) Corporate finance (Vol. 7). New York: McGraw-Hill/Irwin.
49. Schinas, O. and Stefanakos, C. N. (2012) Cost assessment of environmental regulation and options for marine operators. *Transportation Research Part C: Emerging Technologies*, *25*, pp.81-99.
50. Siggelkow, N. (2007) Persuasion with case studies. The Academy of Management Journal, 50(1), pp.20-24.
51. Sorrell, S. (2007) The economics of energy service contracts. *Energy Policy*, 35(1), pp.507-521.
52. Stopford M. (2009) *Maritime economics*, Routledge 2nd Edition, London and New York.
53. Sys, C., Vanelslander, T., Adriaenssens, M. and Van Rillaer, I. (2016) International emission regulation in sea transport: Economic feasibility and impact. *Transportation Research Part D: Transport and Environment*, 45, pp.139-151.
54. TE (2017a) *Consumer Price Index/Estonia*. https://tradingeconomics.com/estonia/consumer-price-index-cpi accessed 1.11.2017.
55. TE (2017b) *Labour costs/Estonia.* https://tradingeconomics.com/estonia/labour-costs. Accessed 1.11.2017.
56. Wiśnicki, B., Czermański, E., Droździecki, S., Matczak, M. and Spangenberg, E. (2014) Sulphur Regulation–technology solutions and economic consequences for the Baltic Sea Region shipping market. In: Ernest Czermański (ed) *Institute of Maritime Transport and Seaborne Trade*, University of Gdańsk.
57. WoodMackenze (2016) *Global marine fuel sulphur cap - challenges of a 2020 implementation*. https://www.woodmac.com/reports/refining-and-oil-products-global-marine-fuel-sulphur-cap-challenges-of-a-2020-implementation-43374172. Accessed on 30.11.2016.

Appendix 2

Structured Experts' Interview Questions

Interreg Baltic Sea Region
EnviSuM

Economic Impact of SECA Regulations in the Baltic Sea Region

Structured Experts Interview Questions

Guidelines:

1. At least 3 expert interviews for each country
2. Please endeavour to receive answers to all questions.
3. You can ask state/country specific questions

Introduction

- A short introduction of the EnviSuM project, its activities and objectives.

Background Information **Estimated time: 25-35mins**

Interviewer: Name: Institution:

Interviewee: Name: Position: Name of Company: Maritime sector:

Date, duration and location of interview: Date: Duration: Location:

Ports

Port profile and key activities

1. Name of the port.

(1min)

2. Please describe the services your port offer and the type of ships that call at your port.

(2mins)

3. What are the SECA related activities in your port?

(2mins)

4. How has the SECA regulation affected your overall ports development plans?

(2mins)

Process Change

5. How do you monitor SECA compliance in your port? What do you check/monitor?

(2min)

6. What type of compliance sanctions or incentives do you have for ships that use your port?

Sanctions:

Incentives:

(2min)

7. Please give a brief description of your waste management system. Is this process a standard framework for any EU port or adjusted to fit your port and your type of vessels?

(2,5mins)

8. What facilities upgrades did you make due to SECA compliances?

(2,5mins)

9. What are your port charges? Has any of your port charges increased/decreased due to SECA regulation?

(2mins)

10. Have you had to employ more staff, buy more equipment, upgrade or do more installation as result of the SECA regulations? Can you explain in specifics?

(2min)

11. How has the fluctuations and uncertainty in oil and bunkering fuel price and its supply affecting your activities?

(2min)

12. How many (what percentage) of the ships that call at your port use the scrubber technology/LNG/MGO?

(1min)

SECA future plans

13. Do you have any future SECA related plans? (E.g. On-board energy, LNG bunkering facilities, water treatment).

(2mins)

Shipowners, ship operators, Shipping companies
Profile and key activities

1. What percentage of your business activities takes place in the Baltic Sea?
   (1min)

2. What percentage of your business activities takes place in SECA in general?
   (1min)

3. How many fleets do you operate?
   How many:
   Type:
   Design:
   how big:
   How expensive
   (2,5min)

4. Which department in your company handles regulations issues?
   (1min)

5. How many staff and their management level?
   (1min)

New process

7. Have you made any new business activities related to SECA? (e.g. investments, change in business processes, additional administrative procedures, recruitment of new staff, dismissal of staff)
   (2mins)

8. Can you estimate the total amount of SECA investments you have made up until now?
   (Please use the report sheet attached or leave it with the interviewee to pick up later)
   Compliance:

   a. Investment (CAPEX)
      Cost:
      Interest rate:
      Payback period:

   b. Annual operating cost (OPEX)
      Maintenance:

   c. Additional administration cost (training e.t.c.):

Future SECA related activities

9. What other future SECA related investment plan do you have?
   (1,5mins)

Maritime suppliers, fuel producers
Company profile and Key business activities
1. Please give an overview of your products or services. **(1,5mins)** 2. Who are your key business partners? Suppliers Refineries Logistics Ports Ship operators'/shipping lines Shipping companies/operators **(2mins)** 3. Which parts of the Baltic Sea region do your partners come from? **(2mins)** 4. Who handles environmental issues in your company and what do they do? **(5mins)** 5. How many staff do they have in this department and what is their level in management level? **(2mins)** 6. What is your source of environmental regulations information? **(1,5mins)**
SECA related Process change
7. What is your annual company turnover? **(2mins)** 8. What percentage of your turnover is SECA induced? **(3mins)** 9. Can you give the expenditure in your company has made due to the SECA regulations? (e.g. hiring of new staff (how many staff), staff training / buying new equipment's, machine, updating refineries machinery) (Please use the report sheet attached or leave it with the interviewee to pick up later) **(10mins)** 10. What are the new additions or reduction to your company's products/portfolio after SECA? **(2min)**
SECA future plans
11. What are your technical and administration options for SECA compliance? **(2mins)** 12. How much will it cost you to carry this out? **(2mins)** 13. What other SECA related activity do you have? **(2mins)**

Curriculum Vitae

Personal data

Name:	Eunice Omolola Olaniyi
Date of birth:	29th January 1979
Place of birth:	Zaria, Nigeria
Citizenship:	Nigerian

Contact data

E-mail:	eunice.olaniyi@ttu.ee, omololaolaniyi@gmail.com

Education

2014–2018	Tallinn University of Technology, Estonia **PhD**
2013–2014	Salford University, UK **MSC, International Business**
2011–2012	Nigeria Institute of Public Relations (NIPR) **Public Relations Professional**
2010–2011	Project Management Institute, USA **PMP (Project Management Professional)**
1997–2003	Ladoke Akintola University of Technology, Nigeria **Bachelor of Technology (B.Tech), Pure and Applied Biology**
1990–1996	**West-Africa Senior School leaving Certificate**

Language competence

Yoruba	Mother Tongue
English	Fluent

Professional employment

2016–…	**EU Project Management and Research** EnviSuM Project - Environmental Impact of Low Emission Shipping: Measurements and Modelling Strategies - Funded by European Union (European Regional Development Fund).
2011–2012	**Northern Regional Customer Service Manager** Paints and Coating Manufacturers Nigeria Plc.
2008–2011	**Customer Service Manager** Chemical and Allied Products Plc. subsidiary of United Africa Company of Nigeria Plc. (UACN) Nigeria
2006–2008	**Marketing Executive** Chemical and Allied Products Plc. subsidiary of United Africa Company of Nigeria Plc. (UACN) Nigeria
2005–2006	**Clinical Administrator** Nordica Fertility Clinic, Lagos, Nigeria
2004–2005	**Peer Educator**, UNICEF, Nigeria

Elulookirjeldus

Isikuandmed

Nimi:	Eunice Omolola Olaniyi
Sünniaeg:	29. jaanuar 1979
Sünnikoht:	Zaria, Nigeeria
Kodakondsus:	Nigeeria

Kontaktandmed

E-post:	eunice.olaniyi@ttu.ee, omolololaolaniyi@gmail.com

Hariduskäik

2014–2018	Tallinna Tehnikaülikool **Doktorant**
2013–2014	Salford University, UK **Rahvusvahelise äri magistrikraad**
2011–2012	Nigeria Institute of Public Relations (NIPR) **Avalikud suhted**
2010–2011	Project Management Institute, USA **Projektijuhtimine**
1997–2003	Ladoke Akintola University of Technology, Nigeria **Rakendusliku bioloogia tehnoloogia bakalaureus**
1990–1996	Keskharidus

Keelteoskus

Inglise keel	Kõrgtase
Yoruba	Emakeel

Teenistuskäik

2016– …	**EU projektijuhtimine ja nooremteadur** EnviSuM Project - Environmental Impact of Low Emission Shipping: Measurements and Modelling Strategies - Funded by European Union (European Regional Development Fund).
2011–2012	**Klienditeeninduse juht** Paints and Coating Manufacturers Nigeria Plc.
2008–2011	**Klienditeeninduse juht** Chemical and Allied Products Plc. subsidiary of United Africa Company of Nigeria Plc. (UACN) Nigeria
2006–2008	**Turundusjuht** Chemical and Allied Products Plc. subsidiary of United Africa Company of Nigeria Plc. (UACN) Nigeria
2005–2006	**Kliiniline administraator** Nordica Fertility Clinic, Lagos, Nigeria
2004–2005	**Koolitaja** UNICEF, Nigeria