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Published: 02/05/2018

*Document Version*
Peer reviewed version

# Cost effects of maritime environmental legislation – A mixed methods study on the impact of regulatory compliance

Research Paper submitted to WCTRS – SIGA2 – Maritime and Ports

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**Compliance costs with maritime environmental legislation – A mixed methods study**

Abstract
The maritime shipping industry is an interesting subject for legislative impact studies. It is particularly well placed to avoid legislation due to its international nature, relocatable assets, and challenging enforcement of rules. Increased political measures to protect the marine environment meet an industry characterized by a decade of strained financial resources, excess supply of capacity and consolidation. Non-compliance with environmental rules is one path companies might take to stay competitive within their industry and vis-à-vis other transport modes. Around 5-15% of industry participants are believed by shipping experts to neglect rules on vessel-source pollution intentionally or unintentionally. The objective of this study is to identify and quantify cost effects of maritime environmental legislation, relate these with company characteristics like company size, average vessel age, or area of operations, and to investigate the impact of regulatory compliance.
A mixed methods design was employed to develop both a theoretical model of compliance costs effects and to quantify the effect sizes of determinants identified. In a first step, twelve in-depths exploratory expert interviews were conducted with key stakeholders within the shipping industry and analyzed by way of qualitative content analysis. A theoretical framework emerged that was evaluated, strengthened and fed with quantitative data from questionnaire data from 120 shipping companies active in the North and Baltic Sea area. Partial least squares analysis was conducted to determine compliance cost effects for different types of shipping companies. It was found that solely organizational capacities played a significant role in determining compliance behaviour, while individual motivations, exterior determinants and company characteristics like size and vessel age showed no significant effect on compliance.
European transport policy making depends on scientifically sound studies on the impact of policy on different transport sectors. An in-depth impact assessment on environmental legislation for the maritime industry, with the specific focus on company characteristics, does not only provide insights into this specific industry, but highlights mechanisms applicable to environmental policy making in other transport sectors and helps in building a transport policy that takes into account compliance issues, company characteristics and the interconnectedness of different transport modes - for a sound response to the tragedy of the commons.

Keywords—regulatory compliance, compliance costs, marine environmental protection, mixed methods research, clean vessel operations, North and Baltic Sea area.

## Introduction

This paper studies the impact of legal compliance on compliance costs with maritime environmental legislation as part of a more comprehensive research project on compliance cost effects. The commercial shipping industry is characterized by increased possibilities to avoid regulation via moving assets that may easily be relocated to other jurisdictions, varying levels of enforcement of international rules in port states, global commons in the form of international waters where enforcement is hardly possible, at times colliding interests between flag and port states as regards environmental protection and offering low-cost solutions to shippers and, according to Tan, 'a generally secretive and fragmented nature'. (Tan 2006, 6) Regulatory avoidance and free-riding are inherent to the sector, a recent OECD report argues. (OECD 2014, 86) This international, hard-to-regulate-or-control industry is increasingly faced with legislative endeavours to protect the marine environment, particularly in specially protected areas, like the North and Baltic Sea. If shipping companies' decisions are based on cost-benefit considerations, it is likely that incentives to violate cost-incurring environmental rules will increase with cost pressure.

The researchers briefly discuss advances in maritime environmental legislation and their cost effects, the concept of regulatory compliance and the associated rational choice approach. A model of compliance determinants developed inductively from qualitative data analysis and a review of prior studies is presented. A concise presentation methodology applied is ensued by a discussion of results of the quantitative study, involving partial least squares analysis of questionnaire data. Statistical results are discussed and compared with theoretical concepts. The present study serves to enhance knowledge of compliance behaviour and contributes to a fit-for-purpose assessment of existing and future maritime environmental legislation.

Novelty of this study stems from both the theoretical model development and empirical testing of the model. The path model is both based on literature review – leading to a comprehensive model of compliance drivers specifically focused on the shipping industry – and knowledge gained from 12 in-depth expert interviews to enrich and refine that model. Empirical testing is done with data from 120 questionnaires distributed to owners and operators of commercial vessels in the North and Baltic Sea area. This research is relevant in providing a consolidated, consequentially organized model of determinants of compliance for the shipping industry based on prior studies, qualitative content analysis of primary interview data and statistical analysis of primary questionnaire data. Special considerations applicable to the shipping industry are explored and the model developed stands as a first to explain compliance behaviour with maritime environmental legislation.

## Maritime environmental legislation in the North and Baltic Sea area

Environmental legislation to protect sea areas from harmful vessel-source emissions has received increased political attention in recent years. With the aim of fostering cleaner ship operations, stricter legislation has been passed on the national and international level. Rules on sulphur and nitrogen oxide emissions, the introduction of invasive alien species through ballast water and other sources of pollution are currently being phased in or will soon come into force in the North and Baltic Sea area. Examples of such rules sorted by type of pollution are listed in Table 1. Legislative measures are demanded to show positive effects, e.g. on the health of the marine environment and society, in excess of potential negative economic and social effects, e.g. in the form of more expensive transport services. (Marine Strategy Framework Directive, Art. 8). Compliance may lead to more efficient operations. It is however in sum likely to increase costs to industry, thus raising the likelihood of deviant behaviour.

| | |
|---|---|
| **Oily water** | Applicable from 2002/2004/2005 |

| | |
|---|---|
| (Prohibition of all operational discharges of oil) | (IMO 1973; MEPC 2002; MEPC 2004; MEPC 2005) |
| **Garbage** (Prohibition of all operational discharges of garbage) | Applicable from 2000 (MEPC 2013a; MEPC 1991; European Parliament and European Council 2000) |
| **Hull coatings** (Prohibition of all hull coatings containing TBT) | Applicable from 2008 (IMO 2008) |
| **Air pollution I** (Limitation of the amount of sulphur in fuel to 0.1%) | Applicable from 1 January 2015 (IMO 2005) |
| **Air pollution II** (Mandatory energy-efficient operations lowering $CO_2$ emissions) | Applicable from 2019 (MEPC 2013b) |
| **Air pollution III** (Mandatory nitrogen oxide tier III requirements) | Applicable for new-buildings from 2021 (MEPC 2015) |
| **Sewage water** (Prohibition of all discharges) | Applicable from 1 June 2019 for new vessels and 2 June 2021 for existing vessels (MEPC 2011) |
| **Ballast water** (Mandatory management systems) | Applicable from 8 September 2017 (IMO 2017) |

Table 1. Examples of maritime legislation by type of pollution applicable on the North and Baltic Sea

***Costs of compliance with maritime environmental legislation***

Estimated cost effects of maritime environmental legislation for vessel operations on the North and Baltic Sea stem from literature review and interview data. Prior studies considering the combined cost effect of several environmental legal rules are difficult to come by. The sole study identified that accumulated costs of several measures is a study by the OECD. Researchers estimated compliance costs in 2003 to reach around 3.5% to 6.5% of a ship's operating costs. (OECD 2003, 5) As the study is quite dated, results may no longer be applicable. More recent studies usually consider a single legal endeavour. Several studies could be identified presenting cost estimates for compliance with stricter sulphur levels. Sampson et al. argue that the cost of compliance lies in the price differential between full compliance and non-compliance with legislation. (Sampson et al. 2016, 300) Taking sulphur legislation as an example, the costs of compliance are represented in the price difference between distillate fuel and high sulphur fuel or the write-down for a scrubber investment. Depending on study design, total vessel operation costs in North and Baltic are estimated to increase by 6% to 40%. (COMPASS 2010; Notteboom, Delhay, and Vanherle 2010) Studies on cost effects of NOx tier III requirements foresee additional increases of 0.6% to 2.5% (COMPASS 2010) or 6,500 to 400,000 EUR per vessel. (EPA 2012) Installation costs for a ballast water treatment system are given at 100.000 to 1 million USD plus operating costs of 0.01 to 0.2 USD per ton of ballast water treated. (GEF-UNDP-IMO GloBallast Partnerships Programme and IUCN, 2010) As study designs differ, these costs may not be aggregated, but the approximate range of compliance costs becomes evident. Other environmental rules are likely to be less costly, but add further pressure on an industry characterized by overcapacities. (Morley 2016) Scorpecci estimates that compliance costs in 2004 reached up to 20% of the vessel's revenue. He argues that with additional legislative measures, compliance costs will likely increase by 1.5 up to 3 times the amount of 2004 thus increasing the incentive for non-compliance. (Scorpecci 2004, 7) The 2003 OECD study calculated possible savings of up to $400,000 a year for a non-compliant vessel compared to a fully compliant one. (OECD 2003, 5) With new maritime

environmental rules becoming effective in the next years, behaviour formerly not unlawful will be subjected to fines, increasing the risk of non-compliant behaviour.

Primary interview data suggests that while total costs and voyage costs stayed roughly the same or increased only slightly in 2015-2017, voyage costs are expected by most shipping companies to increase by some 5-20% until 2022. (see graph 1, n=69) Environmental legislation is likely playing a role in this increase. With respect to individual measures, graph 2 (n=47) shows results of a ranking by most expensive measure, indicating clearly that air pollution legislation (specifically measures to curb SO2 and NOx emissions), ballast water legislation and legislation on the reduction of CO2 emissions are deemed the most expensive by the industry, while legislation on noise pollution is deemed the least expensive (which makes sense as there are of yet no measures in place), followed by antifouling legislation. A ranking on cost expectations for the years until 2022 (see graph 4, n=35) shows that the costs of ballast water legislation are expected to surpass the costs of air pollution legislation. An increased importance of measures on CO2 reduction may also be seen from the graphs. Interestingly, despite an effect on costs, legislative compliance is no significant determinant of freight rates for shipping companies. Other factors, like changes in the demand for transport capacity, changes in fuel costs irrespective of environmental legislation, and changes in cargo-handling costs, are having a greater influence on costs and prices of shipping companies than environmental legislation.


Graphs 1-4: Total cost development and voyage cost development (2015-2022), Ranking by most expensive legislative measure (2015-2022), Ranking of cost factors by influence on freight rates (2015-2018) (Own data)

***Costs of non-compliance***

Following rational choice theory as explained below, a shipping company will weigh the costs of compliance against the costs of non-compliance. Bell et al. argue that the costs of non-compliance have been increasing in recent years. They discuss several categories of non-compliance costs, namely criminal liabilities (with rising fines and a rising willingness of

regulatory agencies to prosecute), administrative sanctions (including suspension of licenses), clean-up costs (after pollution incidences; often exceeding the fines), civil liabilities (rather unlikely in the case of shipping), and adverse publicity. (Bell, McGillivray, and Pedersen 2013, 39 et sqq.)

## Regulatory compliance

### *Definition of regulatory compliance*

The concept of regulatory compliance applied here follows a letter of the law approach as dissociated from behavioural definitions used in the social sciences and is defined as the conformity of an organization's behaviour with a prescribed legal rule. (Mitchell 1994, 30) Non-compliance is thus a deviation from prescribed legal behaviour. To evaluate cost effects of legislation however, changes of behaviour within the organization leading to cost increases need to be considered, even if they do not lead to a fully compliant organization. Raustiala and Slaughter provide a helpful definition stating that at its roots compliance is a concept of causality looking at the behavioural influences of legal rules. (Raustiala and Slaughter 2002, 539) Behaviour is relevant to the present research if it is directly or indirectly induced by maritime environmental legislation *and* leads to costs in terms of money, time, or other resources. Where legislation has no effect on costs it can be assumed that incentives for non-compliance are nil.

### *Compliance and rational choice*

Following a law and economics approach, this work links regulatory compliance to rational choice theory. The principle of compliance as a cost-benefit calculation has been described in 1968 in a fundamental work on the economics of crime by Becker and defined further by his student Ehrlich. (Becker 1968; Ehrlich 1996) Applying a related definition by Posner, shipping companies are likely to 'economize by buying less of a good or commodity when its price rises' (Posner 1974, 763), specifically are likely to invest less in compliant behaviour if compliance becomes costlier, assuming that costs of non-compliance stay the same. Simpson and Rorie present compliance behaviour as a rational choice of companies between several alternatives. Non-compliance thus occurs where the benefits of unlawful behaviour outweigh the costs of compliance. (Simpson and Rorie 2011, 60 et sqq.) In this context it needs to be noted that non-compliance may both be a product of action or inaction. (M. A. Cohen and Simpson 1997) When applying rational choice theory to compliance, limits to rationality need to be considered, like a lack of access to information, individual characteristics of companies, and circumstances. Simpson and Rorie thus propose an objective utility approach signifying that costs and benefits are 'perceptual, rather than objective'. (Simpson and Rorie 2011, 61) Perceived costs and benefits of a certain legislative endeavour may differ between companies and may lead to dissociated behavioural outcomes. Rational choice theory tells us that shipping companies' incentives to violate the rules are likely to increase with augmented cost pressure. Environmental pollution being an externality, companies would generally only take their individual costs, not the costs to society, into consideration. (Phaneuf and Requate 2017, 5)

### *Practical relevance of non-compliance with maritime environmental legislation*

Studies on environmental compliance exist for organizations in general (i.e. writing on corporate crime), but are very rare for the commercial shipping industry, with the exclusion of fisheries, where the study of overfishing has received increased attention. This research gap may be due to the hard-to-grasp characteristics of the industry discussed above. A rare exception is a 2003 OECD report, estimating that around 10-15% of the world fleet is operated

'in full contravention to the IMO's body of environmental regulations'. (OECD 2003, 4). These numbers may in the meantime have become outdated and the report provides no distinction between different company sizes, flag states, areas of operation or other, but gives a vague indication that non-compliance with maritime environmental legislation may still be of relevance. Further evidence on the practical relevance of non-compliance stems from the annual reports of the Paris MoU on Port State Control. The 2016 report shows that pollution is the number three reason for detention of vessels in European harbours. Non-compliance is regularly found with respect to rules on oily water (1.7% of deficiencies), sewage water (0.8%), garbage (1.3%) and air pollution (1.0%), while unlawful anti-fouling coatings are only detected in a negligible number of cases. (Paris MoU 2017, 48) Ballast water systems do not yet figure in the 2016 report, as they only became mandatory in September 2017. As port state control officers mostly control vessels particularly suspicious of non-compliance, i.e. black-listed vessels, these numbers provide limited evidence on the overall level of compliance with environmental legislation within the shipping industry. Data on compliance behaviour has been measured via questionnaires to build a compliance indicator as described below.

## Mixed methods study

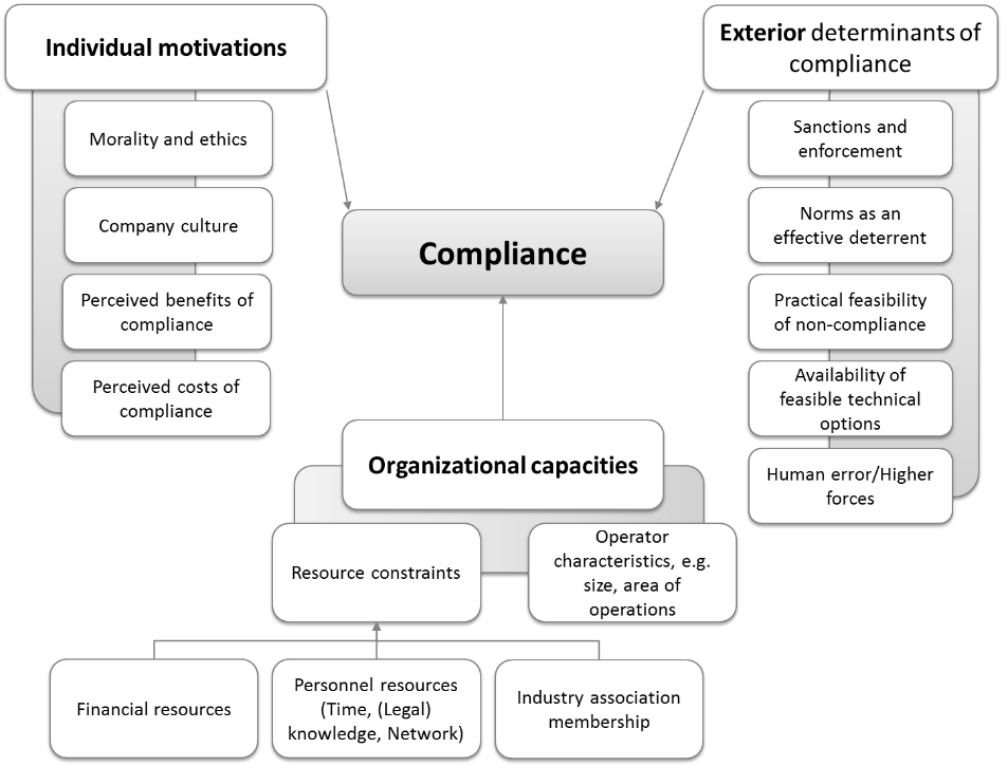
### *Method of the study*

Twelve in-depth expert interviews of 60 to 120 minutes length have been conducted by the researcher in 2015 and 2016 to identify drivers of environmental compliance, enhance the depth of knowledge on existing determinants and highlight cases of variable interdependency. Experts were purposefully sampled based on their superior knowledge on issues of maritime environmental legislation. Data acquired was fully transcribed, anonymized and translated into English where necessary. Guidance questions were related to the shipping companies' level of knowledge and understanding about environmental legislation, their motivations to comply, as well as the effectiveness of control systems and technical compliance options. A theoretical framework was built to serve as a basis for the quantitative study. A 12-page-long, 129-item self-completion questionnaire was drafted and distributed via personalized email to commercial shipping companies with offices in countries bordering the North and Baltic Sea. Of 149 questionnaires received, 121 met basic criteria to be used for evaluation.

Data analysis was conducted using SPSS, Excel and SmartPLS3. Multivariate analysis tools were chosen to test complex relationships between compliance variables. Partial-least squares structural equation modelling (PLS-SEM) is applied here, which is both able to explore patterns in the data and test the a priori established theories as laid down in the theoretical framework.

### *Theoretical framework*

The development of the theoretical framework from qualitative content analysis and systematic review of prior studies as presented in Graph 5 is described in detail in a working paper by Freese and Gille, available on Researchgate (Freese and Gille 2017), and will not be detailed here. It suffices to point out that a great number of determinants were identified, which were clustered under three theoretical concepts, namely individual motivations, organizational capacities and exterior determinants. Items in the questionnaire related to these theoretical concepts and data on proxy variables was collected to evaluate the statistical significance of theoretical relations.




Graph 5. Theoretical framework of determinants of compliance based on exploratory qualitative study and literature review (own research)

***Path model with latent variables***

A path model developed based on the theoretical framework can be found in Figure 6. Path models are widely applied to visualize variable relationships and hypotheses in SEM. (Hair, Ringle, and Sarstedt 2011) Both measurement theory and structural theory are shown in the graph. In this context, a formative measurement model is applied to identify drivers of compliance. Multi-item scales are used to increase predictive validity in line with recommendations by Diamantopoulos et al. (Diamantopoulos et al. 2012) Cronbach's Alpha was employed to determine reliable proxy variables. Indicators were eliminated until Cronbach's Alpha exceeded 0.6, leading to the exclusion of a number of measurements. 'Individual motivations' eventually relies on five indicators with a Cronbach's Alpha of 0.733, 'Organizational capacities' relies on four indicators with a Cronbach's Alpha of 0.638, and 'Exterior determinants' relies on four indicators with a Cronbach's Alpha of 0.601. The researchers refrained from regression analysis based on sum scores (i.e. determining latent variable scores from average values of indicators) for the concepts, as it may not be assumed that indicator weights are equal. Instead, partial least squares was used as decribed below.

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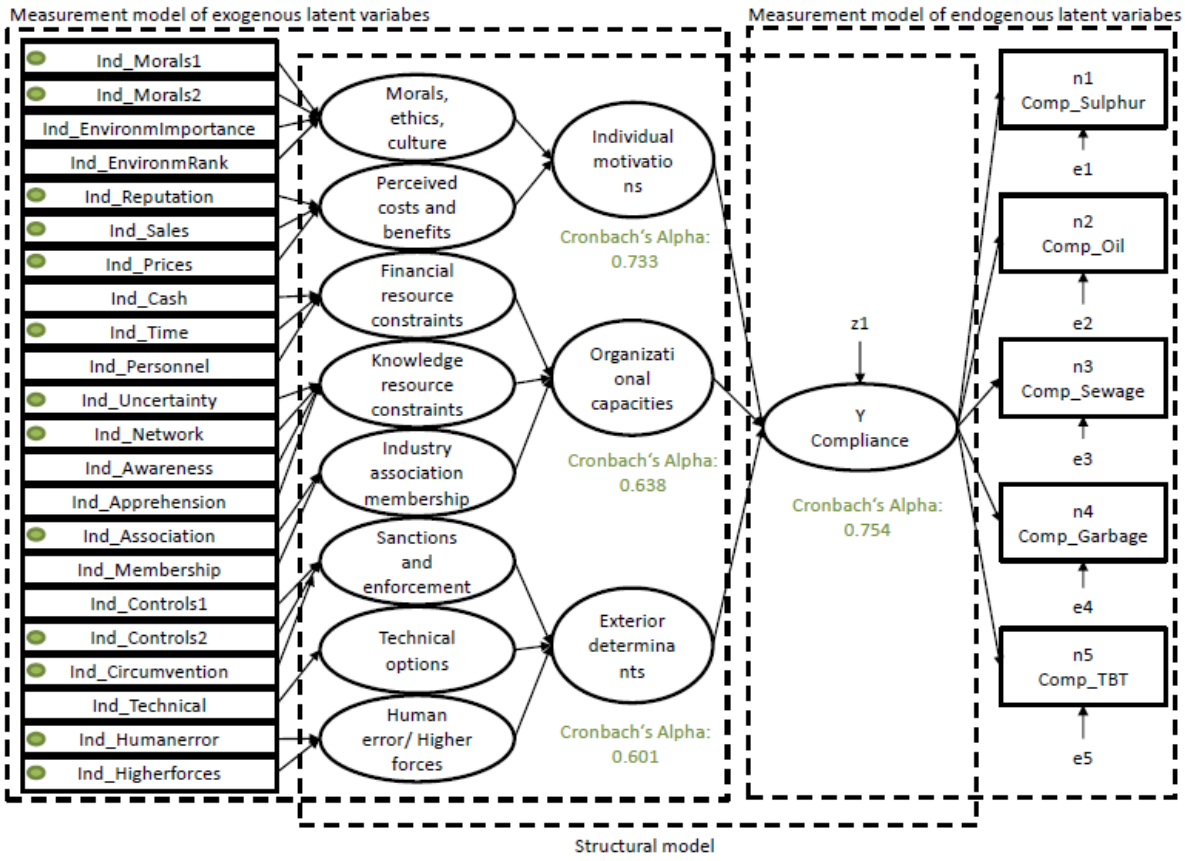



Graph 6. Path model (Structural and measurement model)

***Measures***

Determinants of compliance were identified from literature research and expert interviews. Many of the drivers constitute complex concepts that are defined here as latent or unobservable variables. These constructs may not be directly measured but have to be studied indirectly by using indicators. Proxy variables were created and combined to form a single composite score. Measurement error from poorly worded questions or misunderstandings was aimed to be reduced by using several items to measure a concept. While the compliance index was computed from 5-point Likert scales, data on compliance attitudes was measured on 4-point Likert scales, not allowing for a "middle option", but forcing a taking of sides. Likert items of all scales were symmetric around a middle item and equidistant and may thus be used in SEM. (Hair, Jr. et al. 2018, 9) Control variables included were company size, area of operations, average vessel age and type of operations.

***Missing data***

The sample consists of 121 commercial shipping companies active at least partly in the specially protected areas of the North and Baltic Sea. As data on compliance behaviour is particularly sensitive however, a limited number of companies participating in the study have provided answers to all questions on compliance. Constructs are based on a minimum of 36 companies providing data. Companies having provided information on less than 85% of indicators were deleted from the sample for the purpose of this analysis, leaving 43 companies in the dataset. Following the 10-times rule by Barclay et al., sample size should equal at least 10 times the largest number of structural paths directed at a particular construct in the structural model.

(Barclay, Thompson, and Higgins 1995) As becomes apparent from the path model, latent variables are built upon five indicators at most, making n=43 a barely acceptable number. Results of the study thus need to be treated with great care, as the rough guideline provided by Barclay et al. for minimum sample size is not met. Hair et al. suggest however to deviate from this rough guideline using means of power analysis on the part of the model with the largest number of predictors as an indicator for minimum sample size. (Hair, Jr. et al. 2018, 24) Following calculations by Cohen, with the maximum number of independent variables being five, 37 observations would be needed to achieve a statistical power of 80% for detecting $R^2$ values of at least 0.25 (with a 10% probability of error). (J. Cohen 1992) The sample size is thus deemed acceptable in the light of this being a study on a sensitive topic in a seclusive industry.

Missing data is dealt in two different ways. Mean value replacement is applied if less than 5% of values are missing for an indicator. Other missing data is dealt with by pairwise deletion. Although this might lead to biased results based on different sample sizes per indicator, it seems the best choice in light of the data's many missing values. In these cases mean value replacement would lead to a decrease in variability and thus explanatory power of the data and casewise deletion would further shrink the already small dataset.

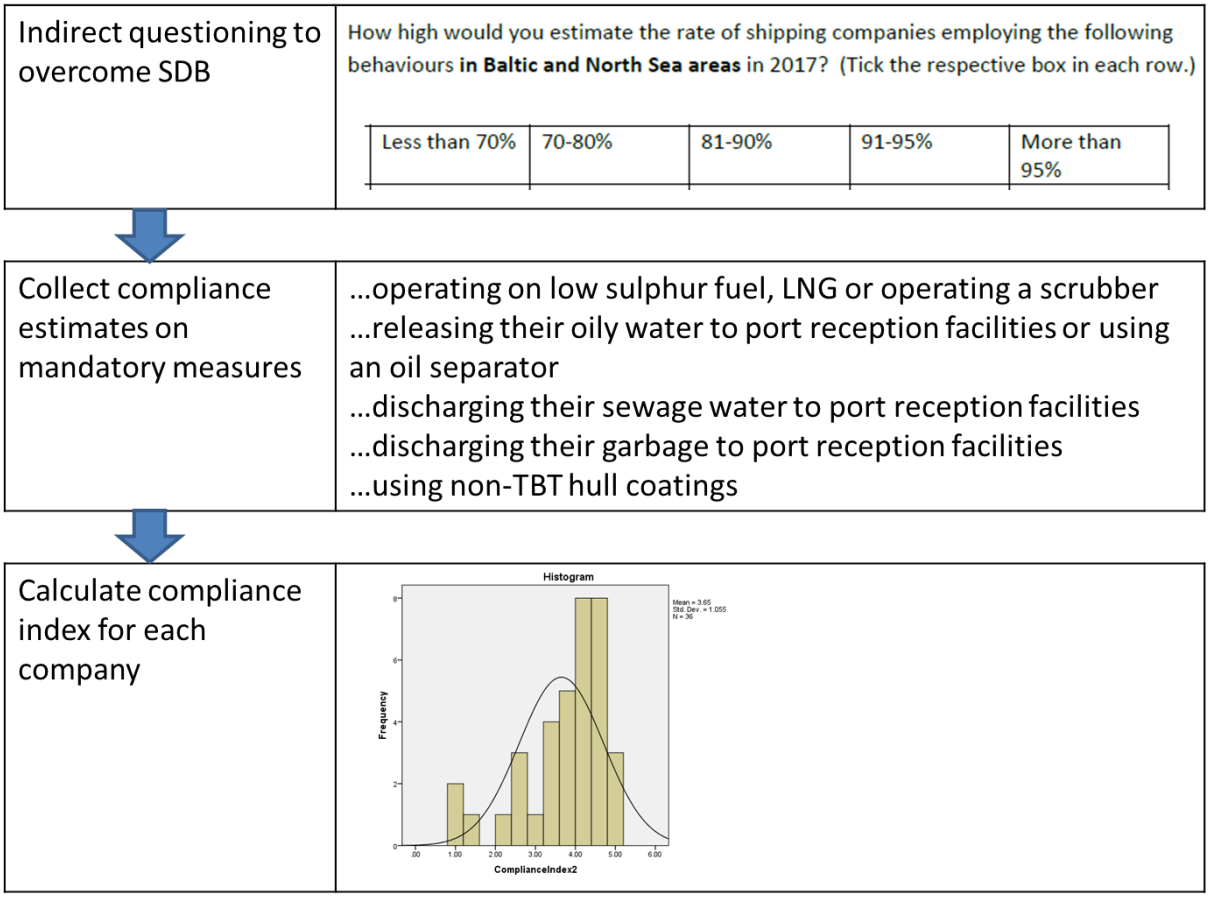
***Data analysis***

Partial least squares (PLS) was chosen as a modelling technique, as it proves apt to deal with specific challenges of the data at hand. PLS consists of a series of ordinary least squares (OLS) analyses and is a two-stage technique where first the outer model is evaluated in terms of reliability and validity and then the inner model is assessed. This structural equation modelling technique is able to handle small sample sizes, has minimal demand on measurement scales, can deal with violations of the normality distribution assumption and is robust with respect to multicollinearity. (Wold et al. 1984) It also treats proxy variables as approximations of the constructs they replace, which is very fitting in this study, and makes it a superior method to CB-SEM for the study at hand. (Hair, Jr. et al. 2018, 16) PLS may both be used to test theories and find relationships between variables. It may be distinguished from more traditional methods of data analysis such as multiple regression in being able to analyse both manifest and latent variables alike. Unobservable variables may thus be measured indirectly. (Hair, Jr. et al. 2018, 3) Measurement errors in observed variables may also be accounted for. (Chin 1998) The characteristics and benefits of PLS-SEM are well explained by Hair et al. (Hair, Jr. et al. 2018) One drawback is the lack of a global goodness-of-fit measure. Henseler and Sarstedt introduced the standardized root mean square residual, SRMR, which is used here to measure goodness of fit. (Henseler and Sarstedt 2013) The consistency of parameter estimates in another issue that needs to be accounted for. Parameter accuracy is however viable, when measurement models meet certain standards, i.e. having four or more indicators with indicator loadings of $\geq 0.7$. (Astrachan, Patel, and Wanzenried 2014) These standards must be taken into account to ensure parameter accuracy.

***Compliance Index***

Self-reported compliance attitudes and compliance behaviour are likely to be influenced by social-desirability bias (SDB), leading to underreporting of noncompliance. (Brace 2013, 210) Asked for their perceptions on compliance, 95.3% of participants reported that the phrase "My company would not do anything that is against the law" was "absolutely true". Research on SDB shows that simply asking participants for honesty is to little avail to overcome the bias. (Phillips and Clancy, 1972) Techniques used in this survey are the omission of a respondent

identifier, assurances of confidentiality, anonymous data collection via on online survey tool or postal self-completion questionnaires, and indirect questioning. In a review of prior studies Fisher found that indirect questioning reduced SDB on variables subject to social influence and that subjects effectively projected their beliefs and evaluations to indirect response situations. (Fisher 1993) Brace presents indirect questioning as a viable method to overcome SDB, but highlights the danger that the researcher may not be sure about the percentage of participants who projected their own behaviour onto others and participants who honestly reported their judgement of others. (Brace 2013, 217) Being aware of this danger, indirect questioning was used to determine levels of compliance and build a compliance index as shown in graph x. As overall compliance levels were estimated to be quite high by experts at the interview stage, compliance levels that were asked for in the questionnaires ranged from "less than 70%" to "more than 95%". Projecting the indirect data onto the companies themselves, a compliance index was calculated for each company. It is important to notice that the underlying scale is not equidistant. An equidistant 5-point-Likert-scale would have yielded much less information, as the researcher already knew from expert interviews, what the relevant compliance categories were likely to be. All other Likert scales in the study are equidistant. The histogram shows a distribution with n=36 (as many participants refrained from answering questions on compliance altogether), a mean of 3.65 (signifying overall estimated compliance levels around 90-95%, which is well in line with estimates from prior studies and expert interviews), a standard deviation of 1.005, and a bell-shaped distribution with a slight negative skew. Cronbach's alpha is 0.754, indicating internal consistency of the scale. It would increase to 0.791 if compliance with sewage water legislation were to be deleted.

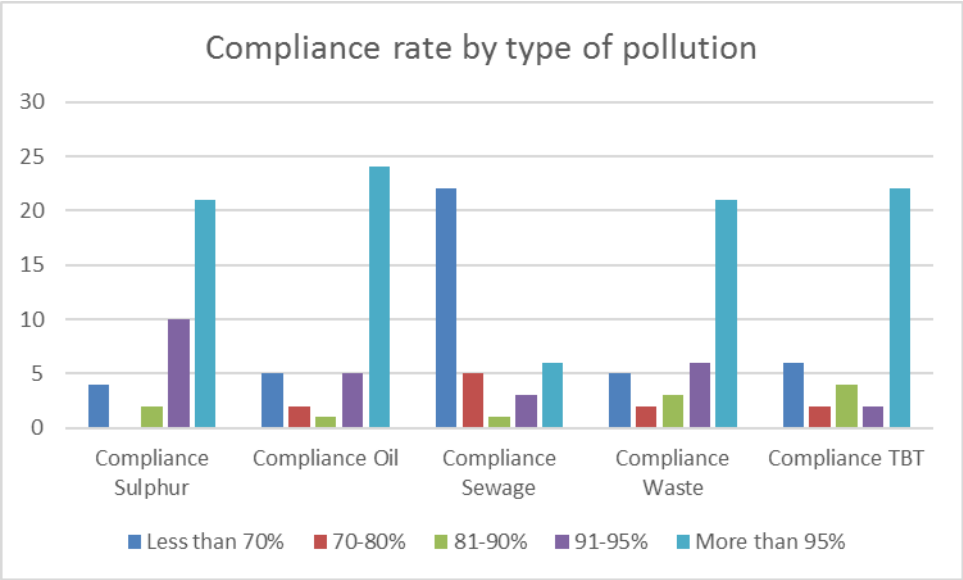



Graph 7. Compliance index calculation

## Results

### *Compliance rates*

Graph 8 (n=37) shows the compliance rate by type of pollution as developed from questionnaire data. It becomes apparent, that for some types of pollution compliance levels are estimated to be higher than for other types of pollution. While compliance with legislation on oil pollution, the prohibition of TBT for hull-coatings and legislation on waste pollution are deemed to be complied with by more than 95% of companies on average, a significant number of participants estimate the compliance with sulphur legislation to be around 91-95%, while most estimate compliance rates to exceed 95% as well. Compliance with sewage water legislation exhibits a different pattern than all other initiatives. The majority of companies participating in the study estimate overall compliance rates within the industry to be lower than 70%.




Graph 8. Compliance rate by type of pollution

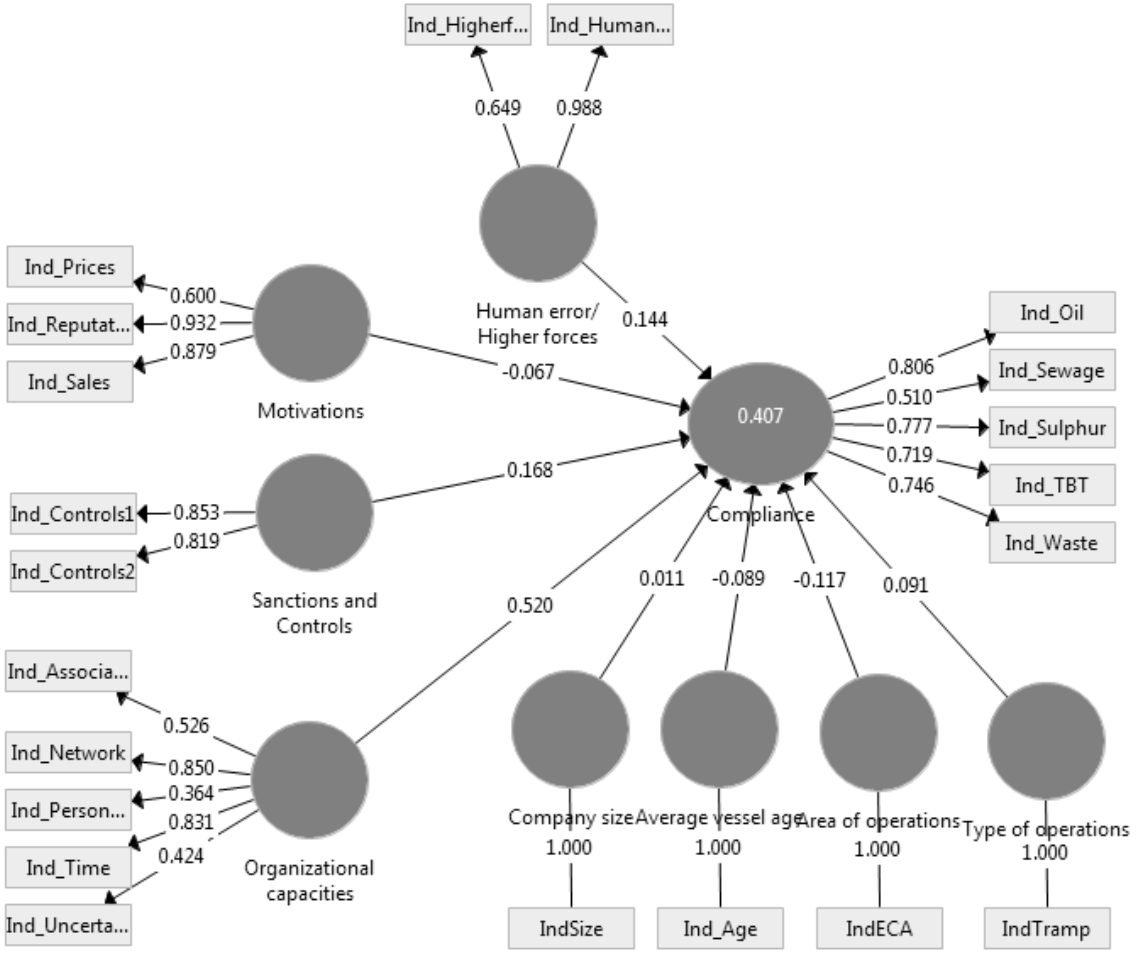
### *Compliance drivers*

PLS-SEM was conducted as described above with results shown in graph 9 below. Histograms of constructs show approximately bell-shaped symmetric curves. While PLS-SEM does not assume a certain data distribution, it is important to note that data distribution is not extremely non-normal, as that would lead to difficulties in assessment of parameter weights. Skewness and curtosis are used here to assess how data deviates from normality with a value lower than -1 or higher than +1 for both considered non-normal. The construct Motivations is not normally distributed in the histogram. The nonnormality of the construct stems from extremely non-normal distributions for indicators Ind_Morals1 and Ind_Morals2 as can be seen by their skewness and kurtosis. These indicators were thus eliminated from the set, leaving three indicators to explain the construct Motivations with a healthy Cronbach's Alpha of 0.771. Other indicators were not deleted, even if their outer loadings were below 0.7 so as not to decrease content validity. (Hair, Jr. et al. 2018, 113) No indicator showed outer loadings between 0.4, as these had already been removed when considering Cronbach's Alpha in preparing the data for analysis with PLS.

The $R^2$-value shows that around 40.7% of variance in compliance behaviour may be explained by the exogenous latent variables. According to Ringle et al., this can be described as a moderate effect. (Ringle, Sinkovics, and Henseler 2009) Model fit is thus far from perfect

but has some explanatory value. Not all path estimates are statistically significant. Path coefficients have standardized values between -1 and +1. Any value close to 0 shows a weak relationship that is usually not statistically significant. As in indication it can be assumed that values above 0.2 are significant, which only is the case for the concept 'Organizational Capacities' with a path value of 0.52. T-values and p-values determined through bootstrapping are shown in the table below graph 9. With a p-value below 0.05, organizational capacities is significant at the 5% level. As can be seen from the outer loadings below, particularly the indicators time and network have high loadings factors, indicating that a lack of time and a lack of a network with other companies might be significantly related to a lower level of compliance with environmental legislation. All other concepts that were determined from expert interviews and literature review could not be found to show a significant relation with compliance rates. Instead, other drivers must explain deviations in compliance levels. Similar to the other latent constructs, no significant relation could be found between control variables and compliance.

No universal measure for model fit is known for PLS. Root mean square residual covariance (SRMR) is used as one measure of model fit here. The model has an SRMR-value of **0.12**. A value of 0 generally indicates perfect fit, while a value below 0.08 indicates good fit when applied to CB-SEM models. Hair et al. argue however that this threshold is too low for PLS-SEM and propose applying a higher (though unspecified) threshold. (Hair, Jr. et al. 2018, 193) SRMR does however not indicate good model fit. RMStheta is considered as a second measure of model fit with a value above 0.12 indicating a lack of fit. The value calculated in Smart PLS for the model at hand is RMStheta=0.208. A different specification of the model is thus necessary due to poor fit.




| | Original Sampl... | Sample Mean (... | Standard Devia... | T Statistics (\|O... | P Values |
|---|---|---|---|---|---|
| Area of operati... | -0.117 | -0.112 | 0.130 | 0.895 | 0.371 |
| Average vessel ... | -0.089 | -0.070 | 0.197 | 0.453 | 0.650 |
| Company size ... | 0.011 | -0.044 | 0.190 | 0.056 | 0.955 |
| Human error/... | 0.144 | 0.150 | 0.189 | 0.764 | 0.445 |
| Motivations ->... | -0.067 | -0.022 | 0.197 | 0.341 | 0.733 |
| Organizational ... | 0.520 | 0.495 | 0.181 | 2.868 | 0.004 |
| Sanctions and ... | 0.168 | 0.169 | 0.145 | 1.158 | 0.247 |
| Type of operati... | 0.091 | 0.112 | 0.181 | 0.501 | 0.617 |

***Reliability analysis***

Measures of construct reliability are shown in the table below. As in this study new measures for concepts are developed, a Cronbach's Alpha of 0.6 is deemed as acceptable, in accordance with assessments by Nunnally (Nunnally 1978) and Hair. (Hair, Jr. et al. 2018, 24) Normally, a minimum of 0.7 is demanded to describe a reliable construct. Composite reliability tends to overestimate reliability slightly, while Cronbach's Alpha might underestimate reliability for the type of study at hand, involving Likert scales with few points. Hair et al estimate that true reliability estimates lie somewhere between these indicators. (Hair, Jr. et al. 2018) Following that argument, concepts are shown to be reliable with composite reliability above 0.7 for all concepts and Cronbach's Alpha above or close to 0.6 for all concepts. These measures are comparable to other exploratory studies.

| | Cronbach's Al... | rho_A | Composite Rel... | Average Varian... |
|---|---|---|---|---|
| Area of operati... | 1.000 | 1.000 | 1.000 | 1.000 |
| Average vessel ... | 1.000 | 1.000 | 1.000 | 1.000 |
| Company size | 1.000 | 1.000 | 1.000 | 1.000 |
| Compliance | 0.761 | 0.785 | 0.883 | 0.606 |
| Human error/... | 0.687 | 2.202 | 0.816 | 0.699 |
| Motivations | 0.771 | 0.980 | 0.853 | 0.667 |
| Organizational ... | 0.589 | 0.690 | 0.750 | 0.400 |
| Sanctions and ... | 0.572 | 0.575 | 0.823 | 0.700 |
| Type of operati... | 1.000 | 1.000 | 1.000 | 1.000 |

## Main findings, limitations and further research

Study results show that organizational capacities of a shipping company, particularly available time to collect and apprehend legal information, a strong network with other companies, and the membership in an industry association, is statistically significant and positively correlated with increased levels of compliance with maritime environmental legislation. All other constructs that were developed from expert interviews and prior studies could not be found to show statistically significant effects. These results may be explained by a lack of correlation between compliance and compliance drivers identified, but may also be an effect of measurement errors, errors in translating the latent concepts into viable proxy variables or may be a result of the small sample size. Also, instrumentation of the questionnaire to receive a desired outcome is possible, where participants overestimate compliance costs and underestimate noncompliant behaviour to discourage further political involvement in the industry.

The results are not untypical for exploratory studies, where tentative first steps are made to identify relationships between abstract concepts and much still needs to be learned in terms of describing and measuring the latent concepts. Also, the research shows the difficulties in conducting mixed methods research. The theoretical concept presented above shows an outcome of thorough qualitative research, but it does not seem to withstand statistical scrutiny.

Next steps would be the further development of indicators to describe latent variables and a further search for explanatory factors of compliance that are not represented in the theoretical framework so far. Also, statistical analysis based on a larger sample size would be valuable to improve the analysis of compliance drivers and to further the understanding of regulatory compliance as a measure to improve environmental legislation.

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