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A COMPLIANCE COST ANALYSIS OF THE SECA REGULATION IN THE BALTIC SEA^{*}

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Abstract. This paper measures and analyses the cost of sulphur emission control area (SECA) regulations that came into effect on the 1st of January 2015 in the BSR. Given the upcoming 2020 global sulphur directive, the role of the SECA regulatory costs analysis is vital in shaping global compliance. The specific measure of regulatory costs used the data of ship traffic in the BSR and their fuel consumption before and after the SECA implementation to estimate the change in shipping costs in the SECA area. The result indicates high costs, but not overly significant or negative as was predicted before the enforcement primarily because of the reduced cost of maritime fuel

Keywords: SECA Regulation; Costs of Regulation, Clean Shipping, Sustainability, Global sulphur cap

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1 Conceptual Foundation and Premises

Regulations compliance do not come cheap. There are costs attached to them, but policymakers pursue the implementation of regulations on the premise that the benefits would far outweigh the costs (Atkinson & Mourato, 2008). However, whether the outcomes are worth the costs remain a cause of disagreement among scholar up until now (Pray et al., 2005). Worldwide, governments try to analyse the economic implications of the regulatory decision and even though the OECD (2005) study shows that regulations have a minimal economic impact, the tendency of lawmakers to have an idea of the impact of their regulation has not reduced. Other broad sets of research have suggested that sometimes, regulations promote healthy competition in the industries that are related to such regulations (Demirguc-Kunt et al., 2003).

This study, in particular, focuses on the costs related to the International Maritime Organisation (IMO) adoption of an integrated approach in response to the growing environmental challenges to solving the issue of atmospheric sulphur pollution from shipping activities. The Sulphur regulation is in two-fold. The first was directed to the creation of the sulphur emissions control area (SECA) that prohibits shipowners to use fuel with sulphur content higher than 0.1% while the second is the global sulphur limit that pegs the sulphur content in marine fuel to 3.5% and 0.5% from 2020 in non-SECA areas (IMO, 2008;2013;2016).

Specifically, because they are often very strict, environmental regulations always generate controversial debates and arguments especially on their negative influence on economic growth (Benshalom, 2006). However, Porter & van der Linde (1995) explained that strict environmental policies would have an overall positive impact on any industry or sector in the end because they stimulate efficiency that would compensate the costs of the regulation and nurture innovation in new technologies. Lähteenmäki-Uutela et al. (2019) tested this hypothesis on the SECA regulation and found it to be true. Some industrial sectors even start to think of how to turn green and sustainable solutions in their business into a competitive advantage (Hunke & Prause, 2014). Despite this, regulations imply that the actors within that industry spend much revenue in their responses to regulations (Rugman & Verbeke, 1998). Some of the supporting highlights of this summary are that strong environmental regulations increase production costs, increase waste disposal dilemma and reduce capital flow (Hahn, 1998). On an economic point of view, industries are often localised in countries or environment with less stringent laws and low production costs (Beaton et al., 1995; Sunding, 1996).

With a contrary opinion, Lee (2017) reasoned that environmental regulations are supposed to support economic growth in addition to protecting the environment. However, designing a clear, comprehensible and well-organised regulation is a huge challenge, which is why policymakers follow up on the implementation, the appropriateness and the relevance of regulations. There is other literature supporting that environmental regulations do not make a significant economic impact. Xing & Kolstad (2002) said that the overall regulatory implementation costs could be small and neglectable. In other words, the positive impact of the regulations creates a balance between their costs and their benefits. Although there is no definitive blueprint to enforcing any regulations; ultimately, the critical effort is making them work for the stakeholders (Cole & Elliott, 2003).

Further, while other contradictory views put a direct negative relationship between strict regulations and economic factors like price, profit, foreign direct investment and others, consistent with previous studies, Olaniyi, Prause & Boyesen (2018a) explained that environmental regulation is not the only variable that affects the economy.

Therefore, as concluded by List & Co (2000) & Chung (2014), FDI might not have a significant or direct implication on the economy or the industry implied so it may not be true that regulations affect FDI or capital movement.

However, as shall be seen later in this work, environmental regulations such as the SECA involve dangerous financial undertakings relating to new and improved technologies, engines and factories upgrade suggesting that its implementation may influence production costs directly. For example, the SECA regulation has witnessed several compliance activities that have to do with installing abatement technologies like the scrubbers in close to a 100 ships in the BSR, engine upgrades needed to switch from high Sulphur fuel oil or fuel needed for engine flush to use the low sulphur fuel. In some cases, there has been a complete change of engines for the use of alternative fuel. While in respect to technological development for a region, the numbers may not look impressive but at least 7-9% of the ships plying the BSR water have had one form of abatement technology installed on board or have had a complete change of their engine to enable the use of alternative source of energy to run their ship (Olaniyi et al., 2018b). These activities affect production one-way or another, they either change the production cost or transfer them and whichever way, changes are made.

There are also discussions about how trade influences delivery of economic growth that focuses on whether improved economy can be attributed to local activities or not, it probes if actual growth can occur because of different types of investment that would stem from regulations that have more stringent effects on economic growth rate (Martin & Sunley, 1998). Likewise, business owners in the maritime sector were afraid that it could negatively affect the spatial distribution of the industries in the BSR and subsequently international trade flow. This issue was also intensively discussed when the SECA law was enacted; there were many debates on the potential impact on the competitiveness of the maritime companies within the BSR (EfficienSea2, 2016). It was speculated that the increase in costs could lead to the relocation of affected companies. Hämäläinen (2015) forecasted that paper machine and mill closures should be expected in Finland due to the SECA directive because global paper companies would react to the cost challenge by relocating their bulk paper production to the periphery closer to markets. There were also prediction of a possible cost increase for container shipping on the Asia-North Europe trade lane (an industrial sector sensitive to maritime transport costs) would range between 1.2% and 3.6%, however, OECD/ITF, (2016) reported an increase that did not exceed 0.5% in 2015 which have been stable over the years.

For the benefits of sulphur regulations to outweigh the costs, it will heavily rely on what reduction measure is being chosen by the stakeholders (Jiang et al., 2014). Fortunately, the SECA regulation is reported to have brought about significant emissions reductions (Johansson & Jalkanen, 2016; Lähtenmäki-Uutela et al., 2019a). In early research done in Denmark to measure air pollution in three monitoring areas to determine the sulphur oxide (SO₂) concentration in the air, SO₂ concentration had dropped to 47% during January- May 2015 compared to 60% which has been the average concentration during the same months in 2011-2014 (OECD/ITF, 2016). The port of Gothenburg also showed a significant decrease of 80% since the introduction of the 0.1% SO₂ emissions requirement in 2015. The same was seen at port-city of Hamburg and in about 4,000 tests conducted in the middle of the BSR Sea between 2016 and 2017 there was close to about 95% emissions compliance rate and about 85% compliance around the borders (Olaniyi, 2017).

The BSR ports also experienced changes due to the SECA regulations that first made it compulsory for ships berthing in the EU seaports longer than 2 hours to switch their primary engine fuel to marine gas oil (MGO) or marine diesel oil (MDO). Although this rule had its consequences for the ports in that many shipping lines schedules were reorganised at the bid to reduce their time of staying in the ports (Nugraha, 2009). A situation that has dramatically reduced in the BSR and would further reduce after the 0.5% 2020 global sulphur limit rule implementation.

When the SECA regulation was enforced in 2015, there was vigorous debate on the negative impact it would have on the maritime business environment. There were many speculations, simulations, and predictions. Because of the

upcoming 2020 global sulphur directive, the role of the SECA regulatory costs analysis is essential in shaping global compliance. Moreso, for the sake of other future legislative programs, it is crucial that policymakers have a clear view of the cost implications of the implementation of the SECA regulation on the environment and the business sector of the maritime sector. Thus, the authors focus on the costs of SECA regulation as exemplified by the BSR experience in this study.

It is almost four years of SECA, and the questions still linger; how have we fared? How expensive has the compliance been? To remove scepticism concerning costs, it is critical for stakeholders (especially the shipowners who are the direct target of the regulation), policymakers, and other regulators to have some idea of the costs and impacts of the regulation. Having this information will help them make better decisions about how the current system could be made more efficient, which new regulations should be implemented, and how much to invest in enforcement of regulations.

Curiously, while many reports have countered the previous adverse reports and predictions, up until now there are still no real time numbers regarding SECA regulatory costs, what we have available are only the ex-ante numbers. The study tackles this issue through a cost analysis of the SECA regulation for the BSR. Using the data of ship traffic in the BSR and their fuel consumption before and after the SECA implementation, the authors estimated the change in shipping costs and together with the previously calculated administrative burden, calculated the total cost for the SECA regulation in BSR. The authors desire that this study can serve as a benchmark for an efficient future regulatory system.

The remainder of this article is divided into four sections. The first describes regulatory impacts and how they are mapped. The second discusses the methodology of the study, and the third expands on the findings and the analysis. The last section provides the conclusion.

2 Charting the SECA Regulatory Impacts

Even though maritime transport is far less regulated than land-bound transport, there are still specific apprehensions commonly voiced with the costs that arise from regulatory compliance because they could run into millions of euros (Gollop & Roberts, 1983). This situation is also actual of shipping regulations whose implication on the activities of the maritime sector stakeholders are directly or indirectly linked to the economic decision that will ensue in their efforts to comply. Most authorities start regulatory projects believing that the investments are economically justified, i.e. the benefits to society supersede the costs (Renda, 2017).

For SECA, the choice for compliance had depended on the time the ship 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 became the lowest cost option (Carr & Corbett, 2015). In their efforts to reduce the compliance costs, the European Commission also put forward a set of measures to support the promotion of innovations for new abatement technologies (IMO, 2013). For abatement options, the spread between marine gas oil and heavy fuel oil determines the efficiency of a compliance option. In the case of a scrubber installation, this means that when the spread between MGO and HFO is considerably high, a shipowner would consider the abatement option since the scrubber investment yields a higher net present value than the use of MGO (Jiang et al., 2014; Atari et al., 2019).

Since investments, choices have a significant effect on a company or even a cluster; wrong investment decision can cause adverse setbacks and warrant years of recovery (Benetto et al., 2014). Strategic actions for regulatory compliance is thus very crucial (Demil & Lecocq, 2010). This dilemma forced the shipowners and ports to look for innovative ways to evaluate the financial attractiveness of their options for sulphur reduction and at the same time stay afloat profit wise (Wiśnicki et al., 2014). Their predicament of investment choices and sudden market changes

lead to intensive capital investments and increased operational costs associated with new and changed personnel, materials purchased, legal costs, paperwork.

For sustainability and effectiveness, enforcement of the SECA regulation is critical. The targeted SO_x emission reductions will only be a dream if regulation is not enforced. This can disrupt shipping markets especially if ship owners see that that regulation is slacked, they can become complacent if they believe there is little or risk them if they are not compliant and put those who obey the regulation at a disadvantage over those who do not. Hence, the need for a level play especially when the cost to comply is put into consideration (OECD/ITF 2016). In order to ensure sustainable compliance, the government must take the responsibility of creating a balance between the regulations and their implementation through the measurement of the costs and benefits done to reduce the open loop and areas of financial wastage.

One of the approved methodologies used for the assessment of regulatory costs is based on Renda et al. (2013). In their work, they started with mapping out areas of regulatory impact, which they first classify as direct and indirect costs. Direct costs can be further classified into compliance costs and hassles costs that are linked to waiting time, delays, corruption that are difficult to identify, quantify, or monetise.

The compliance costs are categorised into regulation charges, substantive compliance costs, and administrative burden. Regulation charges are costs such as taxes, levies and other related fees. Substantive compliance costs are the total sum of three types of cost (i.e. capital, operational and financial). Capital costs (CAPEX), occurs when it requires acquisitions or upgrades of physical assets such as property, industrial buildings or equipment. Operational and maintenance cost (OPEX) represent variable costs that appear in the form of annual expenditures for wages, energy, materials and supplies, purchased services, and maintenance of equipment. Financial costs are investment merge for OPEX, which is an ongoing cost for running a product, business, or system whenever a new legal provision changes the structure of the working capital (OECD, 2005).

Administrative burdens are costs incurred whenever a company is confronted by the necessity to provide information that arises by the operation of law such as the SECA, which include costs that are obvious and can be objectively measured (e.g., the cost of work, material, services such as bookkeeping and so on). In other words, administrative burdens are the part of costs that businesses sustain because they are a regulatory requirement. This information is irrelevant regarding an activity that a business is required to perform because of a regulatory information obligation if the business would also perform such acts in the absence of such obligation, i.e. administrative activities that the businesses will continue to conduct if the regulations were removed (Olaniyi & Prause 2019). For example, the SECA administrative burden related to shipowners have to do with recording into bunker delivery notes (BDN); time spent recording (fuel sample, scrubber emissions logbook, fuel switchover before entering SECA, waste disposal logbook). Others are training and awareness of staff (also include hiring), off hiring days, i.e. installations and maintenance, time to write applications for subsidies, grant and loans related to SECA investments and other specified obligations. They can be little fragments of activities that are not only time consuming because of their repetitive nature but can also be costly if care is not taken.

A complete regulatory cost analysis should consider all kind of opportunity costs related to compliance, i.e. in the case of SECA regulation the additional fuel costs for SECA compliant fuels as well as the costs for abatement investments in case of using non-compliant fuels, since these costs that would be absent in the absence of the regulation. In the context of green and environmental issues, these costs are also known as “incremental cost” that does not involve the cost of business as usual (GCF 2018). These costs are calculated on the bases what type of cost they are, i.e. administrative, compliance costs, non-financial costs, directly or indirectly spent and frequency of costs (i.e. one-off or recurring). In the case of SECA, the price difference between the high sulphur fuel oil (HFO) and the SECA compliant fuel is the opportunity cost related to compliance. The same goes with the time spent on ship retrofit otherwise know as the off-hiring days”.

Indirect costs are changes in markets or experiences of end-users, government agencies or other stakeholders who are not directly related to the regulation calculated based on transferred costs to the consumer. It is also a type of cost that is transferred to the end users. In short, indirect costs are incurred when the regulation modifies or alters the market structure usually due to several reasons (Pray et al., 2005). An example of an indirect cost is the installation of a telephone line in a company, which may be needed to set up an enquiry line but because the telephone is also used for other purposes, the cost of connection is not added to the cost of regulations but is included in the overall overheads (Winter & May 2001). Bringing this to the SECA regulation and shipping, it could mean the need to buy a new ship because a shipowner wants to expand his business, but because of the SECA regulation compliance, decides to build the new ship with an LNG engine. Since the shipowner would still build a ship regardless of SECA for his expansion, the cost of the newly built ship is not included as a direct cost, but the difference between the cost of installing a regular engine and the LNG engine becomes the direct cost and is deducted as such.

3 SECA Regulatory Costs Analysis

Regulatory costs are more evident and measurable when concentrated on a particular group of stakeholder that are associated with regulation (Deringer, 2014). In earlier work, Olaniyi et al. (2017) categorised maritime stakeholders to which extent the SECA regulations and the analysis impact them showed that the shipowners are the most affected followed by the ports and port authorities. The least affected are the least public authorities and ministries, and one does not need to wonder why little or no work has focused on them since the inception of the law. This study is dedicated to the cost of SECA that relates to the ship owners.

The SECA related cost analysis for the BSR takes into account the data of ship traffic in BSR as well as the maritime fuel consumption. HELCOM, the Helsinki Commission monitors environmental and safety-related aspects of BSR shipping and publishes the results periodically. This research uses two relevant references from HELCOM, namely the estimations of shipping emissions for the year 2015 that are based on over 1.65 billion AIS-messages of about 8,000 IMO registered commercial ships as well as the HELCOM report on maritime activities in BSR. Mainwhile, Johansson and Jalkanen (2016) calculated ships emissions and their total maritime consumption for 2015 in the BSR based on the AIS position data using the Ship Traffic Emission Assessment Model (STEAM) of Jalkanen et al. (2009;2012;2016) and Johansson et al. (2013). The HELCOM (2018) report on maritime activities in BSR further delivered an overview of daily maritime traffic in Baltic Sea as well as an overview on the different types of ships plying in BSR yielding the study central two key figures:

1. The average number of daily plying ships on BS: ca. 1500 ships
2. Total fuel consumption for shipping in BSR: ca. 5 million tons

The two HELCOM reports also allocated the consumed maritime fuel to the different ship types. With this data, it becomes easy to know which compliance method ships in BSR are applying, especially the number of scrubbers and LNG installation. Thus, the research methodology extrapolates the maritime fuel consumption to the later years. It splits up the daily plying ships on BSR into those that were using the SECA compliant fuel like MDO/MGO before 2015, those that switched from high Sulphur fuel oil (HFO) to (ultra) low sulphur fuel (ULSFO) and those that used abatement investments like scrubbers or LNG. Consequently, the additional SECA-related costs are calculated by multiplying the number of ships proportionally distributed according to their method of compliance (to evaluate their fuel consumption) by the specific compliance costs per fuel ton and ship.

Costing Model and Assumptions

The estimation of additional fuel costs related to SECA regulations requires the determination of several parameters. It is first essential to know the description of fuel use before SECA, i.e. fuel use in the year 2014 and before, and

the situation from 2015 after SECA implementation. There were already ships, which were using the low sulphur fuel and did not have to invest after SECA. Thus, only the ships that had to switch from HFO to low Sulphur fuel or ships that had installed one form of abatement technology from 2015 incurred additional SECA costs. Putting it differently, the additional costs due to SECA implementation is calculated by comparing the situation before SECA, i.e. 2014, before, and after SECA, i.e. from 2015 to determine the number of ships that used SECA compliant fuel MGO or Diesel before SECA. All other ships that switched from HFO to other cleaner fuels or that installed abatement technology had to accept additional costs due to SECA.

The Helsinki Commission (HELCOM) latest published reports gained from the AIS data of ship traffic on Baltic Sea on maritime activities, HELCOM (2018) revealed that around 8000 IMO registered ships visit the BSR annually and about 1500 of those ships ply the BSR daily. Nearly half of these ships are cargo vessels, ca. 20% are tankers, and the rest are passenger ships, ferries, container ships and other vessels. Olaniyi, Atari & Prause (2018b) investigated the current abatement devices on BSR ships so that HELCOM table of the daily plying ship is shown in table 1:

Table 1: Distribution of BSR ships according to SECA compliance Method

Ship type	Percentage	#daily plying	#Scrubber	#LNG	#SECA fuel
Cargo	48%	720	8		712
Tanker	22%	330	1	2	327
RoRo & RoPax	8,5%	128	69	16	43
Service	5,2%	78			78
Container	4,3%	65	5		60
Fishing	4,1%	62			62
Others	7,4%	117			117
Sum	100%	1,500	83	18	1,399

Source: Adapted from HELCOM (2018)

Then, according to Jalkanen et al. (2016), the 1500 ships that daily travel on daily travel on the Baltic sea consumed about 5 million tons of maritime fuel in 2015. Using the detailed HELCOM (2016) view of fuel consumption by ship type, the maritime fuel consumption according to the daily plying ships on the Baltic Sea was evaluated. Already, the fuel study of Trafikanalys (2016) for the Baltic Sea after SECA had calculated the total consumed maritime diesel/gas oil percentage in BSR in 2014 to be about 20%, a result comparable with another maritime fuel mix from other studies (i.e. Concawe 2016; IEA 2017). In addition to that, expert interviews confirmed that outside SECA areas or without SECA regulations, shipowners had always used MDO/MGO, in general, to complement HFO for special purposes but not to propel exclusively commercial vessels. The reasons have been that the HFO has special physical properties that make it necessary to complement its use with diesel (Stopford 2016). Thus, the results indicated that there were no remarkable changes in the number of a number of the daily plying ships on the Baltic Sea after eliminating MDO and MGO from the annual maritime fuel consumption in BSR shown in table 2.

Table 2: Annual maritime fuel consumption in BSR (2015)

Million fuel tons	2015 fuel	2015 Diesel	2015 Scrubber	2015 LNG	2015 SECA fuel
Cargo	0.869	0.174	0.008	0.000	0.687
Tanker	1.094	0.219	0.003	0.005	0.867
RoRo & RoPax	1.472	0.294	0.635	0.147	0.396
Service	0.040	0.008	0.000	0.000	0.032
Container	0.758	0.152	0.047	0.000	0.560
Fishing	0.048	0.010	0.000	0.000	0.038
Others	0.692	0.138	0.000	0.000	0.554
Sum	4.973	0.995	0.692	0.153	3.134

Source: Adapted from HELCOM (2016)

The consumed fuel per tons in 2015 is proportionally distributed based on the number of daily plying ships and their choice of SECA compliance. For example, in the case of cargo vessels that are equipped with the scrubber, it is assumed that 8 of these scrubber vessels consumed “8/720” of the non-diesel fuel tons in 2015. This action gave the distribution of the consumed fuel tons according to the ships’ compliance methods whether Diesel/MGO, scrubber, LNG or ultra-low sulphur fuel oil (ULSFO) that we name in the table as well as in the sequel as SECA fuel. Due to the neglectable number of other modes of SECA compliance method, table 2 depicts a fair representation of the maritime fuel situation in 2015.

Next, after identifying the ships and the distribution of the different maritime fuels or abatement technologies used, it becomes possible to evaluate the additional costs of SECA compliance. The consumed MDO and MGO fuel before SECA is first is assumed to be zero (0 €) per ton since there are was no fuel switch. Therefore, no additional costs for SECA compliance can be recorded in this regard. For the HFO users using the scrubber technology, the study used the results of Olaniyi et al. (2019) that calculated the average additional costs for scrubbing per one ton of HFO with ca. 37€ per. In a comparable approach, BPO (2017) estimated the additional costs of using LNG to propel ships to ca. 41€ per ton to open the option to evaluate the volume of consumed fuel switch from HFO to low Sulphur fuel fuels.

As might have been expected, the evaluation of fuel switch to low sulphur fuel is linked to a couple of issues. The first is to decide the type of HFO under consideration since HFO has different viscosities with prices. The second is related to the type of the SECA-compliant fuel used from 2015 since also there are different options of low Sulphur fuel (i.e. ULSFO, MGO or MDO), which also have different prices. Unfortunately, a peep into public statistics regarding the distribution of consumed fuels does not lead to satisfying results for the BSR, so the authors decided to carry out expert interviews to obtain reliable results realised from Tallinn and Rostock.

Interviews outcome showed that it is within the limit to assume that over 90% of used HFO represents IFO380 that also enjoys the lower price compared to the IFO180. Similarly, answers regarding the low sulphur fuel revealed that the preferred fuel is one with the lowest price, which is the ULSFO. Consequently, the additional costs of the switch from HFO to the SECA-compliant fuel (SECA fuel) are evaluated by the price spread between the HFO IFO380 and the ULSFO.

A spread calculation for the years from 2015 to 2018 is thus realised easily by calculating the average spread per ton that leads to the following figures (table 3) using the Rotterdam daily fuel prices (ECG 2019):

Table 3: Fuel price spread calculation between IFO380 and ULSFO/MGO (2015 – 2018)

Spread	2015	2016	2017	2018
Mean ULSFO-IFO380	186.26 €	150.43 €	151.92 €	182.83 €
StD ULSFO-IFO380	24.53 €	20.28 €	18.27 €	19.19 €
Mean MGO- IFO380	214.12 €	170.39 €	167.58 €	210.99 €
StD MGO-IFO380	23.62 €	20.20 €	19.84 €	19.38 €

Source: authors own calculation

Atari and Prause (2018) and Olaniyi et al. (2018) analysed the statistical properties of the maritime fuel spreads and were able to show that the spread is an underlying normal distribution, which makes it possible to calculate confidence intervals together with their characteristic error probabilities. However, as shall be seen later in the study, the authors consider only the spread between the ULSFO and IFO380 HFO since shipping is a price sensitive

business and the ships that used the HFO before 2015 are still able to operate with ULSFO, as most shipowners preferred the ULSFO compared to MGO due to lower price.

The next stage of the analysis deals with the issue of forecasting fuel consumption from 2015 into the following years. Here, one often-used approach is to extrapolate the increased maritime traffic from 2015 into the following years with fuel reductions from energy savings from new technologies (Kalli et al., 2013).

Finally, the consumed maritime fuel in 2015 was extrapolated to the following years by assuming an annual maritime traffic increase of 1.5% together with an annual increase energy efficiency of 2% within the whole BSR fleet according to Kalli et al. (2013). Thus, the 2016 total fuel consumption in BSR, as well as the fuel consumption of the following years, are forecasted (table 4) by taking the current annual fuel consumption in a million tons and multiplying it by $1.015 * 0.98$, i.e. $4.947 = 4.973 * 1.015 * 0.98$.

Table 4: Fuel consumption in the BSR (2015-2018)

Million tons	2015	2016	2017	2018
Fuel consumption	4.973	4.947	4.920	4.894
Annual Diesel part	0.995	0.989	0.984	0.979
Non-MGO/MDO fuel	3.978	3.957	3.936	3.915

Source: authors own calculations

The most critical data for the estimation of the total fuel cost for shipping in BSR is the MGO/MDO maritime fuel consumption estimated at 20% of the total fuel consumption. Further, because of the higher price for MGO/MDO compared to the ULSFO, this percentage is assumed to stay almost stable over the years (2015 – 2018).

4 Findings and Discussion

Based on the previous reflection it becomes possible to tackle the question of additional costs of SECA regulations from 2015 to achieve, the following figures (table 5):

Table 5: Additional costs in million € of SECA regulations in 2015

	2015 total fuel	2015 Diesel	2015 Scrubber	2015 LNG	2015 SECA fuel
Million tons in 2015	4.973	0.995	0.692	0.153	3.134
Add. Costs per ton		0.00 €	37.00 €	41.00 €	186.26 €
Million €		0.000	25.604	6.273	583.739

Source: authors own calculations

Hence, the calculation sums up to about 616 million € as total additional costs for SECA compliance in 2015. By dividing the additional compliance costs by the consumed fuel in BSR in 2015, the calculation also yields average additional compliance costs per ton of consumed fuel of about 124€ due to SECA regulation. With the same approach, the additional SECA compliance costs for 2016 – 2018 can be estimated which is done in table 6:

Table 6: Additional costs in millions € of SECA regulations (2015 – 2018)

	2015	2016	2017	2018
Fuel consumption per million ton	4.973	4.947	4.920	4.894
Non-MGO/MDO fuel	3.978	3.957	3.936	3.915
Mean ULS-IFO380 Spread (€)	186.26	150.43	151.92	182.83
Annual add. Fuel costs (million €)	615.616	500.641	502.608	563.940

Source: authors own calculations

By taking the average over the years 2015 – 2018, the calculation yields additional annual costs of SECA compliance to be about 550 million € for the BSR which equals to about 110 € additional costs per consumed fuel ton for shipping in BSR. As discussed earlier, following Atari & Prause (2018) study, the price spread of maritime fuel is assumed to be normally distributed, so it is possible to fix confidence intervals to determine the real additional costs from the study estimations with a given error probability.

Particularly for reliability, this result has to be compared to findings of other works done before the enforcement of SECA regulations in 2015. Kalli et al. (2013) estimated the additional SECA compliance costs to be between 400 – 700 million € per year and Johansson & Jalkanen (2016) also gave a more technical approach to the same study. These results are entirely in line with our research estimating the annual SECA compliance costs based on real costs from 2015 to 550 million € which represents precisely the middle of the confidence interval of Kalli et al. (2013). Our research also points out that the ex-ante predicted additional SECA compliance costs by renowned experts that ranged up to several billion EURO was by far too high and do not cope with the reality (Olaniyi & Prause 2019). The same argumentation applies to the before 2015 estimated annual additional SECA compliance costs between €5 and €30 billion by 2020 that seems not to be reasonable when comparing our results (Platts, 2016). By summing up all results, it turns out that the estimations of this research fits well to the already published forecasts and helps to correct unrealistic estimations by using real data from the first four years of SECA experience in the Baltic Sea Region.

In order to give a full picture concerning the additional SECA compliance costs another thing to be under consideration also the costs for the administrative burden of SECA regulations. These costs have been investigated by Olaniyi & Prause (2019) to an annual amount of about 2.9 million € for the BSR. Thus, by taking under account also these costs, the estimation gives total additional costs for SECA compliance of annually in table 7:

Table 7: Annual total additional costs of SECA compliance

Total annual average costs	Million €
Additional annual fuel costs	550
Annual administrative burden	2.96
Sum	553

Source: authors' own calculations

In 2014, the average HFO price showed a ton price of IFO380 in Rotterdam to be around 532€. However, with the enforcement of the SECA regulations in 2015, the majority of the HFO fueled ships in BSR could switch from HFO to ULSFO that has comparable properties with the HFO but is SECA-compliant. An analysis of the price range of ULSFO at Rotterdam between 2015 and 2018 showed an annual average price per ton of 450€ (2015), 364€ (2016), 456€ (2017) and 584€ (2018). It was at the middle of 2018 that the ULSFO prices reached and further partly exceeded the HFO price so that the nearly first four years of SECA implementation passed by with the ULSFO price below the maritime fuel prices before SECA. This development kept the maritime fuel costs below the price level in 2014 so that there was no need to increase maritime transportation price.

The future development of the oil price is, of course, open but currently, the fuel price still ranges around the 2014 annual average. This suggests that the shipping companies that avoided investments in abatement technologies could end up falling into a strategic trap of a further increase in oil prices and would not be able to keep up with their costs. This situation can force an increase in transport prices that can weaken their competitiveness in the maritime industry. On another hand, shipowners who had decided early to invest in SECA compliant abatement investments may enjoy increasing benefits due to higher margins from the opportunity to use cheaper HFO (Atari et al., 2019; Olaniyi et al., 2019).

Practically, regulations usually do not show promising economic outcomes or a balanced cost/benefit; however, policymakers proceeded with the implementation if end-result is somewhat “bearable for the actors (Hammitt, 2000). There has been evidence to show that regulatory costs are often overestimated in conservative ways. For example, in their study, Goodstein and Hodges (1997) saw that the costs of proposed regulations regarding asbestos, benzene, coke ovens, cotton dust, strip mining, and vinyl chloride were significantly overestimated (Hammitt, 2000), same attitude witnessed in the maritime industry at the implementation of the SECA regulations. A way to look at it is that the costs of regulations are often passed down to the end-users to forestall any loss the companies related might have, although this is not seen as a direct impact since they involve value, trade-offs but leaves the end users with less disposable income (Keeney, 1997).

Though maritime sceptics did not receive the SECA regulation with great enthusiasm, so far, the outcome has been impressive and a high level of compliance witnessed in the BSR (Lähteenmäki-Uutela et al., 2019a; b). As stated above, one reason for these observations can be attached to the decrease in the oil price from 2014 that lead to lower maritime fuel costs and lasted until 2018. Thus, the economic impact of the SECA regulation showed that there were less dramatic impacts than was predicted including possible modal shifts, changes in transport patterns and logistics pricing issues (Olaniyi et al., 2018a). Already at the begin of the EnviSuM project, Olaniyi (2017) highlighted that based on a survey among maritime stakeholders in BSR there is no evidence to show increased prices in BSR logistics sector, a result further confirmed by the statistical analysis of foreign trade flows and maritime transport by Wenske (2018). Besides, latest results on the estimation of the administrative burden by Olaniyi & Prause (2019) and a real option based evaluation of abatement technology investments by Atari et al. (2019) also showed a neglectable impact on the maritime industry. Notwithstanding, for a more profound cost-benefit analysis of the SECA regulations in BSR, these costs have to be paired into a relationship with the benefits. There are several benefits attached to the Sulphur regulations in the BSR, some of those include the increase of the air quality within BSR and the reduction of the annual emission of Sulphur into half. However, one benefit with the most consequence is the 1000 less premature deaths experienced due to cleaner air (Prause et al., 2019) and a push of blue growth innovation activities in BSR investigated by Lähteenmäki-Uutela et al. (2019a;b).

5 Concluding Remarks

This study attempted to provide the calculations on the costs of SECA regulation post-2015 enforcement. Despite some *a posteriori* estimations done before its implementation and shortly after, until now, the empirical study on the estimation of the total cost analysis for ship operators is missing. This paper fills this gap, and the underlying data in the related research were elaborated within an EU funded project EnviSuM - Environmental Impact of Low Emission Shipping: Measurements and Modelling Strategies.

Many extensions of the SECA results are readily apparent, as expected, regulations would always have a direct impact on all actors involved but more heavily on some than for others. This is why sometimes when regulations are designed to be general for all within the same industry; they impose burdens on a particular sector more than other as the case seen with the shipowners and other stakeholders within the same cluster. On the positive side, the SECA regulations seem to have created more innovative technological awareness among the shipowners since its enforcement.

It has been over three years after the SECA regulations implementation in the BSR, and a renew focus is on the 2020 global Sulphur limit, a law which affects a broader audience and culture than the SECA. The findings of this study surely have important policy implications in helping to provide and design effective future implementation strategies of regulatory instruments that ensure sustainability. Nevertheless, a question remains on whether there is a country-specific advantage in the cost of regulations although the BSR maritime sector have made much effort to control emissions issues, their regulations and their related costs.

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