ECONOMIC IMPACTS OF SECA REGULATION ON MARITIME COMPANIES IN THE BALTIC SEA REGION – LITERATURE REVIEW AND LOW EMISSIONS RECOMMENDATIONS: PART 2

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Abstract: *This is the second part of our research. Two publication databases were queried: Science Direct (SD) and Web of Science (WoS). The search query in these channels was performed using keywords "SECA, economic impacts" to investigate how SECA implications were studied for clean business development. Two main topic groups were discovered. The first group includes topics that focus on solving negative impacts (economy of maritime businesses); and the second group consists of topics that focus on the positive impacts on health and the environment, particularly in SECA port regions. After the screening process, the data included 21 papers that matched the query specifications. The decision was made to only use the most recent studies that were completed after 2015. The results indicate that ship owners and fuel producers can use various methods simultaneously to adapt to the SECA regulation.*

Keywords*: Literature, SECA, Impacts.*

1. EMPIRICS: THEMES, SUBJECTS AND FOCUS AREAS OF THE SELECTED PAPERS

The following empirical observations conclude our study started in Part 1. For this purpose, Table 1 covers article titles, main topics (defined by the authors), journals, impact factor (IF) of the journal, and the number of citations. Table 1 is sorted by the impact factor, the highest is the first. The list shows the thematic diversity of journals. All studied journals are high ranking, as they belong to these most appreciated catalogues. Additionally, only a few articles were published in low impact journals (no impact factor or less than 0.3). One interesting observation is that the maritime-related subjects have been published in multidisciplinary journals, as indicated by Table 1. The most general themes such as energy, the environment or cleaner production, are identifiable in the journal profiling. Research on these topics concerns several industries and stakeholders. The SECA regulation is an EU directive forcing maritime businesses to adapt to a new situation; the selected articles present a large arsenal of different ways that companies could comply with low emission requirements. The presented articles' themes cover the whole maritime sector, from refining industries through fuel maintenance to engine modifications. Approximately 30% of the articles are published in Transportation

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Research Part D. Citation volumes are still rather low, reflecting the fact that these papers were published recently. There are some papers that already have some citations (top is 8). In total, there are 51 citations to these papers. Alternative fuels are a major study field in terms of citations. There is a growing need to find alternative fuel options for ships to replace HFO and scrubbers or low sulphur marine diesel. LNG seems to be one popular and relevant option mentioned in discussions concerning low emission bunker.

Lower maritime emissions require new reliable and solid technological solutions. These in turn require radical innovations that are harmonized to operate in accordance with the older existing solutions. Thus, there is also an incremental element involved. One of the key questions is how to build scalable solutions and methods, so that the new applications can be completed and installed in vessels at reasonable costs, producing added value through their functionality. The scalability of the new solutions is not covered in these studied papers. On one hand, new clean bunker could be understood as a scalable environmental solution as such; and on the other, scrubber installations are more uniquely built and modified for every vessel in question and therefore scalability is difficult to verify.

Table 2 lists all the keywords obtained from the 21 papers. Keywords were unavailable for only one article. Each article contains a number of keywords that can be related to broader categories. As we can perceive, these articles discuss several topics from the perspectives of e.g. marine fuels, modelling, strategy, hinterlands and ports. These keywords clearly show that during these two years, SECA and its impacts have generated a diverse field of studies, presented in these scientific articles. The selection word "impact", in itself, leads to mainly economic and environmental topics being prominent in these papers. Emission levels and the bunker type used have an interactive relation with each other. A significant amount of daily operating costs (25–60%) results from bunker consumption when ships are in operation. The emissions of the vessels mostly consist of CO2, SOx and NOx, as well as other discharges (e.g. black carbon, BC) from the burning. The keywords of the articles indicate that there is a significant amount of research addressing how SECA (and other environmental) regulations impact on the whole maritime business sector's models and the maritime dependent supply chain.

The implementation of binding regulations causes modifications to the traditional maritime operation models. The SECA regulations have been studied quite extensively, as the maritime sector is a complicated business environment. From an environmental viewpoint, lower emissions will become a global norm. This requires fast and decisive action in every oil dependent industry sector, and the maritime and transportation industries must also act quickly in the coming years. Therefore, it is not surprising that both economic and environmental topics have been widely discussed in the presented articles. Emission regulations (on-shore or off-shore) and changes in technical solutions (change of fuel, scrubbers, new engines, or modifications of engines) onboard have an impact on profitability. Additionally, due to the complicated business situation and strong competition in the maritime supply chain market, estimated profits are probably declining. In all likelihood, new disruptive innovations (scalability should be included) currently under development may mitigate some of the negative economic factors.

The presented literature clearly demonstrates that researchers have revealed that companies are looking to find solutions from different angles and directions, using various technical solutions and business model methods. The papers also address the diversity of combinations of these solutions and methods. Generally, the papers agree that

the road to a cleaner marine environment (and emission free shipping operations) is a project requiring knowledge from numerous disciplines and problem solving perspectives, creating a highly complex system, in which each part affects another. Traditionally, marine operations have not focused on emission regulations. Instead, their focus has been in creating a profitable business where environmental issues have been secondary concerns. Therefore, an important message from these papers is that on every level: the local, regional, national, European, and global levels, there is a crucial need for internationally agreed, strict environmental regulations that should be followed and monitored to ensure a fair competition environment. The articles strongly stress from many angles that the pollution levels should be reduced using all reasonable means. Investments should be focused on non-polluting technology.

In the near future, large environmental investments should also be made in the maritime sector. In order to demonstrate this need in accordance with the article contents. It includes the title, author and shortened version and main points of the abstract. The papers were sorted according to main topics as indicated in Table 1. Global environmental protection will affect, in the end, all emission-producing businesses. Normally, various economical resources are required for investments to get environmentally positive results. There are various ways to mitigate emissions at a reasonable cost, so that business remains profitable under stricter environmental regulations, such as SECA. The economic aspects are closely linked with environmental regulations and cleaner nature.

Table 1. Titles, authors, main topics, publishing journals, impact factors and citations

Titles	Author(s)	Main topics	Journals	If/Cit
Renewable methanol as a fuel for the shipping industry	Svanberg, M. (2017)	Economic Environmental Methanol	Renewable and Sustainable Energy Reviews 94 (2018) 1217–1228	If 9,18 Cit. 0
Evaluation of gas turbines as alternative energy production systems for a large cruise ship to meet new maritime regulations	Armellini, A. et al. (2018)	Technological Alternatives	Applied Energy 211 (2018) 306–317	If 7,90 Cit. 4
Environmental economics of lignin derived transport fuels	Svetlana V. Obydenkova, S. V. et al. (2017)	Economic Environmental Ethanol Plant	Bioresource Technology 243 (2017) 589–599	If 5,81 Cit. 6
How to recognize and measure the economic impacts of environmental regulation: The Sulphur Emission Control Area case	Lähteenmäki-Uutela, A. et al. (2017)	Environmental Socio-Economic	Journal of Cleaner Production 154 (2017) 553-565	If 5,65 Cit. 1
Sectoral and technological systems of environmental innovation: The case of marine scrubber systems	Makkonen, T. and Inkinen, T. (2018)	Environmental Product Innovations	Journal of Cleaner Production 200 (2018) 110-121	If 5,65 Cit. 0
The development and comparison of CO_2 BOG re-liquefaction processes for LNG fueled CO_2 carriers	Byeong-Yong Yoo, B-Y. (2017)	Economic Alternative Fuel Systems	Energy 127 (2017) 186-197	If 4,97 Cit. 5
The activity-based methodology to assess ship emissions - A review	Nunes, R.A.O. et al. (2017)	Environmental Health	Environmental Pollution 231 (2017) 87-103	If 4,36 Cit. 6
Explaining choices in energy infrastructure development as a network of adjacent action situations: The case of LNG in the Baltic Sea region	Gritsenko, D. (2018)	Alternative Fuels Emissions Governance	Energy Policy 112 (2018) 74–83	If 4,04 Cit. 4

Table 1. Titles, authors, main topics, publishing journals, impact factors and citations - continued

Titles	Author(s)	Main topics	Journals	If/Cit
A chemometric investigation of aromatic emission profiles from a marine engine in comparison with residential wood combustion and road traffic: Implications for source apportionment inside and outside sulphur emission control areas	Czech, H. et al. (2017)	Environmental Health	Atmospheric Environment 167 (2017) 212-222	If 3,71 Cit. 1
The costs and benefits of a nitrogen emission control area in the Baltic and North Seas	Åström, S. et al. (2018)	Economic NECA Health	Transportation Research Part D 52 (2017) 185–201	If 3,45 Cit. 4
The impact of alternative routing and packaging scenarios on carbon and sulphate emissions in international wine distribution	Harris, I. et al. (2018)	Economic Health Environmental Emissions	Transportation Research Part D 52 (2017) 303–321	If 3,45 Cit. 0
The implications of the new sulphur limits on the European Ro-Ro sector	Zis, T. and Psaraftis, H. N. (2017)	Economic Environmental Modelling	Transportation Research Part D 55 (2017) 162–174	If 3,45 Cit. 8
A sustainability assessment of ports and port-city plans: Comparing ambitions with achievements	Schipper, C. A. et at. (2017)	Economic Environmental KPI Sustainability	Transportation Research Part D 57 (2017) 84–111	If 3,45 Cit. 1
Marpem: An agent-based model to explore the effects of policy instruments on the transition of the maritime fuel system away from HFO	Bas, G. et al. (2017)	Emissions Alternative Fuel Systems	Transportation Research Part D 58 (2018) 261–279	If 3,45 Cit. 1
A global review of the hinterland dimension of green port strategies	Gonzalez, M. et al. (2018)	Environmental Performance Hinterland	Transportation Research Part D 59 (2018) 223–236	If 3,45 Cit. 1
A multiple ship routing and speed optimization problem under time, cost and environmental objectives	Wen, M. et al. (2017)	Economic Freight Costs Modelling	Transportation Research Part D 52 (2017) 303–321	If 3,45 Cit. 8
Health costs and economic impact of wind assisted ship propulsion	Ballini, F. et al. (2017)	Economic Health Health-Economic	Ocean Engineering 146 (2017) 477–485	If 2,21 Cit. 1
Maritime energy contracting for clean shipping	Olaniyi, E. O. et al. (2018)	Costs Investments Innovation	Transport and Telecommunication Journal MAR 2018	If 1,54 Cit. 1
Towards EU 2020: An Outlook of SECA Regulations Implementation in the BSR	Olaniyi, E. O. (2017)	Comply SECA Approaches Economic	Baltic Journal Of European Studies 7 (2) Oct 2017	If N/A Cit. 4
The impact of environmental regulations on regional development in Eastern Estonia	Prause, G. and Olaniyi, E. O. (2017)	Shale Industry Oil Refinery Socio-Economic Business Development	New Challenges Of Economic And Business Development - 2017: Digital Economy 461-472	If N/A Cit. 0
Strategic Energy Partnership in Shipping	Olaniyi, E. O. et al. (2018)	Strategic Energy Partnerships Scrubber Technology	Reliability and Statistics In Transportation And Communication (Book) Oct 18-21, 2017	If N/A Cit. 0

Table 2. Keywords of the articles.

IMO Cruise ship Emissions Optimization Gas turbines	Effectiveness of regulation Regulatory impact assessment Environmental regulation Maritime industry Sulphur Exhaust gas emissions Shipping	Ship speed optimization Multi-commodity pickup and delivery Branch-and-price Combined ship speed and routing
REMPI IVOC Heavy fuel oil Marine gas oil PAH	Environmental innovation Marine scrubber system Maritime industry Sectoral system of innovation Technological system of innovation	Agent-based modelling Liquefied natural gas Maritime fuels Policy evaluation Simulation Sulphur emissions System perspective
Clean shipping; Emission reduction Envisum project Eu 2020 Institutionalism SECA	SECA Regulations Business models Entrepreneurship Clean shipping Strategic Management	Port Port-city Sustainability Assessment Methodology Key performance indicator
2G ethanol plants Lignin Fuels Life cycle assessment	Wind assisted ship propulsion Health economic externalities Air pollution EVA model	International freight transport Wine port/node/route selection CO2e reduction Sulphur emissions
LNG as marine fuel CO_2 carrier CO_2 transport LNG LNG fueled ship CCS	Business model Emission reduction Envisum project SECA regulation Maritime Energy Contract	Shipping Air pollution Greenhouse gases Cost-benefit analysis NOx control cost Co-benefit
Energy infrastructure Governance Polycentric LNG Baltic Sea region	Investment appraisal, VAR, Scrubber, SECA, Energy Contracting Business model	Green port Shipping Environment Emissions Climate change Congestion Intermodal Hinterland
Activity-based method Air pollution Shipping emissions Climate change	Sulphur emission control areas Maritime emissions Modal shifts Ro-Ro shipping	

Based on their abstracts, the analysed papers form 5 identifiable higher-level thematic groups: 1) Governance; 2) Alternative fuels; 3) Economic; 4) Health-Environment; and 5) Technology-Innovation. These themes are closely linked to each other, and thus the ultimate goal is to study lower emission (or even emission free) maritime transportation. Economic impacts are probably the most important issue (from a business perspective) in the discussions regarding the impacts of SECA and other emission control regulations on the maritime sector. The common outcome is that (strong) regulation is needed in order to tackle global climate change. In addition, positive improvements in air quality also have direct impacts on quality of life.

Replacing oil with alternative fuels (especially with methanol or LNG) is one way to mitigate emissions to air. Gritsenko (2018) points out that LNG, in particular, is fulfilling policy expectations in three key areas: enhancing energy security, providing low-sulphur bunker fuel, and balancing renewables in the power sector around the Baltic Sea region.

However, LNG use requires modifications in existing engines and new supply chain investments in transportation, warehousing and bunkering. The number of vessels operating on LNG is still limited but will steadily increase worldwide. Even marine transportation is producing a minor (but significant) part of harmful emissions on a global level; regional and local emissions are significant. For example, in China, there are voluntary restrictions on the use of polluting fuels like HFO due to high emission levels.

Armellini et al. (2018) note that as a consequence of the new and upcoming regulations imposed by the IMO, polluting emissions produced by large ships are now under strict control and the ECAs, which request even lower pollutant emissions, will be extended. To react to these changes, ships propelled by Internal Combustion Engines (ICEs) burning HFO can be equipped with abatement devices, such as scrubbers and Selective Catalytic Reactor (SCR) systems. However along with these solutions, other methods can be considered, such as the use of Marine Gas Oil (MGO): a more expensive fuel, but with significantly lower sulphur content. The use of MGO allows users to consider a further and more drastic modification of the power system, namely the use of Gas Turbines (GTs) in place of ICEs. Along with scrubbers, these gas turbine ships still use rather matured solutions, which are challenging to modify into zero-emission vessels.

Economic-environmental modelling is an interesting topic, which Zis and Psaraftis (2017) present in their paper. They describe a comprehensive system perspective of the maritime fuel system and an agent-based model (MarPEM) that can be used to study the effects of policy instruments on the transition away from HFO. The use of MarPEM to assess the effect of three policy instruments that each influence the maritime fuel system differently, and future studies can use this work as a basis to study the effects of other policy instruments. Similarly, Schipper et al. (2017) developed a comparative methodology to assess the sustainability performance of a mixed set of ports (different locations; sizes; profiles). This methodology involves ranking various long-term port plans and port vision documents against a set of social, economic, and environmental key performance indicators (KPIs) in order to evaluate and interpret future sustainable port-city development plans.

Reflecting on the extensive nature of the literature, it may be summarized that emission free maritime transportation is not easy to achieve with the existing matured (and polluting) technologies. A positive challenge is that there are several alternatives to lower air and sea emissions. A common feature to all these actions is that they require investments, new ways of thinking, and innovative product development of the future technologies. Currently, companies combinations of emission-lowering methods (e.g. LNG and wind assistants) that are the easiest to implement. In addition, improvements in the routing of vessels can be utilized. It is essential to recognize each individual context in the search of optimized (low or non-polluting) environmental solutions for maritime businesses.

2. DISCUSSION AND CONCLUSIONS

The identified papers indicate that the SECA regulation has been studied extensively since the discussion regarding the emission regulations in maritime sector began. Before 2015, a number of researchers anticipated considerable challenges and difficulties for the entire maritime transport sector in all SECA regions. However, the global bunker price decline mitigated the cost increase. Currently, the prices are soaring again, and the impacts will

become apparent in the near future. In the Baltic Sea, maritime transport is crucial, especially for heavy export industries. Maritime transport is also the economic life-line of trade for countries such as Finland, Norway, and Sweden. The studied articles covered varying broad topics, such as the economy, the environment, modelling, governance, alternative fuels, innovation studies and health. A majority of the 21 papers were published in established and high-ranking scientific journals, even though there are only a limited number of citations since they were published recently.

In Figure 1, there is a hierarchical illustration of the SECA operators. The graph is based on the literature, indicating how the different functionalities are connected with each other. In this model, the smallest environmental 'actor' is a vessel, followed by the company (ship owner). After that, the following levels include nations, multinational collectives and alliances (e.g. EU, NAFTA), and global agreements. The lower part of Figure 1 presents key elements and options that impact emissions in this model.

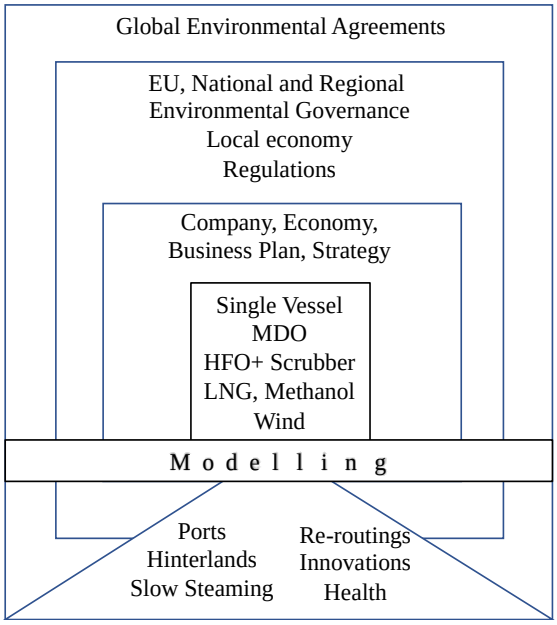

Figure 1. Operators and functions in SECA regulation according the reviewed papers.

Global environmental regulations are (and will be) created from these identified components, based on complicated and rather loose agreements. Together with the literature, Figure 1 addresses one basic reason for the extreme complexity of environmental regulation. Extensive volumes of actors, companies, and national economies are involved in this complex system. There are also various understandings regarding the goals of emission regulation. It is worth noting that the article sample did not include any papers dealing with political science or law. In the end, politics are at the centre of the whole system, as regulation decisions are always political. The articles stressed that the utilization of the environment impacts not only company balance-sheets, but also the surrounding areas and societies through which transport volumes are flowing. Therefore, regulation issues will probably become stricter and also provide new possibilities for cleaner production and environmental innovations. Particularly when new regulations are set to reduce emissions such as NOx and BC, the impacts of these constraints should be anticipated and researched thoroughly in advance.

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