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Measurement of port performance from users’ perspective

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Abstract

Purpose – Going beyond the usual approach of measuring port performance – focusing on the efficiency of port operations – this paper aims to look into shipping lines and other port users’ perceptions on port performance.

Design/methodology/approach – The paper develops a framework measuring the perceptions of port users (i.e. shipping companies, shippers, etc.) on port performance. A typology of elements that shape port users’ perceptions has been developed with an eye on capturing the peculiarities of different port markets. Based on this typology, a tool to assess users’ perspectives, and subsequently evaluate, any given port has been developed. The tool provides port authorities the flexibility they need for customized approaches. The developed evaluation mechanism has been tested on a group of European seaports, and the results are presented by this study.

Findings – The framework and its pilot application unveil the key parameters that port users take into consideration when evaluating the effectiveness component of port performance. Moreover, the importance and evaluation ratings of specific performance parameters allow for a GAP analysis of the collected data.

Research limitations/implications – The paper advances scholarly and practical discussion on how of port users’ perceptions can be a valuable tool for port performance measurement.

Practical implications – The proposed tool can be a valuable add-on for port authorities to evaluate their performance from the port users’ point of view and take the necessary actions to improve it. Also, the tool can be used for the evaluation of a new process, infrastructure. The evaluation of port users’ perception of port performance can and must be part of a European ports observatory, as it is a set of indicators that clearly reflects the satisfaction of port users by engaging their view on port performance issues, instead of relying almost exclusively on port-generated data.

Originality/value – The paper develops a framework for measuring port user’s perception on port performance, which is flexible and can be applied in any port.

Keywords Port performance, Users’ perspectives, European ports

1. Introduction

Port performance measurement is gaining ground in contemporary port management. Intense competition and the transformation of port authorities towards a more
commercialized and industrialized role are vital: ports, in their vast majority, are actively engaged into complex supply chains, aiming, among others, to increase market shares. In this environment, port authorities are moving into their transition to “port development companies” (De Langen and Van Der Lugt, 2017).

In this setting, the importance of port performance measurement emerged as a necessary condition for ports to be benchmarked vis-à-vis their competitors. In general, port performance can be achieved if a given port task is measured against pre-defined standards of accuracy, completeness, cost and speed. Some ports are monitoring their performance based on pure operational features while others encompass wider aspects, such as administrative and financial performance parameters. This trend has been recorded by the relevant academic research with scholars studying port performance issues (Beuren et al., 2018), focusing mostly on the examination of operational parameters (the efficiency component) of performance especially through the use of Data Envelopment Analysis and Stochastic Frontier Analysis (Nguen et al., 2018). There are also several studies examining the correlation between port efficiency and the port’s governance model with a focus on the ownership status of a port. Notteboom et al. (2000) used the Bayesian Stochastic Frontier Model to a set of 36 European and four Asian container terminals and they concluded that there is not a clear relation between the port efficiency and the ownership status of port terminals (private or public owned). Also, Cullinane and Song (2003) studied the relation between port privatization and/or deregulation policies and operational efficiency. In contrary with Notteboom et al. (2000), they concluded that the degree of private sector involvement is positively related with the productive efficiency of ports based on a sample of UK and South Korean ports. Yuen et al. (2013) in their study unveiled that foreign participation in the ownership status of Chinese ports increases the container terminals’ efficiency.

One missing link towards a comprehensive port performance evaluation is the inclusion of port users’ perceptions, i.e., how a port’s user perceives and evaluates port performance elements, that is to say, how they rate a port based on their experience. This gap has been acknowledged by academia which progressively turned its interest in measuring the effectiveness components. Brooks (2007) states that port performance measurement provides several efficiency measures, although, on the other hand, little emphasis has been put on port’s effectiveness and meeting port customers’ and stakeholders’ needs, with customer satisfaction measurement being missing in the port industry. The lack of port user’s satisfaction measurement has been identified also by Pallis and Vitsounis (2009) as a major gap for a comprehensive port performance measurement. They argued that ports are focus on the efficiency biased performance measurement, neglecting the perspective of their users.

Contributing to this debate, the paper develops a framework for measuring port users’ perceptions (i.e., shipping companies, shippers, etc.) on port performance. In doing so, a typology of elements that shape port users’ perceptions has been developed with an eye on capturing the peculiarities of different port markets. Based on this typology a tool for assessing users’ perspectives, and subsequently for evaluating any given port, has been developed. As port evaluation is a case-sensitive issue, the tool provides port authorities the flexibility they need for a customized approach. The tool has been applied on a group of European seaports.

The framework, and its pilot application, unveils the key parameters that port users take into account when evaluating the effectiveness component of port performance. Moreover, the importance and evaluation ratings of performance criteria allows for a GAP analysis of
the collected data. The paper discusses both the findings of the field research and the application perspectives of this tool, unveiling barriers, advantages and disadvantages of this process.

2. Literature review

Aiming at facilitating international seaborne trade and being accelerators of efficient maritime transport systems and facilitators of supply chains, in which they are embedded (Robinson, 2002), ports need to be efficient. A vast interest on port efficiency measurement has been triggered, among others, by the increasing competition among ports (Tongzon, 1995) and is still evident, as ports are seeking continuous improvements in the port services quality.

Port users’ perceptions only recently came at the forefront of the scholarly research on port performance. The majority of studies focused on identifying port efficiency factors as well as on measuring port efficiency followed by a turn towards the exploitation of port performance parameters. For some researchers, port performance includes elements of port attractiveness (Lirn et al., 2004 who identified a list of 47 criteria affecting port attractiveness). Others examined elements of port competitiveness that can also be used for determining port performance, implicitly assuming that efficiency is a proxy of competitiveness. Yeo et al. (2011) concluded on 38 components of port competitiveness and applied a methodological framework to measure experts’ perceptions (see also the study of Yuen et al., 2012). Brooks (2007) focused on the correlation between port performance measurement and port governance.

Significant work has been carried out in measuring port performance. In a general approach, Martilla and James (1977) described the advantages and disadvantages of Importance-Performance analysis with normalized pairwise estimation, aiming at demonstrating that consumer’s satisfaction is a function of both expectations and judgments of attribute performance. As Comtois and Slack (2010) concluded, the most widely used method for measuring port performance is data envelopment analysis (DEA), with Ensslin et al. (2018) supporting this view. The study of Valentine and Gray (2001) used DEA for examining the relation between container ports efficiency and their ownership status. Park and De (2004) examined the applicability of an alternative DEA for measuring port’s efficiency. Lin and Tseng (2007) applied models of DEA for analyzing the operational efficiency of container ports in the Asia-Pacific region and based on the results to identify potential trends. Beuren et al. (2018) used DEA to measure and compare the efficiency of the main Brazilian ports.

Port performance research has been redefined following the ascertainment that port performance is a function of efficiency and effectiveness (Brooks and Pallis, 2008), with the latter being neglected up then, although some thoughts have been expressed in literature (Park and De, 2004; mentioned customer satisfaction as part of marketability in their approach). Brooks and Pallis (2008) supported that components of port performance are the efficiency and effectiveness with the latter being the users’ perceptions of port performance. From the port’s side of view, effectiveness is to do the right thing, to respond to current and potential users’ peculiar needs and expectations.

Still, the majority of academic research and industry practices are mainly focused on the efficiency side, i.e. to do things right. Thus, it is no coincidence that port performance has been associated with the operational efficiency alone (Brooks and Pallis, 2013). As mentioned by Beresford et al. (2010), common approaches on measuring port performance
are focusing on facilitating vessels, cargo-handling equipment and assets usage. This is the majority of the studies developed by ports where port users usually are participating in the evaluation of performance indexes developed according to the operational profile of the port. Such an approach is based on the assumption that the port performing the exercise knows what is best for a port user and what the port user is looking for. A risk in this approach is to confront port users as a unified entity with the same strategies and goals.

The way to proceed towards a holistic approach is to take into account port users in port effectiveness evaluation. Most port performance measurement schemes fail to include this performance component (Brooks et al., 2011). Consequently, measuring port performance is heavily relied on operational efficiency measures (Pallis and Vitsounis, 2009) resulting in a gap between port performance and port users’ expectations.

Roll and Hayuth (1993) in their study on the comparison of port performance with the use of Data Envelopment Analysis, make a reference to the term “port user satisfaction” without further analysis. With the evolution of the related research and the active participation of ports in port performance exercises, port users came into the scene only recently, in comparison with the port performance research (see for example the studies of Lirn et al., 2003; Ng, 2006; Tongzon, 2008; De Langen, 2008).

The most comprehensive attempt on measuring port users’ perception on port performance was initiated by Brooks (2007) who identified users’ satisfaction as a critical performance indicator to be measured in an effectiveness-oriented organization. Some years and several empirical studies later, Brooks et al. (2011) concluded with the proposition of a systematic approach for measuring port effectiveness. Brooks et al. analyzed how port users evaluate port effectiveness, which in turn is a synthesis of three questions:

1. How do port users evaluate ports?
2. What is most important to them in terms of services received?
3. How do they evaluate the performance of ports they use?

In other words, they focused on three port performance components, the overall satisfaction, the competitiveness and the effectiveness in service delivery. For measuring port effectiveness, they developed an online survey using 37 evaluation criteria addressing decision makers using Canadian ports. The paper unveiled the rating of each one of the criteria in terms of importance per category of port users (i.e. shipping lines, cargo interests, supply chain partners) and rating of the criteria used in relation with the three components of port performance.

While port users’ perceptions play a vital role for developing a comprehensive framework for measuring port performance, any approach aiming at incorporating them in port performance measurement should take into account the subjectivity that users’ perceptions entail, as each user has its own assessment criteria to evaluate port performance. Also, it must be highlighted that each port market has its own characteristics that need to be taken into account, for example passenger ports (Vaggelas and Pallis, 2010) have quite different characteristics from cargo ports. These characteristics are related with port operational issues such as the types of port services provided, the different handling needs that each cargo and passenger traffic has, the importance of performance in cargo handling operations, the provision of value-added services, to name a few. With some exceptions (Pantouvakis et al., 2008),
the related studies on port performance measurement have been focused on container ports and terminals.

3. Methodological framework and pilot application

3.1 Methodology

The methodology followed is based on a three-step approach aiming at clarifying all the critical aspects on measuring port users’ perceptions on port performance towards a holistic approach. As already mentioned, the majority of port performance measurement related studies are focusing on container ports. This study goes beyond the container market aiming at providing a framework applicable to several types of port markets, namely, container ports, dry bulk ports, liquid bulk ports, Ro-Ro ports, break-bulk ports and cruise ports, allowing for a more comprehensive approach on port effectiveness.

Secondly, as the tool used for measuring port users’ perception is an online survey (Brooks et al., 2011 stated that best effectiveness metrics from managerial perspective comes from questionnaires addressing users), it is critical to define the term port user, thus defining the target group of the survey. The term “port user” might have as many definitions as the different perspectives someone might have on port operations, the port area, the port cluster, etc. For the purpose of this study, a “port user” is an entity that consumes port services, or uses the port infrastructures.

The third step is to identify the criteria that shape port users’ perceptions on port performance. Towards this end and based on literature review, a set of criteria has been developed for each of the six port markets. The criteria are grouped following a sequence that is based on the sea-port-hinterland concept, i.e. criteria dealing with operations in:

- the port-sea interface;
- the port area; and
- the port-land interface.

This grouping aims at:

- following the cargo-passenger flows in ports (i.e. from sea to port and then to hinterland and vice versa);
- making easier for the participants to spot the most interesting, for them, part of port operations to be evaluated; and
- to give the ability to the port to identify the performance gaps and focus on a specific segment of port operations (these are the operations related with the sea-port interface, the port-hinterland interface or the in-port operations).

The criteria are related with several port operational aspects such as:

- availability, i.e. whether a port service and/or infrastructure is available upon request;
- accessibility, related with the easiness of reaching the port;
- connectivity, dealing with parameters defining the port embeddedness in transport chains;
- quality, related with qualitative parameters of port services and/or infrastructure;
- timeliness of services, i.e. the provision of services takes place on the most appropriate time;
• adequacy, which is related with the sufficiency of port services and/or infrastructures for a particular purpose; and
• cost, concerning the cost of using port services and/or infrastructure.

Based on literature dealing with port performance, efficiency and effectiveness in ports, criteria for evaluating port users’ perceptions and experiences from ports, the paper identified a set of criteria that shape the port user’s perception on port performance. The review unveiled 21 criteria that are common for the port markets under examination, while 16 more criteria identified for container ports, 14 criteria for Ro-Ro ports, 12 criteria for dry bulk ports, 14 criteria for break-bulk ports, 10 criteria for liquid bulk ports and finally 11 criteria for cruise ports. Table I presents the criteria that identified through the literature review and have been fine tuned to be used for measuring port users’ perception on port performance.

The above-mentioned port markets and the respective criteria have been used for the development of an ICT tool aiming at measuring the users’ perception of port performance through a three-step application. With an eye on the active and increased participation of ports, the tool provides the ability to the participating ports to add their own criteria. Thus, the tool gives to the port authority the ability to customize the tool according to their peculiar needs, along with an increased level of confidentiality.

At the first phase of the ICT tool application the participating port selects the port markets and the criteria for which the port wants to be evaluated by the users. At the end of this phase the port authority has develop the structure of the survey that will be sent to the port users.

At the second phase of the exercise, the port authority invites port users to answer the survey through a port performance measurement campaign.

The third phase includes the participation of the port users that have been invited to the exercise. Shipping lines and other port users are asked to evaluate the criteria for each one of the port markets that the port authority has selected. The port user evaluates each criterion based on his experience from the specific port (satisfaction) and on the importance of each criterion in shaping his perception on port performance (expectation).

3.2 The pilot application
The framework and the ICT tool has been tested through a pilot application in selected European ports. Following a promo campaign, eight ports from five European countries accepted their participation in the pilot phase, which run between February and July 2017. These ports are mainly multipurpose ports, thus covering our goal for testing the framework and the tool in different port markets.

A follow-up during the pilot exercise was essential, aiming at achieving the highest possible engagement from the participating ports. Some techniques used were:
• prompt participants to proceed with the second phase of the pilot exercise;
• notify them on the extension of the pilot phase; and
• provide insights into how to increase the response rate by their users.

3.3 GAP analysis
The paper proceeds with a GAP analysis based on the results of the pilot application aiming at providing additional insights for the participating ports. With GAP analysis dealing with the gaps between satisfaction and importance, the methodology can identify priorities for
<table>
<thead>
<tr>
<th>Sea-port interface</th>
<th>Common criteria Port</th>
<th>Port-land interface</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of berths-mooring buoys</td>
<td>Coordination of port community/stakeholders</td>
<td>Efficiency of cargo/passenger clearance</td>
</tr>
<tr>
<td>Operational depth</td>
<td></td>
<td>procedure</td>
</tr>
<tr>
<td>On-time arrival/ Total length of the quays</td>
<td>Transparency of port charges</td>
<td>Response to innovativeness</td>
</tr>
<tr>
<td></td>
<td>On-time information</td>
<td>Accuracy of information</td>
</tr>
<tr>
<td></td>
<td>Response to users' requests</td>
<td>Online information</td>
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<td></td>
<td>Port safety</td>
<td>Port security</td>
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<td></td>
<td>Response to regulation changes</td>
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</tbody>
</table>

*Container ports*
*Feeder container services*
*Deep-sea container services*
*Container handling cost*

<table>
<thead>
<tr>
<th>Common criteria Port</th>
<th>Port-land interface</th>
</tr>
</thead>
<tbody>
<tr>
<td>Efficiency of (un)loading operations</td>
<td>Efficiency of cargo/passenger clearance</td>
</tr>
<tr>
<td>Number of operational gantry cranes</td>
<td>procedure</td>
</tr>
<tr>
<td></td>
<td>Response to innovativeness</td>
</tr>
<tr>
<td></td>
<td>Accuracy of information</td>
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<tr>
<td></td>
<td>Online information</td>
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<td></td>
<td>Port security</td>
</tr>
</tbody>
</table>

*Ro-Ro ports*
*Ro-Ro services*

<table>
<thead>
<tr>
<th>Common criteria Port</th>
<th>Port-land interface</th>
</tr>
</thead>
<tbody>
<tr>
<td>Storage capacity for trailers-trucks</td>
<td>Efficiency of cargo/passenger clearance</td>
</tr>
<tr>
<td>Number of operational tractors</td>
<td>procedure</td>
</tr>
<tr>
<td></td>
<td>Response to innovativeness</td>
</tr>
<tr>
<td></td>
<td>Accuracy of information</td>
</tr>
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<td></td>
<td>Online information</td>
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<td>Port security</td>
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<tr>
<th>Sea-port interface</th>
<th>Common criteria</th>
<th>Port-land interface</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Dry bulk ports</strong></td>
<td>Efficiency of (un)loading operations</td>
<td>Storage capacity for dry bulk cargoes</td>
</tr>
<tr>
<td></td>
<td>Dry bulk cargoes handling cost</td>
<td>Dry bulk cargoes storage cost</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Number of operational cranes</td>
</tr>
<tr>
<td><strong>Break-bulk ports</strong></td>
<td>Number of operational cranes</td>
<td>Open storage capacity for break-bulk cargoes</td>
</tr>
<tr>
<td>Efficiency of (un)loading operations</td>
<td></td>
<td>Number of handling equipment for break-bulk storage</td>
</tr>
<tr>
<td>Break-bulk cargoes handling cost</td>
<td></td>
<td>Break-bulk storage cost</td>
</tr>
<tr>
<td><strong>Liquid bulk ports</strong></td>
<td>Liquid bulk cargoes handling cost</td>
<td>Efficiency of (un)loading operations</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Storage tank cost</td>
</tr>
<tr>
<td><strong>Cruise ports</strong></td>
<td>Cruise passengers handling cost</td>
<td>Number of operational passenger terminals</td>
</tr>
<tr>
<td>Efficiency of berth allocation system</td>
<td>Efficiency of passengers (un)loading operations</td>
<td>Efficiency of baggage handling operations</td>
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<tr>
<td>Baggage handling cost</td>
<td></td>
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</tbody>
</table>

Table I. Measurement of port performance.
If satisfaction is lower than importance, then expectations are not fully met and there is room for improvement. Such an outcome can be of high value for a port in pursuit of increasing performance and especially effectiveness as it can highlight the underperformed port operations, providing an input for a relating decision-making process.

4. Results and reporting

As already explained each criterion has been attributed a twofold evaluation from port users: in terms of satisfaction, and in terms of the given importance. A seven-point scale has been used for rating, with 7 indicating the maximum level of satisfaction and importance and 1 indicating the minimum level. The response rate at the various campaigns launched by the participant ports equals to 19.2 per cent, of the port users invited to the exercise. The overall evaluation of the port markets is presented in Figure 1 and is calculated based on the average of all the evaluations provided for the criteria included in each one. The color of the evaluation rating is related with the seven-point rating scale with red color being ratings ($R$) in the range $1 \leq R < 3$, deep orange ratings in the range $3 \leq R < 4$, orange ratings between $4 \leq R < 5$, yellow for ratings in the range $5 \leq R < 6$ and finally green for ratings in the range $6 \leq R < 7$.

The port users gave almost equal importance to each one of the port markets under examination. On the other hand, there are significant variations as regards the satisfaction of port users. The lowest rate of satisfaction is attributed to the container and dry bulk terminals of the pilot ports, with the satisfaction being at the middle of the rate scale, i.e. 4 out of 7. With an average 4.5 the port users rated their satisfaction by using the Ro-Ro and the break-bulk terminals of the pilot ports that are active in these two markets. Finally, the highest rate of satisfaction has been attributed to the liquid bulk and the cruise terminals, which gained an average rate of 5.5.

4.1 Container port market: satisfaction and importance evaluation

For the container port market, port users rated high ($\geq 6$), in terms of importance, almost all the criteria that define their overall perception on port performance. On the contrary they gave average values to the criteria based on their experience from using a pilot port. Table II shows the top- and the least-rated criteria in terms of satisfaction and importance. For each one of the two groups (top- and least-rated), the following tables show the top-three and the bottom-three criteria in terms of rating, whenever it's possible, as in some cases more than three criteria have the same satisfaction or importance rate.

Based on port users' ratings, the top criteria based on their satisfaction from using the pilot ports are the number of deep-sea container services, the efficiency of (un)loading...
operations and the efficiency of the pilotage services. The results unveiled also an above average satisfaction for major operational and connectivity parameters of a container port, i.e. the port’s connectivity (sea side) and the cargo handling efficiency. It must be noted that these criteria did not score high in terms of importance. Criteria related with cost, port operating hours, port hinterland transportation, clearance procedures and ports responsiveness are shaping the importance relevant list.

Port users reported that they evaluate low in terms of satisfaction, criteria related with container storage and the related storage costs, the efficiency of container clearance procedures, hinterland intermodal connectivity. The least-rated criteria in terms of importance are the number of deep-sea container services, and the efficiency of bunkering and ice-breaking services.

In terms of port management, the results shows that that for container services, almost everything is significant for port users. This justifies the fact that the container port market is a highly demanding one from the port users’ point of view.

4.2 Ro-Ro port market: satisfaction and importance evaluation
For the Ro-Ro port market, port users gave a high rating of 6.5 to 11 elements out of a total of 35 elements that have been selected by the pilot ports and evaluated by their users. Table III shows the top- and least-rated criteria from the perspective of the port users in terms of importance and satisfaction.

Based on port users’ evaluation the top criterion based on their satisfaction is the efficiency of dredging operations, while in the second place, they rate high (with 5.5) a set of
core port services. Overall, port users declared satisfied by the performance level of the Ro-Ro terminals.

Port users rated average (four out of seven) five parameters dealing with port and storage costs, storage capacity, efficiency of clearance procedures and of bunkering services. On the other hand, they evaluated as the less important parameter in formatting their overall perception of port performance, the efficiency of dredging operations, while in the second place they rated equally six parameters. This is a fine example between the expectation and the actual experience of a port user. Although, in terms of satisfaction, the efficiency of dredging operations is high, this parameter is not important in shaping their overall perception on port performance.

4.3 Dry bulk port market: satisfaction and importance evaluation
Also, in the dry bulk port markets, port users gave high ratings in terms of importance, with 11 out of 35 criteria (those selected by the port authorities) being rated with 6.5 (Table IV).

Regarding satisfaction, port users gave a rate of 5 to six criteria, dealing with pilotage, safety, security and port’s accuracy in vessel’s arrival and departure. The least-rated criteria reveal that port users are dissatisfied by the efficiency of dredging operations while they gave an average rating (4 in the seven-point scale) to 11 criteria dealing mainly with core operations in a dry bulk port-terminal such as cargo handling and storage. In terms of
importance, the least-rated criteria included the efficiency of bunkering and ice-breaking operations, as well as the efficiency of waste-management operations, showing the low ranking of these services in port users’ perception on port performance.

4.4 Liquid bulk port market: satisfaction and importance evaluation

For the liquid bulk market, the pilot application of the tool, unveiled (Table V) that port users are more than satisfied by the liquid bulk ports and terminals as more than 50 per cent of the criteria (34 in total) received an average rate of 6 and above. More specifically, 1 criterion (tank storage capacity) received a satisfaction rate of 6.5, and 17 other criteria received a rate of 6. It is worth mentioning that port users declared more than satisfied for several criteria dealing with core operations in a liquid bulk port or terminal such as loading and unloading operations, storage, adequacy of port infrastructures, operating hours and time-accuracy of vessels facilitation. On the other hand, and in terms of importance, port users rated with 7 the operational depth, something expected, as the depth is a crucial parameter for liquid bulk terminals, owing to the fact that tankers and especially oil tankers have an increased draft comparing with other types of vessels. In the second place the respondents gave a rate of 6.5 to 11 criteria.

<table>
<thead>
<tr>
<th>Ranking</th>
<th>Satisfaction</th>
<th>Importance</th>
<th>Rate</th>
<th>Ranking</th>
<th>Importance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Top-rated</td>
<td>Port operating hours, on-time arrival, on-time departure, efficiency of pilotage service, port security, port safety</td>
<td>Total length of quays, operational depth, port operating hours, on-time arrival, efficiency of pilotage services, efficiency of towage services, vessel-related port costs, efficiency of (un)loading operations, dry bulk cargoes handling cost, response to users requests, customs operating hours</td>
<td>5</td>
<td>1</td>
<td>6.5</td>
</tr>
<tr>
<td>Least-rated</td>
<td>Operational depth, efficiency of bunkering, efficiency of ice-breaking, Dry bulk cargoes handling cost, coordination of port community, response to innovativeness, online information, accuracy of information, storage capacity for dry bulk cargoes, dry bulk cargoes storage cost, customs operating hours</td>
<td>Efficiency of bunkering</td>
<td>4</td>
<td>1</td>
<td>5.5</td>
</tr>
<tr>
<td></td>
<td>Efficiency of dredging operations</td>
<td>Efficiency of ice-breaking operations</td>
<td>3</td>
<td>–</td>
<td>5.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Efficiency of waste reception services</td>
<td>–</td>
<td></td>
<td>5.5</td>
</tr>
</tbody>
</table>

Source: Author
Regarding the least-rated criteria, in the third place from the end with an average rate of 5.5 there are 14 criteria. In comparison with the other port markets, the liquid port market shows a different perception of port users in terms of satisfaction. The lowest rate of satisfaction is 5, showing that port users are satisfied with the liquid bulk ports participated in the pilot phase, as the lower rate is actually quite above average.

4.5 Break-bulk port market: satisfaction and importance evaluation

For the break-bulk port market port users gave the highest ranking in terms of satisfaction to port safety while in the second place there are 19 criteria dealing with almost every aspect of operations in a break-bulk port/terminal. In terms of importance port users gave a rating of 6.5 to eight criteria (Table VI).
For the least-rated criteria, port users, based on their experience from the pilot ports, gave a rating of 3 out of 7 to the efficiency of ice-breaking services, followed by the connectivity of ports with rail networks and the quality and efficiency of rail services, both of which rated with 3.5. Regarding importance, port users gave the lowest rate to efficiency of dredging operations, which means it is the less important in shaping their total perception on port performance. In the second place of the least important criterion the port users listed four criteria dealing with innovativeness, warehouse capacity and rail connectivity and efficiency.

### 4.6 Cruise port market: satisfaction and importance evaluation

For the cruise port market, port users gave high ratings to five criteria dealing mainly with timeliness of cruise vessels facilitation and security, which are crucial parameters for cruise business, with the latter being at the epicenter of relevant policies at international and EU level (Pallis and Vaggelas, 2007). In terms of importance, almost
the same criteria as in the case of satisfaction, are ranked high. The only exception is that port users consider of high importance the efficiency in cruise passengers clearance procedures, although this criterion has not been included in the top-rated criteria in terms of satisfaction.

As regards the criteria that attracted the least importance and satisfaction of port users, four criteria rated with 5.5 in terms of importance, while in terms of satisfaction the lower rate is 5 attributed to two criteria related with port costs. In the third place, with an average rate of 5.5, there are 14 criteria.

As regards the least-rated criteria in terms of satisfaction, port users declare that the adequacy of parking spaces was the most insufficient parameter in the pilot ports, based on their experience, followed by the services to cruise passengers and the customs operating hours. In terms of importance, port users declared six criteria as being the least important, with an average rate of five out of seven (Table VII).

### 4.7 GAP analysis

A GAP analysis has been conducted based on the results of the pilot exercise. The GAP analysis has been applied for each port market. If the score of a service is positive (above zero) then port users ranked the service as a very important one, but they are not satisfied by it. In this case, port authority actions are required. If the mean score of a service is negative (below zero) then respondents rated this service relatively unimportant but are very satisfied

<table>
<thead>
<tr>
<th>Ranking</th>
<th>Satisfaction Criterion</th>
<th>Rate</th>
<th>Importance Criterion</th>
<th>Rate</th>
</tr>
</thead>
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<tr>
<td><strong>Top-rated</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>1</td>
<td>Port operating hours, on-time arrival, on-time departure, efficiency of ice-breaking operations, port security</td>
<td>6</td>
<td>Efficiency of ice-breaking operations</td>
<td>7</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>On-time arrival, on-time information, accuracy of information, port security, port safety, efficiency of passengers’ clearance procedures</td>
<td>6.5</td>
</tr>
<tr>
<td><strong>Least-rated</strong></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>3</td>
<td>Customs operating hours</td>
<td>5.5</td>
<td>Efficiency of bunkering, efficiency of dredging operations, number of operational passenger terminals, efficiency of baggage handling operations, baggage handling cost, coordination of port community</td>
<td>5</td>
</tr>
</tbody>
</table>

**Table VII.**

Top- and least-rated criteria for cruise port market

<p>| | |</p>
<table>
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<tr>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>Number of parking areas</td>
</tr>
<tr>
<td>2</td>
<td>Services to passengers</td>
</tr>
</tbody>
</table>

**Source:** Author
by it. In this case no action is required. The closer the gap is to zero the better balance there is between importance and satisfaction.

Table VIII presents the GAP analysis results in an aggregated way per port market. There is a GAP scale from –3.5 to 3.5 with a 0.5 pace, in total 15 GAP values that can be attributed to the criteria. For each value the table presents the number of criteria that scored this value per port market.

Port users identified major gaps in the majority of the criteria attributed to the container port market. Their perspective is that certain significant criteria are experiencing low levels of satisfaction. Criteria with large gaps (i.e. from 1 to 2.5) need to be a priority for improvement initiatives. A smaller gap was identified for several criteria, whilst a high negative gap (i.e. high levels of satisfaction and low importance) is only attributed to the “deep sea container services” criterion.

The Ro-Ro market evaluation reveals smaller gaps than the container port market, although a large gap (equal to 2.5) is revealed for the “vessel-related port costs,” thus improvement action is considered essential. Several criteria have a good balance between satisfaction and importance, thus action is not recommended as a priority in these cases, nor in the case of those criteria revealing negative gaps.

The dry bulk market does not reveal a satisfying performance. High positive gaps were identified for most of the criteria that have been evaluated by the port users, showing that there is a need for further improvements. Action is considered essential for all criteria that reveal high gaps between satisfaction and importance.

Liquid bulk port market is one of the markets where port users gave positive evaluations. Positive gaps are small with only those referring to costs (cargo-handling costs and vessel-related costs) and the operational depth having a positive gap of 1.5. The rest either have a balance between satisfaction and importance or they present a very small positive gap.

Break bulk market’s GAP analysis points out that there is a lot of room for improvements. Port managers should primarily focus on actions related to the hinterland connections (rail and road), adequacy of handling equipment for that specific type of cargo and related handling services. For these cases, GAP analysis indicates large positive gaps. Only the efficiency of dredging has been evaluated without unbalance between satisfaction and importance.

Finally, the results of the GAP analysis reveal a smooth picture for participating ports active in the cruise port market. In general, as seen from the above table the positive gaps are not high. Availability of parking areas and the services to passengers are the factors that have been evaluated as the most unsatisfying, revealing a positive gap at the scale of 1.5. Room for improvement though is available for the rest of the criteria with positive gaps, while at the same time port users seem quite satisfied with the rest of the criteria, as a lot of

<table>
<thead>
<tr>
<th>Port market</th>
<th>–3.5</th>
<th>–3</th>
<th>–2.5</th>
<th>–2</th>
<th>–1.5</th>
<th>–1</th>
<th>–0.5</th>
<th>0</th>
<th>0.5</th>
<th>1</th>
<th>1.5</th>
<th>2</th>
<th>2.5</th>
<th>3</th>
<th>3.5</th>
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<tr>
<td>Container market</td>
<td>1</td>
<td></td>
<td>5</td>
<td>12</td>
<td>11</td>
<td>8</td>
<td>1</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ro-Ro market</td>
<td>1</td>
<td></td>
<td>4</td>
<td>13</td>
<td>13</td>
<td>7</td>
<td>1</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dry Bulk market</td>
<td>4</td>
<td>16</td>
<td>11</td>
<td>5</td>
<td>1</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Liquid Bulk market</td>
<td>2</td>
<td>12</td>
<td>14</td>
<td>3</td>
<td>3</td>
<td></td>
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<tr>
<td>Break-Bulk market</td>
<td>1</td>
<td>2</td>
<td>11</td>
<td>20</td>
<td>4</td>
<td>1</td>
<td></td>
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<td></td>
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<tr>
<td>Cruise market</td>
<td>3</td>
<td>8</td>
<td>15</td>
<td>10</td>
<td>2</td>
<td></td>
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Source: Author
them reveal a good balance between satisfaction and importance, with zero or low negative gaps.

In a nutshell, best-performing port markets in terms of the evaluation of port users’ perspectives are the cruise and the liquid bulk markets, and corrective actions are needed for the rest of them.

5. Discussion: overall experience and lessons learned

The pilot phase implementation has provided a significant feedback, both from the perceived value of the proposed framework perspective, based on the results, as well as from an operational perspective. In general, most of the ports participated in the pilot phase have been open, curious and interested in the process and the results. This is justified by the fact that a lot of non-technical questions have been communicated to the research team referring mostly to the effectiveness of the process itself.

On the added value of the proposed framework and its application, the paper draws attention to a rather neglected parameter on port performance measurement – that of the port users’ perception of port performance (Vaggelas et al., 2017). Incorporating port users’ perception in any port performance measurement framework can lead to an integrated and holistic approach.

Moreover, the proposed framework provides three key attributes that proved to be essential during the implementation phase. The first one is customization, as each port has unique characteristics and needs. The ability of the tool to be customized based on the peculiar needs of a port, through the selection of port markets as well as of the criteria per port market that are going to be assessed by the port users, is an advantage of the proposed framework increasing the degree of applicability and thus the acceptance of the tool.

The second attribute is confidentiality, as the ICT tool can be controlled by the port authority or the terminal operator, in case of applying the tool in a specific port terminal, thus securing that the whole process and any sensitive data are only accessible by the authorized personnel. Many ports are reluctant in sharing information because of:

- the sensitive nature of port business in terms of security;
- the fact that ports are business entities; thus confidentiality issues arise especially with regard to business information and data; and
- the fact that ports are usually introvert organizations, though steps have been taken in the past few years toward extroversion.

The third attribute is flexibility. A port authority can apply the proposed framework at any given time and for any given reason. For example, on the occasion of the construction of a new container terminal the port authority can run the exercise to selected port users, aiming at assessing their perception on port performance prior and after the new infrastructure.

The discussion on the deficiencies of the proposed framework starts from the fact that port users asked to evaluate criteria related with port’ performance that have been selected by the port authority itself. The twofold approach that has been followed (Phases 1 and 2 of the tool) has been revealed to be rather inevitable. The involvement of port management at the structure of the surveys through the criteria selection has unavoidably provided an aspect of what ports consider important when measuring port performance. As already mentioned, this was inevitable as during the phases of design, development and finally application of the proposed framework and the relevant ICT tool, it has been evident that port authorities sought for a more active participation and control over the design and
implementation of the tool aiming at safeguarding the privacy of the subsequent results. Previous studies, with the most indicative example being that of PricewaterhouseCoopers and Panteia (2013), highlighted efficiency drawbacks in the port industry and in general brought at the forefront the port efficiency as a parameter of port policy. As a result, ports became even more suspicious in participating in relevant studies. A suggestion for future research is to limit the involvement of port authorities in the selection of the criteria to be evaluated by port users avoiding any bias in the process. Also, the active participation of port users in the development of the list of criteria (for example, through interviews) is something worth to be explored in a future research.

Another drawback has been the low participation rate of port authorities and of port users. For port authorities it seems rather difficult to undertake corrective actions, as the insights from the whole procedure reveal that a lot of communication and promotion is needed, but only if contacts have been made with port management key personnel in advance. Promotion campaigns (via e-mails) seem to be rather impersonal and the sense is that if those are addressed to unauthorized departments of a port authority, they rarely get the attention they deserve. Also, a campaign is needed to overcome port’s hesitation in participating in a port users’ performance measurement exercise, as this is a sensitive issue for the port industry, as already discussed. To overcome this drawback is not just an issue of applying some corrective actions. It is an issue that is strongly related with the nature of port business and the fact that port authorities are rarely extrovert organizations. Thus, to overcome this issue a lot of effort is needed aiming at building trust and a common understanding without prejudices between port authorities and the research community.

All in all, port authorities should adopt a more extrovert strategy, targeting among others, their users. The paradigm of the airline industry, where the airline companies and the airports are evaluated by their users shows that users perceptions should not be a taboo issue but rather a tool for developing business strategies. As regards port users, there were also low response rates revealing some common outcomes as in the case of port authorities. As suggested to all port authorities’ representatives that used the ICT platform campaign, a lot of follow-up is needed. Another suggestion aiming at increasing port users’ participation would be an informative campaign before proceeding with the online survey. The port authority can also run the exercise periodically to acquaint its users with the evaluation campaign, thus building a long-term relationship aiming at higher participation and response rates in the future.

Concluding, port performance issues and especially the port users’ perception on it, continues to be a taboo issue for the port industry. The request from port authorities for having a control over the ICT tool and its application along with the low participation of ports, shows that they are not yet ready to move towards an increasing engagement of their users in a port performance evaluation scheme.

6. Concluding remarks
The paper presents a framework aiming at measuring the perceptions of port users – such as shipping companies – on port performance. With port users’ perceptions being the missing link in port performance measuring tools, the paper suggests a framework that can lead to a comprehensive approach. The results of the pilot phase reveal several drawbacks in port performance elements in the participating ports especially for the container port market, the dry bulk port market, the Ro-Ro port market and the break-bulk port market.

The proposed tool can be a valuable add-on for port authorities to evaluate their performance from the port users’ point of view and taking the necessary actions to improve it. It can also be used for the evaluation of a new process, infrastructure, etc. in a port, as the
exercise can be applied even in the case of one and only criterion for which the port users will provide their feedback. In addition, the proposed tool can be used for several other purposes, i.e. a port authority can use it for performing evaluation processes internally. For example, running an exercise on port authority’s employees regarding their perception on port operation and performance. The tool can be used for any purpose aiming at evaluating a decision, a process, an infrastructure or a service in a port, being a useful component in a decision-making process.

As regards port policy implications, the evaluation of port users’ perception of port performance can be part of a European ports observatory through a set of indicators that clearly reflects the satisfaction of port users by engaging their view on port performance issues, instead of relying almost exclusively on data generated by port authorities. The measurement of users’ perception is the missing link in the existing port performance measurement initiatives, aiming at a more holistic approach were the users are the key for a robust evaluation. The development of a European ports observatory could be the first step towards the creation of a level playing field in the European port industry at least regarding the development of a common ground for port performance measurement.

The paper contributes in the dialog regarding port performance, going beyond the typical efficiency approach and bringing into the scene, the port users’ perception on port performance, thus examining the issue from an effectiveness point of view.

Being a vital part of port competitiveness, performance is at the core of port strategies, but usually the approaches used differ, depending on the peculiar characteristics of each port, needs and requests. The proposed framework can be the base for the formation of a common approach towards port performance measurement.

There has been a lot of dialog done lately regarding the improving of quality of port services and the adoption of sustainable development goals. More recently, a coalition of 30 European transport organizations launched a campaign for a “strong connecting Europe Facility for the next financial period 2021-2028.” The slogan is “More EU budget for transport, the best investment plan for Europe,” a move that reveals an urgent need for quality adjustments within a lack of finance resources. In addition, the international port community is taking up the challenge towards a more sustainable port industry, by setting up the “World Ports Sustainability Program”.

Ports, as any other commercial entity, are seeking quality to increase their competitiveness and at the end, their viability in a strongly competitive environment. Port performance, on the other hand, is an attribute of quality and as such, exploiting the measurement of port performance is essential for understanding the notion of quality. The measurement of port users’ perceptions on port performance is a strong link in the enhancement of quality of port services as a strategic tool and as such can provide additional perspectives regarding port effectiveness and quality schemes.

References


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The role of standardisation in European intermodal transportation

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Stephan Decrauw
Rotterdam School of Management Erasmus University, Rotterdam, The Netherlands

Abstract

Purpose – This paper aims to study the function of standardisation in intermodal transport. It identifies where standardisation helps to improve intermodal transport, who is active in intermodal transport standardisation, what types of standards are needed and what the decision-making process and implementation of standards should be like to positively influence the performance of intermodal transportation.

Design/methodology/approach – An empirical study is designed to carry out this research project. The empirical study starts with a review of the organisations that are responsible for standardisation and intermodal transport, together with the standards that they have developed, and are developing, so far. It continues with analysing the topics where standardisation helps to improve the performance of intermodal transport. The analysis is based on 12 interviews, followed by desk research, to validate the respondents’ statements.

Findings – The results show that intermodal transportation should be distinguished in continental and maritime transport, which require different standards. In maritime transport, the hardware aspects of the system are highly standardised. However, further standardisation of information exchange offers potential to improve the quality of transport. For continental transport, challenges appear in the heterogeneity of infrastructure and loading units used in Europe. For both systems, openness and consensus are main requirements for the development of successful standards.

Originality/value – Standards facilitate interoperability, quality and safety of intermodal transportation, which leads to better performance. This has drawn little attention in the literature. This study addresses this gap and focuses on Europe.

Keywords Intermodal transportation, Infrastructure

Paper type Case study

1. Introduction

Standards facilitate interoperability, quality and safety of intermodal transportation, which leads to better performance. This has drawn little attention in the literature. This study addresses this gap and focuses on Europe.
The European Conference of Ministers of Transport and European Commission (2001) define intermodal transport as “movement of goods in one and the same loading unit or vehicle, which uses successively two or more modes of transport without handling the goods themselves in changing modes”. However, this definition is very broad, and we focus on intermodal road-rail and road-barge transport in Europe. By extending this definition with some important characteristics of intermodal transport, Bontekoning et al. (2004) give the following definition of intermodal transport:

The (European) movement of goods in the same, standardized, loading unit, which successively (by transhipment) uses rail or barge transport for long-haul and road transport for the short-haul leg in a single seamless journey, without handling the goods themselves in changing modes.

Furthermore, the journey is characterized by decentralized control because of the multiple actors in the chain.

Intermodal transport plays an important role in EU policy on Europe’s future transport network. In the past 30 years, road transport has gained a dominant position in European cargo transport. As shown in Figure 1(a), for the 27 countries of the EU, the current truck/barge/rail split is 75/7/18, which has not significantly changed during the past decade (INeS Danube, 2016). Figure 1(b) shows that except The Netherlands with 33 per cent barge transportation, which is due to a highly integrated inland waterway network, truck transportation is dominant among all other countries (Eurostat, 2013).

Road transport is fast, flexible and relatively cheap. However, the EU cannot be reliant on road transport in the future due to capacity constraints. In recent years, the performance of road transport is diminishing because of traffic jams, higher fuel prices, road taxes and the increasing awareness of environmental issues. Among others, it is believed that a modal shift from road to rail and barge will lighten the pressure on European roads. As long as the cost savings on transportation are lower than the extra handling costs, intermodal transport is cheaper than road transport. Moreover, intermodal transport puts less pressure on the environment compared to road transport.

Unfortunately, intermodal transportation faces challenges such as capacity problems, long waiting times, problems with bookings and limited track-and-trace options.
Intermodal transport is complex due to the large number of actors involved. Therefore, better coordination and information exchange is necessary. Aligning and standardising business processes in the intermodal chain might reduce these problems. Standardisation can facilitate interoperability and compatibility of subsystems to improve the performance of the entire system. This study aims to investigate the challenges of creating and implementing standardisation in European intermodal transport chains.

The rest of this paper is organised as follows. First we focus on a literature review of standardisation in intermodal transport in Section 2. Then, we describe our methodology in Section 3. Subsequently, we present the findings of our study in Section 4 and perform an analysis of the potential standardisation possibilities in Section 5. Our conclusions follow in Section 6.

2. Literature review

Aim of this review is to define the main concepts discussed in this study and gain further theoretical insight about standardisation in intermodal transport. Furthermore, the study tries to identify gaps in the current knowledge and establish the context of the issue under investigation.

The official definition of a standard is (ISO/IEC, 2004):

[...] a document, established by consensus and approved by a recognized body that provides, for common and repeated use, rules, guidelines or characteristics for activities or their results, aimed at the achievement of the optimum degree of order in a given context.

Standardisation is the process of making standards. However, standards do not necessarily have to be established by consensus or approved by a recognised body. Therefore, the definition of De Vries (1997) is more suitable:

[...] a standard is an approved specification of a limited set of solutions to actual or potential matching problems, prepared for the benefits of the party or parties involved, balancing their needs, and intended and expected to be used repeatedly or continuously, during a certain period, by a substantial number of the parties for whom they are meant.

Literature suggests a positive impact of standardisation on transport performance. An example is the standardisation of loading units (Tomlinson, 2009; Egyedi, 1996, 2001). In the late 1950s, labour costs in ports were high because loading and unloading of vessels required much time. The development of the ISO container led to unitisation of cargo. Now, cargo could be directly transferred from producer to customer without repackaging the goods. This made door-to-door transport possible and led to a significant increase in efficiency. The use of containers enabled automation in the transhipment process, which decreased labour costs. As another example, one could discuss that the lack of common standards causes problems for the railway sector. Traditionally, policies differ per country. Every country has developed its own procedures, infrastructure, etc. This leads to two main problems:

- **High costs and low efficiency**: The efficiency of the operational process is seriously influenced by border-crossing procedures, differences in infrastructure, locomotives, train driver licences, safety systems, rail gauges, rolling stock, administrative procedures, etc. between countries. This leads to higher transport costs, lower efficiency and a very low level of integration (Meyer, 2012).

- **Mistakes due to a lack of cooperation and/or communication**: The intermodal transport chain consists of multiple actors who need to effectively and
efficiently exchange information and data in order for the process to run smoothly. A lack of harmonised information systems and data exchange protocols are the main cause for this problem (Bask et al., 2001; Reis et al., 2012; Dullaert et al., 2009).

Many scholars opt for further standardisation to harmonise different transport modes to improve the quality of intermodal transport. According to Bontekoning and Priemus (2004): “innovations in technological and organizational aspects are necessary if the market share of intermodal transport is to expand”. Many see an important role for inter-organisational coordination, integration of operations and information networks. Table I shows which dimensions in intermodal transportation could be standardised. Based on our study and the outcomes of the interviews discussed in Section 4, the fields with most potential for standardisation seem to be infrastructure, information and data exchange and equipment within the intermodal transportation chain. In terms of infrastructure, some important steps have already been made including the development of standards for train control and command systems, called ERTMS (European Rail Traffic Management System). But looking at the recent studies which address this problem, there is still a lot to improve. Because of the multi-actor environment of intermodal transport, it is important that data and

<table>
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<th>Dimension</th>
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<td>Sakalys and Palšaitis (2006), Reis et al. (2012)</td>
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<td>Training</td>
<td>Van de Lande and Henriques (2006)</td>
</tr>
<tr>
<td>Environmental</td>
<td>Noise</td>
<td>Reis et al. (2012)</td>
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Table I.
Possible areas for standardisation
information is exchanged on time, accurately, and efficiently to ensure the seamless journey through the chain. Many studies have found that cooperation and communication between actors is poor, while current information systems are often incompatible. Creating standards in IT systems (e.g. booking, tracking and tracing and invoicing processes), communication flows, data exchange (e.g. XML or EDI), interfaces and procedures creates opportunities for centralising information, leading to a one-stop-shop solution (Sakalys and Palštaitis, 2006).

Many studies also concern standardisation of equipment in intermodal transport. Currently, loading units are optimised for a single mode (Meyer, 2012; Woxenius and Bergqvist, 2011). In intercontinental transport, the ISO container is used, while in intra-European road transport, trailers are often used. Road transport prefers to use semi-trailers, as they are lighter and can load 33 euro-pallets. For deep-sea and inland navigation, stackability of loading units is very important, therefore these modalities prefer to use ISO containers. For rail transport, containers are also more attractive. They can be loaded on flat waggon, are secured by twist locks and are simple to lift. Regular trailers, however, cannot be lifted on trains (they need extra reinforcement) and pocket wagons with a king-pin box are needed to transport the trailers by train.

An important question this study tries to answer is on what level standards should be developed and adopted? Not much has been written about this in literature, but ideas do exist. Standards for freight transport are developed at the national, European (European Committee for Standardization CEN) and international levels (International Organization for Standardization ISO). According to Silborn (2013), standardisation should be established at European and international level because of the long-distance, border-crossing nature of intermodal transportation. Most scholars reason that standards should be set on a European level (Marinov, 2009; Janic, 2001; Van de Lande and Henriques, 2006). In the future, it is expected that rail transport between Europe and Asia will show growth potential, but for now, the EU transport policy focuses on creating a European-wide unified transport network (Merkel, 2018). Therefore, setting standards at the European level seems to be the most logical step.

All in all, in the standardisation literature, ICT gets a lot of attention, whereas other fields of standardisation, including (intermodal) transport, are hardly addressed. There is still a lack of knowledge on standardisation practices. Despite the deep literature on port operations (Vis and De Koster, 2003; Carlo et al., 2014a, 2013, 2014b; Gorman et al., 2014; Gharehgozli et al., 2014a, 2014b, 2015, 2016, 2017a, 2017b, 2017c, 2017d; Gharehgozli and Zaerpour, 2018; Galvao et al., 2018; Steenken et al., 2004; Stahlbock and Voß, 2008) and shipping operations (Sharifyazdi et al., 2018; Mileski et al., 2018; Lee and Song, 2017; Fransoo and Lee, 2013; Christiansen et al., 2007, 2004, 2013; Meng et al., 2014; Tran and Haasis, 2015; Ronen, 1993), the intermodal research field is still in a pre-paradigmatic phase, especially regarding standardisation. Furthermore, most research on standardisation in intermodal transportation is practice-oriented. These studies do recommend standardisation to be used to improve interoperability of European intermodal transportation, but do not further elaborate on this topic. Especially, studies about stakeholders, their stakes and the decision-making process are missing (Caris et al., 2008; Egyedi, 1996). By applying current knowledge of standardisation on intermodal transportation, this study tries to bridge this gap.

3. Methodology
In this section, we introduce the most important concepts to be used in the case study, we give some additional background information on these topics, and identify the relations
between these theoretical concepts. Finally, at the end of the section, we discuss how the empirical data, including the interview process, has been collected.

3.1 Types of standards
A distinction can be made between basic standards, requiring standards, and measurement standards (de Vries, 1997). Requiring standards can be distinguished in performance standards and standards that describe solutions. Another possible subdivision of requiring standards concerns the distinction between: interference standards, compatibility standards and quality standards. Compatibility standards are always descriptive; interference and quality standards can be performance standards and solution-describing standards. In fact, measurement standards are a particular kind of requiring standards, namely, standards that describe a solution for measuring. Most standards concern technical topics, other topics include services and management systems. In many standards, preference ranges are laid down. This study focuses largely on compatibility standards: standards that aim to match different objects or systems to each other. Indeed, many scholars in the field of intermodal transportation mention the lack of interoperability and/or compatibility of the European intermodal transportation system. The differences between transport modes and between national transport systems have led to poor performance of intermodal transportation, while most intermodal transport routes have to cross national borders. Compatibility standards can create solutions for problems in the matching between two processes or entities.

3.2 Modes of standardisation
Wiegmann (2013) distinguishes three modes of standardisation: market-based, committee-based and governmental. In market-based standardisation, standards result from a battle between competing actors. In committee-based standardisation, standards are the result of an agreement between stakeholders represented in a committee. In governmental standardisation, government intervenes in standards setting or imposes a standard. For inter-modal transport in Europe, committee-based standardisation is most important, more in particular standards setting by two formal Standards Development Organisations (SDOs) at the international and European level, ISO and CEN, respectively. The main principles of formal standardisation are: openness, decision-making based on consensus, transparency and coherency. Formal standards are set carefully with involvement of different stakeholders. These standards are updated every five years, if necessary. However, the process is rather slow because of the consensus-based decision-making and the option to provide comments at different stages.

Establishing successful compatibility standards is not easy because each modality or European member state has its own transport subsystems with different characteristics. They all have a certain number of users of the subsystems, this is called the installed base. When a European standard is established, users must switch from their current system to the new common European solution, which leads to switching costs. This is only attractive when the profits of the new standard (better performance due to a higher level of interoperability) exceed the costs of switching. When this is not the case, a lock-in occurs: the different countries stick to their current standards. They are waiting for each other to adopt the new standard. When early adopters adopt the new standard, other parties may step on the bandwagon. Then the new European standard may become the dominant design and for every country, it will become attractive to hop on the bandwagon as this leads to economies of scale because of network effects. The latter means that the functionality of a standard or system becomes more attractive for an individual user increases when more users implement it.
3.3 Interoperability
Interoperability can be defined as:

(...) the ability of systems, units or forces to provide services to, and accept services from, other systems, units or forces and to use the services so exchanged to enable them to operate effectively together without altering or degrading the information exchanged (Clark and Jones, 1999).

To put it simply, two systems are interoperable when they are able to effectively work together. Compatibility standards aim to improve interoperability of a system. But a compatibility standard is not a sufficient condition to achieve interoperability according to Lehr (1995). He states that: “Traditional SDOs are sometimes perceived as too slow and often approve standards that fail to guarantee interoperability. Producers and customers often need to expend significant resources on conformance testing”. If some restrictions for particular parameters are not specified, users can claim compliance to a standard without realising interoperability. So a well-specified standard has a positive influence on system interoperability, but the problem is that it is very difficult to specify a good standard which does not leave any room for different interpretations.

3.4 Data collection
The foregoing can be summarised as follows. Compatibility and quality standards are expected to have a positive influence on the interoperability of the European intermodal system. Interoperability can then lead to improved performance in terms of lead times, price, reliability, etc. The empirical part of our study focuses on these relations. We collect data through personal interviews with actors in intermodal transport in Europe. Empirical data stem from multiple sources. First, a pre-study was done, including an interview with an expert who works in the intermodal rail industry, and visits to container terminals. Our sampling strategy was networking sampling. The limitation of this sampling method is the difficulty of generalising the research conclusions to other instances. Fortunately, our sample consists of a diverse set of expert stakeholders from intermodal transport so the bias, which often occurs in snowball sampling, is likely to be limited. Finally, 12 semi-structured interviews have been carried out from different companies including rail carriers (three companies), barge operators (two companies), intermodal operators (two companies), terminal operators (one company), logistic service providers (two companies), transport research organisation (one company) and trade association of shipping and transport companies (one company). The interview questions can be found in Appendix A. Additionally, background information and statistics about the actors were also obtained, such as data about the number of employees, turnover, target markets and the different products or services of companies that participate. To ensure a high level of reliability and internal validity, respondent validation has been used.

4. Empirical results
This section presents and analyses the outcomes of the interviews. Data across all respondents have been analysed to find similarities and differences between respondents. We distinguish between (Cosmos Project, 2013):

- **Maritime intermodal transportation**: This includes intermodal transport between deep-sea terminals from and to the European hinterland.
- **Continental intermodal transportation**: This includes intermodal transport between European consignor and consignee, i.e. transport within Europe.
4.1 Information exchange and communication

The main issue in intermodal transport, according to the respondents, is the exchange of information within the supply chain. Better communication and exchange of information between stakeholders would improve the performance of intermodal transportation, in maritime and continental intermodal transport. Information-related problems include:

- **Double information:** Information exchange between organisations is not efficient because each organisation in the intermodal supply chain uses its own information system, with their own communication language, software and structure.
- **Wrong information:** Due to the differences between information systems and their structure and language, other mistakes may also occur: wrong input. It must be clear what information is needed in the input fields. For example, a barge operator mentioned that clients often tell the planners that the container to be transported is a 40-ft container. But the client forgets to mention that in fact it is a 40-ft pallet-wide container, which is a few centimetres wider.
- **Timely information:** Often, information is not exchanged in time.
- **The demand for information is unknown:** Often, organisations do not know which information they need to exchange.

4.2 Loading units

In continental transport, different types of loading units are used. In maritime transport, this is not an issue; the standard ISO 20-ft and 40-ft containers are common. Deep-sea vessels, transhipment technologies (e.g. cranes) at terminals and transport modes (barges and train wagons) at inland modalities are perfectly adapted to the dimensions of these ISO containers. Therefore, the process of (un-)loading vessels and transhipping the cargo to trucks, trains and barges is now much more efficient than before the use of standardised containers.

Loading units in continental intermodal transport are more diverse. The first reason is that in continental intermodal transport, typically trucking companies shift cargo from the road to barge/rail, on routes over longer distances where substantial volumes are available. In traditional trucking, semi-trailers are often used. These are able to load more euro-pallets compared to the 40-ft containers used in maritime transport. So for continental intermodal transport to be competitive with road transport it is necessary to use units larger than 40 ft. Second, while continental intermodal transport must compete with road transport, it is important to be flexible so carriers can fulfil the diversified demands of continental European clients. Finally, the loading units are owned by various parties, in contrast to the dominance of deep-sea carriers in maritime transport. Loading units in continental transport can be owned by shippers, trucking companies or the intermodal operators.

The following loading units are used in rail transport:

- **Container:** They are standardised ISO containers, available in lengths of 20, 30, 40 and 45 ft. Tank containers often have different lengths.
- **Semi-trailer:** They are truck trailers that can be loaded on trains, vertically (lifting) or horizontally (driving the units on the wagons).
- **Swap bodies:** They are light loading units which cannot be stacked.

If barges are involved in the intermodal transport chain, mostly transport containers are used but these differ in length and height which leads to problems. For barge transport,
continental transport is more problematic compared to maritime transport: It is easy to load a vessel with only 20’ and 40-ft containers but the different container sizes used in continental transport lead to inefficient use of cargo space.

The same problem applies for rail transport: traditionally flat wagons had a length of 60 ft, so one 20’ and one 40-ft container could be loaded on one wagon. Due the increased popularity of 45-ft containers, modern wagons are now 90 ft long. But when only 20’ or 40-ft containers are used, some space is left unused.

4.3 Infrastructure
Problems in infrastructure are still significant in rail transport. Many technical standards have been developed to improve the interoperability of the European rail network but these are not yet used throughout Europe. Examples include the standards for a single European safety control system and for the electrical power network. Due to the high investment costs these standards cannot be implemented throughout Europe overnight. In The Netherlands, the European standards are implemented on new tracks but not yet on older parts of the railway system. As a consequence, Dutch locomotives must be equipped with both the ERTMS and the national system (ATB). Furthermore, multi-system locomotives are needed, fit for 1,500 and 25,000 V. Even worse, they have to be equipped with additional systems to enable them to drive in other countries.

5. Need for standardisation
From the previous section, we can conclude that remaining problems in intermodal transportation relate to loading units, infrastructure and information exchange. In this section, we deal with the decision-making processes, performance and types of standards that are necessary to solve these problems.

5.1 Loading units in intermodal transportation
5.1.1 Stakes. Each transport modality has its own preferences when it comes to loading units:

- **Road transport/shippers:** In European road transport, semi-trailers are the preferred loading unit. These units have a maximum length of 13.6 m and are wider than ISO containers. This allows to carry more euro-pallets. Regular semi-trailers are not stackable because of insufficient strength. This leads to a lower tare weight which results in lower fuel costs or the opportunity to load heavier cargo. Transhipment to other modalities is not possible because regular semi-trailers cannot be lifted. Shippers also prefer trailers because continental intermodal transport competes with road transport. Shippers do not want to use two containers if they can also pack their pallets in one semi-trailer.

- **Rail transport:** In intermodal rail transport, swap bodies and ISO containers are a good option. These units do not need to be stackable and can be lifted on flat wagons. Swap bodies have the same dimensions as semi-trailers so they have a higher capacity compared to ISO containers. Special intermodal semi-trailers exist, but they need grapple arms to be lifted and pocket train wagons are needed to fit the wheels of the semi-trailers. Therefore swap bodies and containers are easier for rail transport.

- **Barge transport:** The ship cells of barges are adapted to the standardised 20ft and 40 ft ISO-containers. These are not only used in intercontinental deep-sea transport, but also in the maritime intermodal transportation to and from the European
hinterland. ISO containers are stackable which makes them the best solution for barge transport.

5.1.2 Type of standard and decision-making process. Interviewees prefer to develop standards on a European level, while these standards are targeted for the European market only. It aims to reduce the number of different intermodal loading units on the European continent. The EU attempted to develop a proposal for a directive on intermodal loading units in 2004, i.e. COM (2004) 361 (European Commission, 2004).

5.1.3 Implementation/performance. The European Intermodal Loading Unit (EILU) can combine the strengths of swap bodies and containers. They can be stacked but have less deadweight than ISO containers, they have the same pallet capacity and dimensions as swap bodies and can be lifted from the top like ISO containers. Therefore the EILU can be used in both barge and rail transport, opposite to swap bodies and semi-trailers which are used in road-rail transport. The EILU is particularly suitable for barge transport because the units will be stackable swap bodies. But for the most common combination of intermodal transport on the continent, road-rail, the EILU has no added value because units do not need to be stacked and then a regular swap body is more efficient because it has a lower deadweight and can be loaded from both the back and from sides of the unit.

Another reason why one single loading unit will be suboptimal is that continental intermodal transport must compete with road transport, which is very flexible. For example, in road transport, longer heavier vehicles (LHV’s) which can load up to 60 tonnes and have a length of 25.25 m will possibly be allowed for international transports within the EU. This is a direct threat to continental intermodal transport:

- LHV’s require new investments in road infrastructure which come at the expense of investments in rail infrastructure.
- LHV’s are detrimental for the entire society. They do more damage to the current road infrastructure because of their weight and have higher CO₂ emissions.

5.2 Infrastructure in intermodal transportation

Next to the heterogeneity in loading units, continental rail transport also deals with great differences in rail infrastructure within Europe.

5.2.1 Stakes. Currently stakeholders compromise between stakes on a national and European level.

- **National stakes**: Traditionally, rail infrastructure and technical systems are specified on a national level. Safety systems, signalling systems and power systems differ per Member state. Some countries even have a rail gauge that deviates from the standard ISO dimensions.
- **European stakes**: The EU aims for a single rail market. Technical standards have been developed to improve the interoperability and efficiency of the rail network. The European stake is therefore to standardise infrastructure and technical systems at a European level.

5.2.2 Level of standardisation. Currently, standards for rail infrastructure are developed at a European level, mostly by the European standardisation organisations Comité Européen de Normalisation (CEN), Comité Européen de Normalisation Electrotechnique (CENELEC) and European Telecommunication Standards Institute (ETSI). The ISO containers have been developed for global use. Next to that, CEN developed standards for European Intermodal
Loading Units and European swap bodies. When more standards are created, world-wide standardisation is preferred because European organisations want to have influence in the Asian markets, where most containers and materials are being produced. Furthermore, organisations are now investing in rail connections between Europe and Asia to compete with maritime deep-sea transport. Therefore the development of the “hardware” aspects in rail transport should be developed by ISO committees in the future.

5.2.3 Implementation/performance. Many standards have been developed already to improve the homogeneity of the European intermodal rail market. However, implementation of these standards on infrastructure is very expensive; therefore, it takes many years before a standard is implemented throughout Europe. An example is ERTMS; this system is often only equipped on new rail tracks. Implementing it on tracks that are already in use causes a temporary decrease of capacity due to the track work. Next to that, it is impossible to implement such a system on all rail tracks at once. In The Netherlands the new rail tracks are equipped with ERTMS, but older lines are still equipped with ATB. So before ERTMS is implemented everywhere, multi-system locomotives are necessary. Thus, here we can also identify the entrapment between the national and European stake. In the short term the railway companies do not want the loss of rail capacity, but in the long term a uniform rail infrastructure would increase efficiency and make multi-system locomotives redundant. Another example is the connection between the main Dutch cargo track (Betuwelijn) and the German railways. For a long time, the Germans were not willing to invest in an extra rail track to improve the throughput because Germany has to make the financial investments but the Port of Rotterdam benefits from the project. When the connection at the border is improved, rail transport from the Port of Rotterdam will improve, which is a strategic advantage against German ports. These examples show that organisations and countries are often still concerned with their individual stakes instead of the joint European stake. The switching costs from the current situation to European standards are still perceived as very high, it is important that a significant installed base is built so that the other parties will also make the shift.

Respondents see an important role for the EU as the main party to initiate the shift to European standards. Single countries or organisations are often reluctant to invest, they are afraid that other parties will benefit from their investments. When a neutral organisation like the EU will initiate investments the market is willing to cooperate and switch standards. The view of the respondents complies with the strategy of the EU. Via its trans-European transport network (TEN-T) plan, the EU invests money in the implementation of standards. They choose important European rail corridors (TEN-T), which will be designed according to the latest European technical standards. On these corridors, ERTMS must be implemented by 2050. Furthermore, by 2030, the nominal track gauge of 1,435 mm must be implemented. Here, the freight lines must be equipped to allow for 22.5 ton axle load, the line speed should be 100 km/h and trains with a length of 740 m must be able to run on the tracks (Railcargo, 2013). By investing in the interoperability of the most important European railroads, the EU tries to build an installed base for the technical standards created in recent years. But the respondents are afraid that the implementation of the standards will not be successful. The timespan for these standards is so extensive that it is possible that by 2050, already newer and better systems exist. Therefore, the respondents are afraid that the European rail market will never have one single system.

5.3 Information exchange in intermodal transportation
This section describes the role of information exchange standards in solving this problem. First of all, the three information platforms established in The Netherlands will be introduced.
Portbase: The Port Community System of the Port of Rotterdam is an information platform that aims to be the Dutch national Port Community System and also should collaborate with other European port systems. Portbase is a neutral platform with a broad support from parties in the port. This information system provides different services to allow participants to share information with each other.

Neutral Logistics Information Platform (NLIP): NLIP is a neutral information platform for Dutch logistics firms. It connects different systems to standardise information exchange and make it more efficient. The platform will connect Portbase, Cargonaut (information system of Schiphol Airport) and Digipoort (information system of the Dutch Government).

NextLogic: NextLogic is an initiative to improve performance of barge transport between the Port of Rotterdam and the hinterland by means of better coordination of communication and planning, replacing bilateral communication and planning.

5.3.1 Stakes. For information exchange in intermodal transport three levels of stakes can be identified:

1. **Individual stakes**: When all information is available for each organisation, some organisations will have to rethink their core business. Expeditors make money by organising transport for their clients. When everything is transparent and all options are known there is less need for their services. When information can be seen by other parties, they may use their competitors’ information for competitive reasons. Therefore companies are reluctant with whom they share what information. Furthermore, transparency beholds responsibility. When a client is billed for two days of transport whereas the cargo could have been transported in one day, the operator will be held accountable.

2. **Stakes of the port**: The port should facilitate efficient transport of cargo into and out of the port. Better cooperation between stakeholders and more efficient information exchange will improve the port’s performance. As a consequence, more shippers will choose to import and export their cargo via this port.

3. **Stakes of the European and global organisations**: Large firms that are active globally are better off when they are able to deliver the same set of information to all ports and can do this in one format. If every European port is developing its own Port Community System and each National Customs organisation demands different sets of information, globally operating corporations need to adapt to different systems. Their operational efficiency will improve when Port Community Systems and information requirements would be standardised on a European or worldwide level.

5.3.2 Type of standards. For information exchange, different types of standards apply. First off, there are standard communication platforms. For example, Portbase is now the standard Port Community System for Dutch port. Secondly, there are standard communication languages like EDI, XML, etc.

According to the respondents, the communication platforms must be a national de-facto standard which could later on be used for formal European or world-wide standardisation. Portbase and NLIP intend to become the standard communication platform for, respectively, the Dutch Ports and the entire Dutch logistics industry. An installed base of users of these information systems is being created now. The initiators do not care which underlying communication standards are used by different systems. Their goal is to connect all
information systems, regardless of which standards are used. Potential participants must be convinced of the added value of sharing information with chain partners. So at this moment, the information platforms aim to be a de-facto meta-level standard for information sharing in intermodal transport.

The European Port Community Systems Association aims to “promote the highest possible standards in European Port Community Systems”. This shows that the different European countries see the importance of standardising port community systems on a European level. This will make it easier for firms active in multiple European ports to exchange information with port authorities and customs. The respondents advise that standards are developed on a world-wide level because logistics organisations communicate with each other on a global level.

5.3.3 Implementation/Performance. The respondents all mentioned the difficulties actors have to shift mentally from individual stakes to the joint stakes of the port. The switching costs from the organisations’ current systems to joint systems are oftentimes perceived as too high. The benefits in the long-term do not weigh up to the investments on the short-term. They need to get convinced that providing data to other firms and investing in connections between information systems will profit them and the other organisations in the port in the long run. According to the respondents, the awareness of the joint stakes is improving. An increasing number of organisations use Portbase services and there are new initiatives and projects to improve information sharing, e.g. NLIP and Nextlogic.

The use of coordinated communication platforms has a number of benefits.

- **Improved coordination**: While information can be collected from a shared information platform, less bilateral communication is necessary, so communication can be integrated and coordinated throughout the chain.

- **Lower transaction costs**: When information is submitted to a shared platform by one party, every authorised actor has access to this information. So information is not exchanged between, and submitted to, in-house information systems multiple times.

- **Reliability**: When information is exchanged in a coordinated manner and it is re-used by multiple parties the quality of information will improve. Then transport can be scheduled better, leading to a higher reliability.

- **Transit time**: When information is known in advance instead of being delayed, a container can be cleared and picked up from the terminal as soon as possible. This can improve the transit time.

- **Safety**: When authorities and fire brigades know which trains or barges move hazardous cargo and know their location, accidents can be solved before turning into disasters (KNV, 2013).

- **Costs**: When more information is known about the different options for hinterland transport shippers can easily switch between different transport modes. When a client knows the different rail and barge connections between the port and his final destination in the hinterland, when these connections will leave and arrive and how much the transport will cost, the organisation is able to quickly move between different modalities.

6. Conclusions

This study is among the handful papers to go one level deeper into the subject of standardisation in intermodal transportation. It combines a literature review and an empirical part based on desk research and interviews. The findings show potential for the
use of standards in three main areas of intermodal transport: infrastructure, loading units, and information exchange. The interviewees argue that official European standards are needed. In fact, however, transport standardisation is shifting to standards on a world-wide level. A limitation of this qualitative study is that it relies on perceptions of interviewees, though where possible triangulated with written sources. A second limitation is that the respondents of the study were all Dutch. This may lead to a difference in emphasis. In most European Member States, for example, barge transport is not as widely used as in The Netherlands. Finally, as most respondents in the interviews are active in the operational domain of intermodal transportation, they see potential for information exchange. But the standardisation consultant also mentioned quality and environmental standards. Maybe the market has not yet discovered the relevance of such standards.

References


Intermodal transportation


Appendix. Interview questions

**Identifying problems in intermodal transport**

- In which parts of the intermodal chain do problems or possibilities for improvement occur and what are these possibilities?
- What possibilities for improvement are possible at the interface between two different modes of transport?
- What possibilities for improvement are possible due to different procedures for two or more countries?

**Identifying the cause of the problems and identify stakeholders**

- Why do these problems occur? Do they occur due to a lack of collaboration, coordination and/or alignment?
- Which stakeholders are involved in the problems?
- What are the stakes of these actors? Why is there no collaboration/coordination/alignment?
- Are there any previous attempts to coordinate processes?

**Possibilities of standardisation**

- What standards is the company currently using?
- Can standards solve the problem or are other solutions needed?
- Are the official European harmonised standards often used to meet the requirements set by the European commission or do companies find other ways to meet these requirements?
- What types of standards would be the best solution to the current problems? (formal standards vs. consortium or company standards)
On what level are possible standards necessary? (company, chain-wide, national, European or world-wide?)

The decision-making process for successful standards
- Which actors need to be involved in the setting of standards?
- Which actors are critical in the process?
- What are critical success factors for the development and implementation of standards?
- How to break through the lock-in?
- What can be improved in the decision-making process to further improve the quality of standards?

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Maritime Cluster Attractiveness Index

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Abstract

Purpose – The role of clusters in the development and growth of local and national economies has been extensively studied and discussed in global literature. Different methodologies are used for analysing the impact these have in national and regional economies, such as the input–output (IO) and gravity models. This paper aims to detail the methodologies present in the literature and propose a new robust theoretical framework, which facilitates the evaluation and comparison among maritime clusters in terms of attractiveness assisting stakeholders to devise strategies, which will attract companies.

Design/methodology/approach – An index is created composed of five key categories, namely, infrastructure, financing, governance, manpower and institution/legislation. For the analysis of the index, multi-attribute utility theory (MAUT) is used as a tool to evaluate the importance and performance of the different attributes using both quantitative and qualitative criteria. The methodology has been tested via the use the Piraeus maritime cluster.

Findings – The framework has been tested on its robustness and friendliness to the user providing useful insights to the stakeholders. Among the results has been the importance of the finance, manpower and infrastructure attributes, which appear to promote the cluster’s attractiveness. In addition, legislation and institutional partnerships, along with Government support, need to take place improve the performance of the cluster.

Research limitations/implications – A key limitation is the fact that the methodology has been tested in a single case. Applying the methodological framework in a wider sample of clusters will significantly improve the present work.

Originality/value – The proposed model takes further existing research in the field via adopting the philosophy of the World Bank’s Logistics Performance Index. Among the benefits of the proposed index is that it offers the flexibility and robustness to compare among different maritime clusters globally and can be readily used as a benchmarking policy tool at national, regional and global levels at any given point in time and attribute dimension.

Keywords Index, Clusters, Attractiveness, Maritime

Paper type Research paper
1. Introduction

Maritime industry is considered to be a basic industry with a guiding role in regional and global economic development. Business processes rely on shipping for the transportation of commodities and finished goods to the consumption and production areas (Lee et al., 2014). Extra significance is also obvious according to IMO's estimations, which suggest that 90 per cent of global trade volumes is transported by sea, implying the significant transportation role of shipping. The complex nature of the maritime industry, which includes key players, such as, ports, shipping management companies, forwarders, distribution companies and logistics companies (de Langen and Haezendonck, 2012), makes clear the necessity for a systematic and thorough performance analysis of those companies serving this industry. When companies are interconnected and have a common labour pool, they are considered to form a cluster (Porter, 1998).

The role of clusters in the development and growth of local and national economies has been extensively studied and discussed in the literature (Porter, 1998). Cluster definition varies among different nations and industries (Brett and Roe, 2010). Thus, different methodologies are used for analysing the impact these have on national and regional economies, such as the input–output (IO) models, gravity models (Pagano et al., 2012) and the Lotka–Volterra model (Zhang and Lam, 2013), as well as tools including interviews and questionnaires (Brett and Roe, 2010; Shinohara, 2010).

Delimiting a cluster starts by selecting a core cluster activity in a specific region (i.e. financial services in London). In the case of maritime clusters, core activities encompass all those related to cargo and shipping-related services between specific areas. Such activities are logistics, shipbuilding, repair, cargo handling, R&D, ports, bunkering, shipbroking, suppliers etc. Firms share state of the art infrastructure and services, specialised customer markets, human capital resources, know-how and information. These shared resources create synergies between industrial and regional economic development. In addition, clusters fuse indigenous strengths with global best practices from firms in a variety of countries having different institutional systems (Zhao et al., 2009).

Such units and business geographically concentrated exist for decades globally, moreover on different business sectors. Policymakers have embraced the cluster concept, have identified regional clusters and have developed policies and strategies to enhance the development of clusters (Markusen, 1996). A large variety of clusters, each with different characteristics, have been identified. In the case of the maritime industry, the interrelationships between port authorities, terminal operators and suppliers of maritime services are so strong that maritime clusters are formed globally.

The strength of a maritime cluster is dependent on the significance of the interconnections among its members, with education being an essential component (Porter, 1998). Education and research are the primary sources for supply of manpower, knowledge and skills.

Europe has a mature maritime economy, which maintains a strong global position. Key to maintaining its leading position is the stimulation of entrepreneurship and innovation through scientific knowledge and a well-educated and skilled workforce. The European Network of Maritime Clusters was established in November 2005, comprising Denmark, Finland, Germany, The Netherlands, Norway, Poland, Sweden and the UK (European Network of Maritime Clusters). Given this background, this study aims at assessing the attractiveness of the maritime cluster of the port of Piraeus in Greece and identify policy implications.

Nevertheless, cluster analysis in the maritime industry lacks extended and empirical research due to the fact that it is considered as rare phenomenon rather than common practice (Rosenfeld, 1997). According to Folta et al. (2006), economies of agglomeration like clusters, benefit firms in their capability to innovate and attract strategic alliances and...
private equity partners. Regional development policies and strategies play significant role in the local and national economy of the cluster improving the standard of living. A maritime cluster is a network of intensive links among firms, ports, universities, institutions and public authorities, which cooperate as a whole. Successful maritime clusters guarantee that cluster development can achieve prosperity and sustainability (Othman et al., 2011). Moreover, clusters aiming at enhancing or developing their dominance require some level of measurement and performance analysis due to the complexity of their nature.

This paper aims at identifying the factors which add value and enhance the cluster’s performance and proposes a robust framework for measuring the attractiveness of a maritime cluster with the use of a Performance Index. Modern clusters are being observed as supranational phenomena needing new strategies and aspects of policy in both emerging and developing economies (Bialic-Davendra and Pavelkova, 2010). Similarly, works focusing on clusters like Silicon Valley have shown that policy-making combined with a cluster-oriented view can achieve performance optimisation (Delgado et al., 2014). Moreover, several works have also shown that clustering has a positive impact on firm performance due to the fact that it improves access to skilled workforce and specialised suppliers (Du et al., 2008).

A Maritime Performance Index will support the ability to identify the strengths and weaknesses of a maritime cluster, helping researchers and policymakers to adjust policies and strategies. The proposed performance index consists of a group of performance indicators weighted and categorised in five groups (institutional, financial, infrastructure, manpower and governance), leading to a Performance Index similar to World Bank’s Logistics Performance Index. The development of such models increases the understanding of the beneficial role of clustering such as positive externalities, firm performance improvement and innovation capabilities. In the case of the maritime industry, this can lead to a better overall cluster performance such as container management improvement, loading and unloading time reduction, seamless flow of bureaucratic processes and more.

The rest of the paper is arranged as follows. Section 2 reviews the literature, Section 3 discusses the methodology and the design of the index, Section 4 presents the case of the port of Piraeus in Greece and Section 5 concludes the study.

2. Literature review
2.1 Cluster definition
Various cluster definitions exist, such as “a spatially concentrated group of firms competing in the same or related industries that are linked through vertical (buyer/supplier) and horizontal relationships (alliances, collaborations, resource sharing etc.)” (Porter, 1990). Porter did not pay much attention to geographical concentration in his early work on clusters but gradually recognised the importance of geographical proximity.

A cluster is a population, not as an entity. People cluster because of the presence of a large labour pool inside the cluster. The presence of such a labour pool reduces the cost for talent acquisition. Furthermore, such a labour pool allows for the existence of specific training and education programmes, which upgrade the quality of the labour force. This aspect is important as it implies that the internal heterogeneity of clusters has to be taken into account. The notion of a cluster population also implies that cluster population can change. Indeed, entry and exit are important mechanisms for the transformation of the cluster.

In addition, a cluster enables the geographical concentration of like-minded businesses. Firms cluster together due to the presence of suppliers and customers in a cluster. Proximity to suppliers and customers provides cost advantage due to low transportation costs, along with closer monitoring and frequent face-to-face interaction. Even though the geographical aspect is widely acknowledged, the delimitation of the relevant cluster region can be
problematic. No matter how a cluster is geographically defined, firms in the cluster will be strongly linked with firms outside the relevant cluster region.

Finally, a cluster consists of related business units, associations and public-private organisations. Firms cluster together because of the presence of “knowledge spill-overs”, which take place in clusters. Knowledge disseminates due to the frequent interaction among cluster participants and the fact that developments can be detected locally faster (de Langen, 2010). Business units participate in the cluster if they have relatively strong economic links with one or more other business units in the cluster. Associations are included in the cluster if the majority of their members are active and public-private organisations when they are strongly linked to firms in the cluster (de Langen, 2004). Because linkages are vital in the definition of clusters, these are composed of firms that can be competing or acting in a complementary way.

2.2 Cluster theory evolution

Cluster theory has been applied to the maritime sector over the past 10 years. Benito et al. (2003) analysed the maritime sector in Norway using Porter’s framework. They quantified the characteristics of the Norwegian maritime cluster and discussed its advantages and disadvantages. De Langen (2004) analysed the collective activities of Rotterdam’s port cluster and reviewed the roles of four sectors in cluster governance. Cluster analysis has become an important component for many port authorities (i.e. MIC, 2003) emphasising on the competitive advantages induced by geographic concentration. However, cluster theory does not provide insights in relation to the reasons a specific location is preferred against another for the creation of a specific cluster.

Clustering management and policy methods have been under investigation for the past three decades. However, maritime clustering has gained little academic attention in recent years. Clustering policies in agglomerating economies plays a significant role in industry development. Creative industry cluster approach is embedded, according to Chan and Zheng and Chan (2014), in two theoretical sources: cultural approach and local – regional – development. Existing literature emphasises on spatial cluster analysis and functional clustering policies. The former refers to the co-existence of firms linked together due to the regional connection, while the latter focuses on the cluster as a whole, consisting of interconnected parts (firms, associations, etc.) cooperating together in promoting development (Hall, 2000). Thus, the latter analysis appears to be more valuable, assisting policymakers in developing clustering policies. Lai et al. (2014) analysed the clustering effect in terms of innovation. Innovation is one of the most important factors, making clustering research necessary for regional and individual firm development (Giuliani, 2005; Chang, 2011).

Cluster analysis has also become an important tool for regional development policies. In relation to maritime policy development, Othman et al. (2011) examined the factors linked to the performance of the cluster. They identified that a maritime cluster consists of three main sectors, namely, shipping, shipbuilding, ports and terminals. They recommend that the factors for success for a maritime cluster are location, competition, network and governance. Moreover, a factor playing significant role in a cluster’s performance and liable function is the information spill-over among the co-localised firms and institutions (de Langen, 2010). De Langen (2010) also set an analytic cluster performance framework separating cluster structure and cluster governance. Based on his work, the most important factors for cluster performance are the level of agglomeration in the cluster, internal competition among firms, entry-exit barriers and heterogeneity of population. Agglomeration has three distinct drivers (Alfred, 1920), namely, linkages, labour pool and information/knowledge spill-overs.
Internal competition has also been examined in the case of intra-port competition, indicating that ports (and maritime clusters in general) could promote innovation under specific circumstances such as multiple production models and many port service providers (Pallis and de Langen, 2006).

In terms of governance, the presence of a leader firm seems to contribute to the performance of the cluster, as leader firms further and protect the interests of the entire cluster (Albino et al., 1999). Such firms could be a terminal operator of a supply chain management provider (i.e. Maersk), creating multiplier effects and information spill-overs (de Langen, 2010). Information spill-overs among cluster members is of significant importance as they can improve and enhance innovation on firm strategies. Knowledge spill-overs are present in the cluster-making infrastructure to support innovation capabilities. Knowledge inputs may come from suppliers, customers, maritime services providers, universities and other research institutions. This provides extra weight in the significance of the geographic proximity and co-location of cluster members (Baptista and Swann, 1998). This argument is highly supported by Breschi’s (1999) work, who suggests that high concentration of industries is a supporting factor for innovators to gain market power.

Systematic studies on port choice have been conducted for more than five decades. Murphy and Daley (1994) surveyed five groups, namely, port operators, shipping lines, freight forwarders, large and small shippers, with the results showing statistically significant differences in port selection criteria. Subsequent works have identified the influencing factors of port competitiveness for respective port users.

From a shipper’s perspective, a number of surveys have been conducted to identify the factors influencing port selection (Tongzon and Sawant, 2007; de Langen, 2007). The common key determinants identified by the studies are location, terminal infrastructure, port efficiency and frequency of service. In addition, Nir, Lin and Liang (2003) used a multinomial logit model to analyse the shipper’s choice behaviour among Taiwan’s three ports, with selected variables being cost, travel time, shipping route and frequency of service.

In reference to shipping lines, both regional surveys and factor analyses have been conducted to capture the significant factors in port selection (Tongzon and Sawant, 2007; Chang et al., 2008; Yeo et al., 2008). Port charges and port services have long been considered as determinant factors for port selection. Moreover, both studies emphasised that hinterland cargo volume and connectivity are important factors in deciding port attractiveness.

From the perspective of port competition ability, Lirn et al. (2004) used the analytic hierarchy process (AHP) to reveal the port selection process of global carriers. Yang et al. (2005) applied an AHP model to analyse non-quantifiable factors and develop an index system to evaluate container port competition. In addition, there have been studies measuring the attractiveness of ports in terms of port hinterland connectivity, aiming at identifying the factors shippers use when evaluating a port (Veldman and Buckman, 2003; Malchow and Kanafani, 2004; Malchow and Kanafani, 2001; Garcia-Alonso and Sanchez-Soriano, 2009).

Veldman and Buckman (2003) studied the problem of port competition from a shippers’ perspective based on the routing decision. Factors affecting cargo routing, such as transportation cost, transit time, frequency of service and service quality, were quantified. Similar work has been conducted by Garcia-Alonso and Sanchez-Soriano (2009), who analysed the actual inter-port distribution of traffic to examine the port selection process.
However, there are two major limitations in the so far works. The first limitation identified by Tongzon (2009) is that there is an inconsistency between the stated preference and the revealed preference of shipping lines. Second, supply chain services are ignored. As port attractiveness is only one component for port choice, door-to-door multimodal transportation should be given more attention.

Ports have been in the centre of the attention in more recent studies examining maritime clusters. Characteristic is the study of Zhang and Lam (2017), who examined the role of ports in maritime cluster development, using the cases of London and Hong Kong. Similar works focusing on different aspects of cluster on different locations around the globe are present such as, Panama (Pagano et al., 2016), Canada (Doloreux et al., 2015), Malaysia (Othman et al., 2011) and Japan (Shinohara, 2010).

Innovation is another dimension for clusters which is considered to be a function of key variables such as, interaction with business markets, product development and human resources (Lendel and Varmus, 2014). For a maritime cluster, innovation could be identified as the provision of effective services at low cost. Such services could be terminal management with better container handling, which eliminates delays. Empirical research such as the one by Brett and Roe (2010), where Delphi method was used to study the Great Dublin maritime transport cluster, revealed the lack of promotion strategies, the existence of strong internal competition, strong exit barriers and significant access to cluster knowledge, but with low trust levels present among cluster stakeholders. As presented in Figure 1, based on THM (Triple Helix Model), these stakeholders are (Leydesdorff and Etzkowitz, 1996):

- institutions (universities, research institutes);
- firms and enterprises (in this case shipping oriented); and
- central, regional and local government to facilitate clusters’ processes.

This model is a regional development model, which describes the interactions among the different stakeholders of the cluster.

![Figure 1. The triple helix model](source: Authors)
Therefore, an index similar to Leydesdorff and Etzkowitz (1996) is developed to assess the attractiveness of a maritime cluster, using the Port of Piraeus in Greece as a case study.

3. Methodology
The proposed framework enables cluster stakeholders to evaluate the weaknesses and strengths of a cluster, especially in highly competitive cases as is the maritime cluster, where according to Leonard and Swap (2000), skills such as management and knowledge techniques are necessary for the cluster to support its activities.

3.1 Attractiveness index
An attractiveness index includes four key categories:

1. **Policy and regulatory framework**: Within this, the cluster exists and operates. Without a supportive and complementary policy and regulatory framework, the full potential of the cluster for high-end services will be constrained. The factors also include the environmental, sustainability and cultural elements, which encourage maritime-related firms and their workforce to operate.

2. **Institutional structure**: This reflects the structural form of the cluster comprising of both public and private organisations. An institutional structure that lacks awareness, communication and collaboration is unable to maximise the economies of scope, which are inherently part of a successful cluster of high-end maritime services.

3. **Manpower**: This represents the availability of skills and resources to meet the current and future needs of the maritime cluster to further develop unconstrained and create innovation and entrepreneurship.

4. **Tax and financial tools**: These encourage membership, growth, resourcing and innovation within the maritime cluster.

Common goals in a cluster are set through joint activities of members (cluster actors). They are being accomplished in various areas within (i.e. common projects, research, production, services etc.), having both short-term and long-term perspective. Based on existing research, cluster activities can be found in the areas of networking, human resources, research and innovation, business cooperation and promotion, investment financing, governmental and political activities and supporting activities.

As far as the performance of a maritime cluster is concerned, several works have taken place in recent years for identifying the key sectors of the cluster. These sectors can be, ports, shipping lines, agencies, shipbuilding and repair, offshore, marine equipment, bunkering, ship chandlery, ship broking and chartering, classification societies, ship management, logistics, legal services, insurance, finance, education and training, research and development and information technology (Cullinane et al., 2007).

3.2 Conceptual model
The performance index created here is composed of several weighted sub-indexes, which are measurable components-indicators of cluster parts, following the philosophy of World Bank’s Logistics Performance Index. A multi-attribute utility theory (MAUT) approach is applied for the purposes of this work. Multivariate techniques are considered to be more advanced and more complicated as they allow the researcher to study the behaviour of more than two variables simultaneously. Compared to other decision analysis tools, MAUT’s superiority is its high level of robustness, that is its ability to analyse and formulate
problems with a level of imprecision, which is not feasible when using other methodologies (Dyer et al., 1992). Using six factors presented in Table I, MAUT is preferred to other methods such as AHP, structural equation modelling (SEM) and regression analysis (Lagoudis et al., 2006).

According to Von Winterfeldt and Edwards (1986), there are three main models of aggregation weights and single-attribute utilities as presented in Table II.

For this study, the additive model has been selected as it is suited to the purposes of the research. The total index value is calculated based on the following equation:

\[
MCAI = (\text{Infrastructure Category Value}) \times W_1 + (\text{Finance Category Value}) \times W_2 + (\text{Governance Category Value}) \times W_3 + (\text{Manpower Category Value}) \times W_4 + (\text{Institution/Legislation Category Value}) \times W_5
\]

where \(W_i\) = the weight of each Category. The weight \(W_i\) is given by the following formula based on Eckenrode (1965):

\[
W_i = \frac{1}{\sum_{j=1}^{n} W_j}
\]

<table>
<thead>
<tr>
<th>Factor</th>
<th>MAUT</th>
<th>A.H.P.</th>
<th>S.E.M.</th>
<th>Regression</th>
</tr>
</thead>
<tbody>
<tr>
<td>Easy to comprehend</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>No need of special software</td>
<td>●</td>
<td>○</td>
<td>●</td>
<td>○</td>
</tr>
<tr>
<td>Easy to apply</td>
<td>●</td>
<td>●</td>
<td>○</td>
<td>●</td>
</tr>
<tr>
<td>Easy questionnaire design</td>
<td>●</td>
<td>○</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>No sampling restrictions</td>
<td>●</td>
<td>●</td>
<td>○</td>
<td>●</td>
</tr>
<tr>
<td>Comparison of more than two factors</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>○</td>
</tr>
</tbody>
</table>

Table I. Comparison of methodologies

Notes: ● Yes; ○ No

<table>
<thead>
<tr>
<th>Model</th>
<th>Formula</th>
</tr>
</thead>
<tbody>
<tr>
<td>Additive with linear value function</td>
<td>(u(x) = w_1x_1 + w_2x_2 + w_3x_3)</td>
</tr>
<tr>
<td>Additive</td>
<td>(u(x) = w_1u_1(x_1) + w_2u_2(x_2) + w_3u_3(x_3))</td>
</tr>
<tr>
<td>Multiplicative (extended)</td>
<td>(u(x) = w_1u_1(x_1) + w_2u_2(x_2) + w_3u_3(x_3) + w_1w_2u_1(x_1)u_2(x_2) + w_1w_3u_1(x_1)u_3(x_3) + w_2w_3u_2(x_2)u_3(x_3) + w_1w_2w_3u_1(x_1)u_2(x_2)u_3(x_3))</td>
</tr>
<tr>
<td>Multiplicative (compact)</td>
<td>(1 + wu(x) = [1 + w_1u_1(x_1)][1 + w_2u_2(x_2)][1 + w_3u_3(x_3)])</td>
</tr>
<tr>
<td>Multi-linear</td>
<td>(u(x) = w_1u_1(x_1) + w_2u_2(x_2) + w_3u_3(x_3) + w_1,2u_1(x_1)u_2(x_2) + w_1,3u_1(x_1)u_3(x_3) + w_2,3u_2(x_2)u_3(x_3) + w_1,2,3u_1(x_1)u_2(x_2)u_3(x_3))</td>
</tr>
</tbody>
</table>

Table II. MAUT Aggregation models \((n = 3)\)

Notes: \(u\): Overall value function; \(x\): Evaluation object; \(x_i\): Measurement (level, degree) of \(x\) on attribute \(i\); \(u_i\): Single-attribute value function; \(w_i\): Weight of attribute \(i\)
Source: Von Winterfeldt and Edwards (1986)
\( W_i = \frac{R_c}{\text{Sum}(R_c)} \)

where:

\( R_c = \text{sum of converted ranks across judges for each criterion}; \)

\( R_c = \text{Sum}(R_{cj}) \)

in which

\( R_{cj} = \text{converted rank assigned by judge} j \text{ to criterion} c. \)

To make clear the processes involved in weight estimations, a framework table is presented based on the set of attributes in Table III. Column 1 refers to the name of the variable, and in the second column (Normal rank), the score each variable achieves is depicted. This score is the sum of the opinions of all participants for each individual attribute. In the third column the reciprocal of normal rank is calculated. The most important variable takes the value 1 and the rest are adjusted to this variable. The last column is a rank weight based on the third column.

Based on literature, the factors that affect the performance of a maritime cluster fall in the following five categories: infrastructure, financing, governance, manpower and institution/legislation. The evaluation of each factor is based on the mean of each attribute in relevance to the overall sub-mean value of each category (Figure 2). The value for each attribute is collected via questionnaires using a Likert scale from 1 to 5. Each group of questions was consisted of a question measuring the performance and another question measuring the importance of each factor. For performance questions, 1 is for very low performance and 5 for very high. Respectively, for importance questions 1 stands for “not important at all” and 5 stands for “extremely important”. For example, each indicator \( A_i \) will gain a score based on the respondents’ answers. Each indicator of the Category will score a mean value and the whole Category will have a total score of \( P_i \). Overall, category scores will be weighted according to the significance each category has on the performance index.

The performance indicators, which compose the overall Cluster Performance Index, were selected based on the frequency present in the literature. Depending on the frequency of appearance, they are categorised in four groups: above ten times, seven to nine times, five and six times and one to four times. Table IV shows the performance indicators based on frequency of appearance. As seen, the cluster performance mostly depends on “soft” factors

<table>
<thead>
<tr>
<th>Attribute/Indicator (1)</th>
<th>Normal rank (2)</th>
<th>Reciprocal of normal rank = (most imp. score)/Yi (3)</th>
<th>Rank reciprocal weight = Sum(3)/(3) (4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>X1 (indicator 1)</td>
<td>(Most Important Factor Score)</td>
<td>1</td>
<td>0,.....</td>
</tr>
<tr>
<td>X2</td>
<td>Y2</td>
<td>......</td>
<td>0,.....</td>
</tr>
<tr>
<td>X3</td>
<td>Y3</td>
<td>......</td>
<td>0,.....</td>
</tr>
<tr>
<td>......</td>
<td>....</td>
<td>......</td>
<td>0,.....</td>
</tr>
<tr>
<td>X_N</td>
<td>Yn</td>
<td>......</td>
<td>0,.....</td>
</tr>
<tr>
<td>TOTAL</td>
<td>SUM(2)</td>
<td>SUM(3)</td>
<td>1</td>
</tr>
</tbody>
</table>

**Table III.**
Ranking of performance indicators

Source: Eckenrode (1965)
such as people, structure and policies (Checkland, 1989). These systems allow policymakers to make use of existing infrastructure improving the overall performance.

In addition, the most important factors deal with “soft” issues capable to improving regional performance. The first group is composed of the most valuable ones, based on literature. Agglomeration between firms and cluster members relate to the maturity of the cluster and its growth capability. Governance methods and information spill-over have positive effects
on the services offered, whereas R&D capabilities act as enablers for innovation to a region or a cluster. This is one of the basic reasons for some clusters to excel and others to lag behind. Conclusively, education is referred as of extreme importance, enabling multiplying effects on the overall attractiveness of a cluster.

3.2.1 Infrastructure. Infrastructure and services encapsulate the “soft” factors like quality of services in a maritime cluster. This implies that performance is strongly dependent on the quality of these services in combination with the technical infrastructure in the cluster. Indicative factors are:

- **Agglomeration**: It promotes spatial concentration.
- **Bunkering**: It measures bunkering efficiency in the port.
- **Logistics services**: It refers to the quality of services such as warehousing and 3PL services.
- **Throughput**: It refers to the volumes of cargo in and out of the port.
- **Shipbuilding**: It refers to the shipbuilding capability of a maritime cluster.
- **Information spill-over and cooperation**: Experts indicate that cooperation within the cluster is important. This result is important as it provides evidence against the argument that local cooperation is not relevant, given the international nature of port related activities. Thus, a diverse local set of firms and resources is important for the performance of the cluster.

3.2.2 Finance. Finance contains the economic factors that enable firms in the cluster to operate in full efficiency. These factors provide capital and tax support to firms in the cluster. Firm leverage is strongly connected with these indicators. Among the finance factors are:

- **Capital availability**: It describes access to capital for a firm.
- **Tax incentives**: It refers to the taxation and support to firms.
- **Maritime financial services**: It refers to transaction and other costs among the firms of the cluster.

3.2.3 Governance. Governance in a cluster influences the structure of the cluster. Cluster governance variables are incorporated in the framework. The performance of clusters is also affected by changes in the business environment of a cluster. For instance, the development of a new energy-related technology might deeply affect the development of a chemical cluster (de Langen, 2004). Some of the most important indicators are:

- **Externalities**: The presence of externalities in a cluster can affect negatively the overall cluster performance.
- **Internal competition**: Firm competition in a cluster boosts firms' productivity level. The importance of internal competition depends on the level of external competition. When external competition is significant, the absence of internal competition does not affect the performance of the cluster. Porter’s cluster research emphasises the fact that the effect of internal competition is among the strongest empirical findings (Porter, 1990).
- **Entry/exit barriers prevent the entry of new firms**: Legal entry barriers exist in the majority of ports, especially in the cargo handling and port services industries. In general, entry barriers are relatively high in the maritime industry due to legal or financial constraints.
**Presence of a leader firm:** This increases the performance of a cluster, as such firms further the interests of the cluster as a whole (Albino et al., 1999). The whole cluster benefits from the presence of leader firms, due to the “multiplier effects” and “knowledge spill-overs”.

### 3.2.4 Manpower

This category contains all the factors related to human-resource skills and education level of the workforce in the cluster. More specifically, factors such as education, number of employees, number of maritime service providers and suppliers and business culture are critical to cluster performance.

### 3.2.5 Institution and legislation

This category contains all the factors related to academic institutions and other institutions conducting research in cooperation with maritime firms. Among the factors within this category are the cooperation between firms and universities, willingness to innovate and R&D capabilities. The visual presentation of cluster performance can be expressed in a spider diagram as illustrated in Figure 3.

### 4. Case study

#### 4.1 Sample profile

The case study took place in the city of Piraeus in Greece. In total, 70 questionnaires were distributed to maritime related industries such as ship management companies, shipowners, shipbrokers, research institutes, maritime equipment providers and media. The criteria based on which the responding companies have been selected are:

- minimum of 10 years of presence in the Piraeus cluster; and
- to be registered in the Maritime Hellas platform (www.maritimehellas.org).

The questionnaires were addressed to the Managing Directors or CEOs of the sampled companies assuring one response per company. The person answering the questionnaire varied depending on the policy of each company. Similar data collection approaches are present in the literature (Richardson et al., 2012; Manrai et al., 2001). The total number of responses were 30, achieving a response rate of 42 per cent. Table V shows the companies, which took part in this study, with some of the respondents keeping their anonymity. The participation of academic institutions has been limited as there are less than a handful present.

Table VI presents the profile of the respondents. As seen, the majority of the respondents hold middle or executive level positions (43 per cent), with top executives representing 40 per
cent of the sample. Junior executives represent 17 per cent of the respondents. The average years of working experience is above 10 years of working experience in the maritime sector with 67 per cent holding a master’s degree, while only 20 per cent being graduates. A small percentage (3 per cent) hold business certifications such as CFA, Chartering certification etc.

4.2 Analysis of survey results

4.2.1 Finance. Respondents were asked to evaluate both the performance and importance of the finance-related attributes; accessibility to capital, tax incentives, access to stock markets, cooperation with banks, government support for businesses, firm taxation, inflation, salary, insurance costs, information costs and firm expenses.

Table VII presents both the ranking among the factors and the performance of each factor based to the assigned weights. As seen, the most important factor according to the respondents is cooperation with banks, with a normal rank of importance of 130 points. This factor has also the highest performance score of 4.6 out of 5. In terms of performance, the lowest score is assigned to government support with a score of 3.13 out of 5. This result indicates that government and companies lack consistent and efficient cooperation. The second lowest score is assigned to inflation, which reveals that the industry pays little attention to that factor. Finally, the overall score for this category is 3.9834.

4.2.2 Governance. Firm governance in a cluster influences the structure of the cluster and vice versa. For the purposes of this research Governance is composed of the following attributes; presence of leader firms in the cluster, entry/exit barriers, trust between cluster members, internal competition, governmental support for international exposure, presence of intermediaries, power of competitors and collective action regimes.

As presented in Table VIII, the most important factor according to the respondents is trust between firms, obtaining 122 points, followed by governmental support for

<table>
<thead>
<tr>
<th>University of the Aegean</th>
<th>Costamare</th>
<th>ELVIK S.A.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gratia Publications</td>
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<td>Aegean Motorway SA</td>
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<td>GLOBUS Shipmanagement Corp</td>
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<td>Arcadia Shipmanagement</td>
<td>Trefin Tankers Ltd</td>
<td>Piraeus University</td>
</tr>
<tr>
<td>Chartworld Shipping Corporation</td>
<td>EVIA PETROL</td>
<td>GasLog</td>
</tr>
<tr>
<td>Stealth Gas</td>
<td>UPMARITIME LONDON</td>
<td>Vergos Marine Management S.A.</td>
</tr>
<tr>
<td>DYNACOM TM LTD</td>
<td>Psycotherm</td>
<td>IASON HELLENIC SHIPPING</td>
</tr>
<tr>
<td>SELMA</td>
<td>Pireus Bank</td>
<td>MaranGas</td>
</tr>
<tr>
<td>Aluminox</td>
<td>HEMEXPO</td>
<td></td>
</tr>
</tbody>
</table>

Source: Authors

<table>
<thead>
<tr>
<th>Position</th>
<th>(%)</th>
<th>Years of experience (%)</th>
<th>Education (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Senior</td>
<td>40</td>
<td>0-2</td>
<td>20 Bachelor’s</td>
</tr>
<tr>
<td>Middle level</td>
<td>43</td>
<td>3-5</td>
<td>23 Master’s</td>
</tr>
<tr>
<td>Junior</td>
<td>17</td>
<td>6-10</td>
<td>10 PhD</td>
</tr>
<tr>
<td></td>
<td></td>
<td>&gt;10</td>
<td>47 Business qualifications</td>
</tr>
</tbody>
</table>

Source: Authors

Table V. Summary of respondents

Table VI. Sample profile
international exposure. As observed in the finance category, there is a lack of cooperation between government cluster members. In terms of trust among the different parts of a maritime cluster, it is crucial to refer that it can boost the cluster’s exposure and success. The highest score was assigned to the presence of leader firms. Based on literature, the presence of leader firms is necessary in a cluster, as they can access markets smaller firms cannot. The presence of leader firms increases the performance of a cluster, as such firms actively further the interests of the cluster as a whole (Albino et al., 1999). In addition, leader firms facilitate investments improving the quality of the labour force, facilitate data exchange infrastructure and increase working standards of suppliers.

Internal competition is also a factor of high importance as it can result in innovation and increase the capability of doing “business” more efficiently. Moreover, with innovation spill-overs, firms become more profitable. The overall score for the Governance category is 3.1119.

4.2.3 Institutional legislation and innovation. As illustrated in Table IX, this category encapsulates attributes such as cooperation with Universities and research institutes, R&D capability, willingness to innovate, cooperation with government, information spill-over,
legislation and classification societies. *Legislation* is the most important factor based on the results of the survey, as it assists firms to operate within the cluster. Low score is observed for the factors of cooperation with universities and cooperation with research institutes achieving a score of 2.57 and 2.53, respectively. According to the triple helix model (see Section 2 in literature review), academia is one of the three main pillars for a cluster. The results here indicate that there is a gap among these pillars, which needs to be addressed by closer collaboration between academia and industry. The overall score of this category is 2.8903, which is the lowest among the categories.

4.2.4 *Infrastructure and maritime services.* This category encapsulates the physical infrastructure and the services a cluster provides. For the purposes of this study the Piraeus maritime cluster services are presented in Table IX with the following attributes; Port services, Terminal services, Customs, Logistics services, Cargo handling services, Bunkering services, Shipbuilding/Repair services, Shipbroking services, and Infrastructure in Piraeus.

Based on Table X, the most important attribute is *Shipbuilding/repair services*, obtaining 128 points in terms of importance. Shipbuilding is one of the core businesses in a cluster, and thus these services need to be of high quality. In terms of performance this attribute achieves a score of 3.27 out of 5. However, the highest score is obtained by *Bunkering*.
services with a score of 3.60 out of 5, revealing the Port’s long maritime tradition. Despite the fact that bunkering is not one of the core businesses in a maritime cluster, executives considered this to be of highest performance. Lowest performance was assigned to customs services. The overall category score is 3.1840.

4.2.5 Manpower. Manpower refers to factors related to labour abilities and skills. Factors such as quality of education, level of productivity, teamwork ability, employee initiative and business culture are included in this category. Based on responses, the most important factor for this category is productivity with 132 points. Furthermore, as seen in Table XI, all factors of this category scored high enough, implying that Greek maritime professionals are highly qualified. More specifically, quality of education scored the highest, indicating that the manpower of the Piraeus maritime cluster is of high calibre. The overall category score is the second highest with a score 3.6508.

4.3 Piraeus cluster performance index
As a next step, weights are assigned to each category to estimate the overall Index. Two scenarios are examined for this process. In the first case, equal weights are assigned to each factor, whereas in the second, weights are assigned to each of the five categories composing the index based on the rankings assigned by the respondents.

4.3.1 Index with equal weights. Index with equal weights is quite simple to conduct. There are five main factors; thus, each factor has a weight of 0.2. Then weight is multiplied with the factor value (in this case the overall score of each factor) and the final Index is the sum of these five products. Following this process, Table XII shows that the Maritime Cluster Performance Index (MCPI) for Piraeus is 3.3641.

A spider diagram is also used to depict the Index and factor scores (Figure 4).

---

<table>
<thead>
<tr>
<th>Attribute/indicator</th>
<th>Normal rank</th>
<th>Reciprocal of normal rank</th>
<th>Rank reciprocal weight</th>
<th>Mean value (based on Performance)</th>
<th>Weight x mean value (4) x (5)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quality of education</td>
<td>126</td>
<td>0.9545</td>
<td>0.2000</td>
<td>3.87</td>
<td>0.7740</td>
</tr>
<tr>
<td>Productivity Level</td>
<td>132</td>
<td>1.0000</td>
<td>0.2095</td>
<td>3.7</td>
<td>0.7752</td>
</tr>
<tr>
<td>Ability to teamwork</td>
<td>126</td>
<td>0.9545</td>
<td>0.2000</td>
<td>3.73</td>
<td>0.7460</td>
</tr>
<tr>
<td>Employee Initiative</td>
<td>120</td>
<td>0.9091</td>
<td>0.1905</td>
<td>3.2</td>
<td>0.6095</td>
</tr>
<tr>
<td>Business Culture</td>
<td>126</td>
<td>0.9545</td>
<td>0.2000</td>
<td>3.73</td>
<td>0.7460</td>
</tr>
<tr>
<td>SUM</td>
<td>4.7727</td>
<td>SUM</td>
<td>SUM</td>
<td>SUM</td>
<td>3.6508</td>
</tr>
</tbody>
</table>

Table XI.
Manpower attributes  

Source: Authors

<table>
<thead>
<tr>
<th>Category</th>
<th>Value</th>
<th>Weight</th>
<th>Value x weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Finance</td>
<td>3.9834</td>
<td>0.2</td>
<td>0.7966</td>
</tr>
<tr>
<td>Governance</td>
<td>3.1119</td>
<td>0.2</td>
<td>0.6223</td>
</tr>
<tr>
<td>Institution/Legislation</td>
<td>2.8903</td>
<td>0.2</td>
<td>0.5780</td>
</tr>
<tr>
<td>Infrastructure</td>
<td>3.1840</td>
<td>0.2</td>
<td>0.6368</td>
</tr>
<tr>
<td>Manpower</td>
<td>3.6508</td>
<td>0.2</td>
<td>0.7301</td>
</tr>
<tr>
<td>Index</td>
<td></td>
<td></td>
<td>3.3641</td>
</tr>
</tbody>
</table>

Table XII.
Index with equal weights  

Source: Authors
4.3.2 Index with non-Equal weights. When non-equal weights are assigned, weights are calculated for each factor based on the estimations of the respondents. As presented in Table XIII, the value of the weight for each factor is the outcome of the reciprocal rank. As seen, the Maritime Cluster Performance Index with non-equal weights for Piraeus is 3.3703.

A spider diagram is also used to depict the Index and factor scores (Figure 5).

<table>
<thead>
<tr>
<th>Category</th>
<th>Value</th>
<th>Reciprocal rank sum</th>
<th>Weight</th>
<th>Value × weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Finance</td>
<td>3.9834</td>
<td>9.5000</td>
<td>0.2511</td>
<td>1.0004</td>
</tr>
<tr>
<td>Governance</td>
<td>3.1119</td>
<td>7.2787</td>
<td>0.1924</td>
<td>0.5987</td>
</tr>
<tr>
<td>Institution/Legislation</td>
<td>2.8903</td>
<td>7.6587</td>
<td>0.2024</td>
<td>0.5851</td>
</tr>
<tr>
<td>Infrastructure</td>
<td>3.1840</td>
<td>8.6172</td>
<td>0.2278</td>
<td>0.7253</td>
</tr>
<tr>
<td>Manpower</td>
<td>3.6508</td>
<td>4.7727</td>
<td>0.1261</td>
<td>0.4606</td>
</tr>
<tr>
<td>SUM</td>
<td>37.8273</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table XIII.
Index with AHP weights

Figure 4.
Maritime Cluster Performance Index (equal weights)

Figure 5.
Maritime Cluster Performance Index (non-equal weights)

Source: Authors
5. Conclusions
This present study focuses on measuring the attractiveness of a maritime clusters via the creation of a methodological framework. The study has reviewed in depth the methodologies present in the cluster literature, emphasising on maritime clusters, and is proposing a new robust theoretical framework which facilitates the evaluation of the attractiveness of maritime clusters, assisting stakeholders to devise strategies, which will attract companies.

For the analysis of the index, MAUT is used as a tool to evaluate the importance and performance of the different attributes composing the index, namely, infrastructure, financing, governance, manpower and institution/legislation. Among the benefits of the proposed index is that it offers the flexibility and robustness to compare among different maritime clusters globally and can be readily used as a benchmarking policy tool at national, regional and global levels. In addition, its conceptual simplicity in combination with the well tested MAUT methodology, which is used for the analysis of the collected data, makes it a comprehensive tool for both policy and industry stakeholders in evaluating the cluster’s performance at any given point in time and attribute dimension. Furthermore, the active participation of the stakeholders via the use of questionnaires provides a collective perception of the cluster’s status.

With the use the Piraeus maritime cluster case, the framework has been tested in its robustness and friendliness to the user, providing useful insights to the stakeholders. Among the results has been the importance of the finance, manpower and infrastructure attributes, which appear to promote the cluster’s attractiveness. In addition, legislation and institutional partnerships, along with government support, need to take place improve the performance of the cluster.

The fact that the authors had the opportunity to use only one case study to test the methodological framework is among the limitations of the study. Applying and testing the methodological framework in a wider sample of clusters to identify weaknesses and shortfalls will significantly improve the present work. An additional element that can further improve this work is to explore and compare MAUT, which has been justified as the proper tool for data analysis here, with other tools available in the literature (i.e. AHP, SEM and regression) for evaluating and measuring the under-investigation attributes. This comparison will provide further insights for the improvement of the methodology itself.

References


Further reading


*Further reading*


KPMG Hong Kong (2007), “Hong Kong tax competitiveness series: the shipping industry”.


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Legal liability for container security
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Division of Business Management, BNU-HKBU, United International College, Zhuhai, China

Abstract
Purpose – It is commonly known that numerous incidents of container security failure are detected on a daily basis for which nobody is held legally liable. This state of affairs is essentially due to the shippers providing erroneous information, either inadvertently or by design. However, none of the stakeholders such as the carrier, the port operator, the inland transporter or the dry port operator are saddled with the legal responsibility of verifying the correctness of the information provided by the shippers or moving against them legally for misrepresentation of facts.

Design/methodology/approach – This paper discusses the issue of container security from a legal perspective with a specific focus on the liability for security failure. While discussing the reasons for non-development of a globally standardized legal regime for container security, this paper also endeavors to suggest possible solutions for the abysmal state of affairs.

Findings – This state of affairs persists despite the shipper being saddled with the additional responsibility of providing documentary evidence of verified gross mass of the cargo stuffed in the container by International Maritime Organization.

Originality/value – There is apparently no visible legal action that appears to have been taken against the culprit responsible for the security failure. Thus, the loopholes in the existing legal regime are exploited by all concerned for commercial reasons.

Keywords Container liability, Container security, Verified gross mass

Paper type Research paper

1. Introduction
The world of transport has changed considerably over the past few decades. International transportation of goods is increasingly carried in containers on a door-to-door basis, involving more than one mode of transportation under a single contract. The increasing use of containers, together with technological developments improving the system for transferring cargo between different modes, has also considerably facilitated the development of containerization (UNCTAD, 2003).

However, this kind of transportation process signifies the involvement of multiple service providers in addition to the ocean carrier such as rail transport operator, road haulers and inland container freight station operators and so on. Such involvement of multiple stakeholders leads to difficulty in affixing precise responsibility for loss or damage to goods (Hawkes, 1989).

Furthermore, such transportation process is covered by different national multi-modal transportation laws or contract law governing transportation of goods (Closs and McGarell, 2004). All such laws specify the liabilities of the transporter for loss or damage to goods caused when the goods were in the custody of the transporter but is largely silent about the
liability of the shipper for mis-declaration of cargo details such as weight, number and quality of cargoes stuffed in the container (The USA Intermodal Safe Container Transportation Act, 1992). Such mis-declaration results in the mismatch between cargo found stuffed inside the container and the details of the same mentioned in the shipping documents such as bills of lading and the shipping manifests submitted to various stakeholders. This mismatch can be considered as failure of container security.

In addition to the various arguments stated above in the paper, there are a few more listed here under, which will further enhance the general standards of container security if the inland container transportation laws are amended. For instance, it will definitely help in identification of precise risks carried by the specific stakeholders at the time where failure of container security is breached. Furthermore, it will go a long way in increasing the transparency of the entire transportation process. In addition, it will also assist in the enforcement of due diligence responsibility of the carrier strictly. Furthermore, it will help in the reduction of ambiguity in identification of risk holder jurisdiction. Apart from this, it will also assist in apportioning of the blame for the container security risk failure and share of compensation payable. Finally, It will also clarify as to who should prosecute the shipper for misinformation provided if any. Thus, it will also help in resolving the legal implications for resolving the legal implications.

The concept of container security assumed greater importance after the terrorist attacks on 9/11 in the USA. As a result of which the USA formulated various laws and regulations to prevent reoccurrence of such a tragedy. A large number of such regulations focused on the transportation of illegal goods and contraband in ocean containers to the USA. Such laws and regulations were also subsequently legislated in other countries. However, in the interest of simplicity and clarity, this paper focuses only on the US legal regime governing container security.

2. Importance of container security

Container security has yet to find a universally accepted definition. The concept is subjective and has been indirectly defined by International Container Standards Organization as “retention of safety and security of the containerized cargo, as declared in the cargo manifest (in terms of value, quantity and quality) by maintaining the integrity of the container seal or security device (CSD) and non-causal of third party damage” (World Shipping Council, 2006).

The above definition signifies the importance of the following aspects (Marlow, 2010):

- Integrity of container seals is paramount to determining the breach of container security. In other words, if the seals were intact, it would be the onus of the claimant to prove failure of container security.

- The cargo details stated in the cargo manifest are critical in proving breach of container security. In short, it would not be possible to prove failure of container security, until and unless the details of cargo stuffed in the container do not match with those stated in the manifest (Williams et al., 2008).

- It would be left to the prudence and judgment of the customs officer on the site to decide whether or not the container security has been breached, unless the claimant can provide evidence to prove otherwise.

- Neither the container nor the cargo has caused third party damage, even if the seals are found intact and there is absence of discrepancy with regards to cargo details declared in the manifest.
Container security would be considered to have failed on the occurrence of any one or all of the three mentioned events namely tampering of seals, discrepancy in cargo stuffed and manifests and directly causing third party damage.

3. Necessity for an effective legal regulatory regime

According to McNicholas (2007), “mis-declaration of cargo in manifests filed by carriers with respective Customs is a worrisome problem that offers an illegitimate means to transport illegal/illicit cargoes”. The International Maritime Organization’s (IMO) cargo committee inspects approximately 15,000 containers annually and finds a substantial percentage of containers with mis-declared contents. The US Customs have pegged this figure at 32 per cent after conducting a yearlong audit of containers in seven countries.

The mis-declaration could be a noninvasive mismatch due to an inadvertent or deliberate error in packing, stuffing and reporting of the contents by the consignor to avoid customs duty or freight or smuggle prohibited goods or an invasive mismatch due to theft from container or cargo substitution in a container, having same weight to evade detection by weighment.

Generally, Customs assume that if the door handle seal is intact, the cargo inside the container has not been tampered with, despite considerable empirical evidence to the contrary. Hence, unless the container seals are found to be broken, the mismatch of cargo found after opening the container is not considered by the Customs as a trespass. In such circumstances, the Customs hold the carrier who has filed the manifest liable and may levy penalties for short landing of cargo and loss of revenue. It may also allow amendment of manifest in certain circumstances.

However, as far as the Customs are concerned, the onus of correct declaration is on the carrier who is transporting the containers. However, due to commercial and time constraints, the carrier is unable to examine the contents of the cargo stuffed inside the container and is necessarily to trust the information provided by the consignor/shipper.

Since the September 11, 2001 terrorist attacks on the World Trade Center in New York, the focus has been on minimizing security risks associated with the international flow of goods and services. Although the security of ports and sea lanes was beefed up worldwide in the aftermath of 9/11, maritime transportation remained a “weak link” due to the ease of concealment within a ship and the assured freedom of navigation at sea (Bichou, 2011). The growing containerization of trade has compounded the problem of such illicit transfers.

Hence, several initiatives and regulations such as Container Security Initiative (CSI) Customs Trade Partnership against Terrorism (CT-PAT) and 24-Hour Rule were formulated by the USA for strengthening security in the international supply chain. These initiatives were subsequently adopted by most other national governments such as the European Union, Japan, Canada, China and Australia amongst others. These are essentially cooperative efforts between the various national Customs Services and private sector firms to deter illegal activities such as drug trafficking, wildlife and flora smuggling, money laundering and the illegal import and export of prohibited items. After 9/11, the program shifted its primary focus from the prevention of the movement of narcotics to counter-terrorism, although the former remains an important program objective. Its objective is to increase supply chain security through an accreditation process for all private sector stakeholders in the international supply chain, including importers and exporters, brokers, forwarders independent of transport mode, e.g. air, sea, land and terminals (Rowbotham, 2014).
The responsibilities of the carrier for ensuring container security during the sea leg of the international transit have been clearly defined by The Hague Visby Rules. However, the clarity is lost during the land transportation process due to involvement of multiple stakeholders such as port authorities, inland transporters and dry port operators who transport and handle the container to the final destination.

To resolve this conundrum and establish a uniform legal regime to facilitate development and standardization, efforts were made. The process was commenced by the International Institute for the Unification of Private Law about eight decades ago. Subsequently, the Comité Maritime International and a “Convention on Combined Transport – Tokyo Rules” (The Tokyo Rules) were drafted in 1969. The International Chamber of Commerce also assisted in the process by drafting the Combined Transport Document. However, it was not until the late 1980s that the United Nations Convention on International Multimodal Transport of Goods was adopted (hereinafter referred to as the MT Convention). However, the MT Convention has not entered into force as yet (Szyliowicz, 2014).

To resolve the issue of liability involving multimodal transport, two different approaches have been developed: the first is uniform liability approach while the second is the network liability approach. Under the uniform liability approach, a single liability regime is applicable to all transporters involved irrespective of the leg in which the loss/damage occurred (Hancock, 2009). On the other hand, under the network liability approach, different rules, depending on the leg, mode of transport used and the applicable law involved is taken into consideration depending on when the loss or damage occurred (Ulfbeck, 2011). Each system has its own advantages and disadvantages. However, the former approach has become more popular due to its simplicity (Faghfouri, 2010).

The UNCTAD/ICC. (1992) Rules and the Tokyo Rules also entered into force in 1992. Both these Rules form a foundation for liability laws involving the multimodal transporter in case of loss/damage sustained by the goods. This is done by providing for a network system in terms of liability and which has found wide acceptability in the industry (Xerri, 2009).

As regards the liability of the shipper/carrier for erroneous declaration of containerized goods, it becomes apparent and critical to understand the mensrea of the stakeholder on one hand and the liability his act of erroneous declaration has given rise to on the other. Perhaps, considering the potential of damage caused by the liability in question, the time has arrived to look beyond the co-relationship coefficients between the freight earned and the compensation payable. This argument also indicates a necessity for re-visiting the limitation clauses in the various sea transportation legislations. Eventually, it may force the carrier to discharge/exercise its due diligence responsibilities more effectively.

Many of the above mentioned security initiatives are essentially certification programs based on the principle that the customs authorities in a country enter into partnership with companies and offer them reduction in security controls in return for which the companies voluntarily agree to undertake to follow the prescribed security drills. In a study undertaken in 2006, the Cross Border Research Association in Lausanne presented a framework for analysis of security initiatives for the supply chain that all security measures work towards five different goals:

(1) facility management, securing premises where goods are handled, stored and loaded;
(2) cargo management, protecting the goods during all stages of their transportation;
(3) human resources management, ensuring that the background of all personnel is checked and that they are reliable and aware of risks;
4. Amendments to the Safety of Life at Sea

Despite the enactment and implementation of various national and international regulations such as CSI, CT-PAT and 24-Hour Advance Manifest Rule, it has been noticed that, there still exist in a significant number of cases a mismatch between the actual contents found in a container and those that have been declared in the shipping manifest submitted to the Customs by the carrier.

Furthermore, it should also be noted that the manifest itself is prepared by the carrier based on the information provided by the shipper himself in writing. Yet the Customs, Ports and other authorities supervising the process of stuffing, inland transportation and loading of the container on a vessel have found it almost impossible to hold anybody responsible for this mismatch. In addition, the complexity of the global supply chains also makes it difficult for the authorities to precisely identify the particular shipper who has provided the necessary information in writing in the first place.

Furthermore, to rectify this situation, the Maritime Safety Committee of the IMO has recently recommended amendments to the International Convention for the Safety of Life at Sea (SOLAS) regulations relating to declared verified gross mass (VGM) of the container. This amendment has taken effect on July 1, 2016. Under the new amendment, it is mandatory for the shipper to declare in writing the VGM of the contents of the container. However, it still leaves the question as to how the declaration of VGM submitted by the shipper can be re-verified and if so by whom and at what stage. Furthermore, what variations in findings of the re-verified gross mass will be considered acceptable and if found to be incorrect, what action should be initiated against the shipper for inaccurate declaration by whom and under what law and which jurisdiction. It also leaves the question of liability of the shipper for erroneous declaration. In addition, to assist all stakeholders involved in adhering to the new Rules, the IMO has also published specific guidelines.

According to Rule 2.1 of the guidelines, the person responsible for submitting a VGM in a specified format is the shipper. However, the guidelines are silent about the definition of the shipper. The VGM too is expected to be signed by the shipper himself or his duly authorized representative.

In this context, the question about the identity of the shipper also assumes importance, as in a significant number of cases there are more than one shipper and several intermediaries such as consolidators, forwarders, slot charterers present between the shipper and the final carrier. In addition, in a significant number of cases, the cargoes are deconsolidated and reconsolidated before they reach the final destination. This makes it increasingly difficult to identify the specific shipper who should be held responsible for mis-declaration. In addition, there is also the question of factory stuffed containers where containers are stuffed and sealed at the premises of the shipper in the presence of Customs officials.

One of the major leading case on this topic is the case concerning a major fire and explosion on board the container ship ACONCAGUA on December 30, 1998, resulting in extensive damage to the vessel and cargoes on board. The source of the explosion was immediately identified to be a container loaded with 334 kegs of calcium hypochlorite.
(declared to be UN1748). Mr Justice Clarke found the shipper liable to the carrier under the bill of lading contract for shipping dangerous goods in breach of Article IV (6) of The Hague Rules, with an initial judgment amount in the sum of USD 27.75 million, and further extensive quantum issues still to be dealt with. Mr Justice Clarke found that this suggested poor quality control (CSA V v. Sinochem Tianjin Limited [2009]).

After having taken into consideration all the above mentioned facts, it is obvious that the critical importance of container security has been recognized globally and several measures have been adopted and implemented by various national and international organizations, either fully or partially. However, some questions remain unanswered such as the specific responsibilities of the carrier, port operator, inland transporter and dry port operator with regard to container security particularly to the third party.

During our research, it was observed that the application of the liability principle varied in different countries. In some countries, the shipping lines are held responsible, while in others, the consignees have been held responsible and penalized. According to anecdotal evidence, the beneficiary of the mis-declaration is in principle considered liable for the mis-declaration and loss of customs revenue. However, this argument fails to hold water in the absence of appropriate evidence.

5. Conclusions

The responsibility of a carrier for the carriage of a container commences from the time the cargo is stuffed inside the container and the container is sealed by the carrier until the time the container is de-stuffed and the cargo is delivered to the consignee. This responsibility of the carrier is governed by the terms and conditions stated in The Hague/Hague Visby Rules as the case may be. The carriage contract between the shipper and the carrier is evidenced by the bill of lading.

According to these Rules, the carrier is responsible for the safe carriage of goods rendered in his custody by the shipper and hence he is liable to the holder of the B/L for loss or damage which is however limited to a certain amount mentioned in the limitation of liability clause stated in The Hague/Hague Visby Rules.

It should be mentioned here that the cargo details stated in the Bs/L are precisely those which have been provided by the shipper in writing. However according to The Hague/ Hague Visby Rules the carrier is not legally obliged to verify the contents of the cargo whose details are stated in the B/L. The carrier invariably mentions under the column “Cargo Details” either said to contain […] or shipper’s load stow and count. By using these words, the carrier disowns any liability for the contents of the container if the container seal is not tampered with and is intact.

Furthermore, though there are numerous instances of the shipper claiming against the carrier for shortage/damage to the goods, it is uncommon for a carrier claiming against a shipper for excess or heavier cargo found at the destination. It is also not common for a carrier filing a suit against a shipper for failing to declare accurate details. This is because Art III (3)(a-c) and (5) of The Hague Rules are silent about the duty of the carrier to verify the contents of the cargo rendered into his custody for onward transportation, except the quantity, the external condition and the leading marks of the goods.

Even the latest amendment to SOLAS, regulations requiring the shipper to declare the VGM is silent about the obligation of the carrier to re-verify the weight at a government-authorized weighbridge. Furthermore, the amendments are also silent about the responsibility and liability of the authorized weighbridge for their acts of negligence and errors.
As regard to seaports, it can be unequivocally stated that neither the Federal Seaports Act nor the ISPS Code or the CSI regulations impose any obligation for ensuring the container security at the port. This is because the port is legally considered as a Bailee of the cargo in its custody and hence is just providing a sea-land interface. Its duty is limited to ensuring that the container is discharged from the vessel with its seal intact and is eventually delivered to the inland transporter or consignee with similar intact seals. The port does not even handle the shipping documents and as such is unaware of the contents of the container. Hence, the port does not play any role in enhancing/maintaining container security. It should also be noted in passing that the contract between the carrier and the port is silent about the port towards the maintenance of container security.

With regard to the compromising of the ISPS code, it is obvious that the breach of container security also results in the vessel becoming unseaworthy. However, the consignee becomes aware of this factor only after the container reaches destination and is de-stuffed, i.e. after the voyage is complete. As such, it becomes rather fruitless to terminate the contract of carriage. However, in several cases the consignees have refused to accept the consignment due to the contents not matching with the description in the manifest and thus terminating the contract of carriage. Apart from the above, we feel there are also some additional advantages such as it has the potential to reduce misuse of the unknown clause by carrier as provided for by the Hague-Visby rules. It is a widely known fact that in several cases the shippers are essentially subsidizing the empty container repositioning costs of carrier; hence, carriers are not too keen in prosecuting them for erroneous information provided by them.

In the absence of the appropriate laws, different modes of inland transporters are governed by different laws and different procedures too. This might help in standardization of such issues. Such a state of affairs creates confusion and delay, and the culprit escapes responsibility and somebody suffers injustice without redress. Furthermore, the Hague Visby rules are silent about third party liability, and associated risks are inadequately covered.

There is no gain saying by stating the fact that the entire transportation process is governed by multiple laws, some which are civil in nature while some of them are administrative. The objectives and purposes of every such law are different. As such, a single research paper cannot attempt to cover the entire gamut of laws governing the entire transportation process. Nor is this paper attempting to do so. However, this paper is focusing on the simple counterfactual, i.e. ratification of the Rotterdam Rules and its probable impact on the aspect of container security. We are purposely ignoring the other probable impacts of ratification of the Rotterdam Rules as we consider them beyond the purview of this paper.

As regard to the responsibility of the Multi-Modal Transporter (MTO), his duty is limited to transportation of the container to the inland destination from the seaport or other way around and is discharged from all obligations if the container is delivered with its seal intact.

The MTO enters into a contract of transportation with the carrier/shipper as the case may be and that contract is governed by C.O.T.I.P or C.M.R depending on the mode of transport. He also does not handle the documents and purely acts as an agent of the carrier/shipper/forwarder. As such, the MTO too is unable to accept responsibility for container security failure.

The duties and responsibilities of the Dry Port Operator (DPO) are governed by the guidelines of the Department of Commerce’s and Customs and Border Patrol (CBP) under which it is set up and operates. Its operations too are subject to review by CBP. It essentially acts as a facilitator for conducting stuffing/de-stuffing operations by providing labor,
equipment and temporary storage facility. The DPO also organizes the presence of Customs officials on the dry port premises to conduct examination of EXIM cargoes. However, his contractual obligations with the carrier are limited to providing services which are meant to be supervised by CBP and the carrier or his agents. As such the DPO's obligations to ensuring container security is limited to ensuring integrity of container seals and does not extend to examining of cargo contents stuffed inside the container.

In conclusion, it can be said that the responsibility for providing accurate details of the cargo stuffed in the container lies fully and squarely on the shipper. However, the current provisions of the legal regime, i.e. The Hague/Hague Visby and the Hamburg Rules, are silent about the responsibilities of the stakeholders involved in the transportation process about verifying the cargo declaration of the shipper and the legal procedure that should be taken if the declaration is found to be erroneous.

The guidelines on submission of VGM by the shipper to are not without lacunae such as absence of deadlines for submission of VGM, the charges for the Master to weigh any unverified containers etc. The sea carriage contracts, charter parties and the Bills of lading too are silent about the importance of the VGM and need to be reviewed from this perspective. This will provide desired clarity in resolving future disputes involving the rightful responsibility of the shipper.

6. Recommendations
It would be beneficial for the enhancement of the container security if the Rotterdam Rules are ratified by all states and bought into force. This will render the MTO and DPO into Maritime Performing Party responsible for exercising due diligence by discharging their duties. It will also bring the multimodal transport document on par with the B/L.

The weighment certificatе provided by the authorized weighbridge should also be considered a legal document which would make the weighbridge operator liable for erroneous document or negligence.

The Customs supervise the entire container stuffing process, as well as sealing the container before the commencement of the transportation process. However, they are never held responsible or liable for the failure of container security. This is in spite of the fact that they control all the powers for permitting of cargo stuffing and transport. It would go a long way if the Customs were made answerable for security failure.

Finally, the carrier should be obliged to re-verify the cargo details provided by the shipper. If he chooses not to do so then he should be held liable for container security failure.

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The United States Intermodal Safe Container Transportation Act (1992).


**Further reading**


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The enforcement of the global sulfur cap in maritime transport

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Abstract

Purpose – The International Maritime Organization has decided that as of 1.1.2020, SOx content in a ship’s emissions should be no more than 0.5 per cent. The purpose of this paper is to address the various challenges expected to arise from the enforcement of the global cap sulfur regulation.

Design/methodology/approach – The authors outline various enforcement options and present a model that calculates the profits from noncompliance in the high seas, so as to help determine the level of fines that could be imposed in case of violation.

Findings – The main finding is that a harmonized system of fines, which are more than potential savings from cheating, would be a strong deterrent for compliance.

Originality/value – To the authors’ knowledge, no paper in the maritime literature on sulfur regulations has focused on enforcement as of yet.

Keyword Global sulfur cap

Paper type Research paper

1. Introduction

The International Maritime Organization (IMO) has been very active in formulating regulations in an effort to minimize pollution released from ships either in the marine environment or in the atmosphere. A regulation focusing on the sulfur emissions has been introduced by the IMO and will be put into force on January 1, 2020. The global sulfur cap, as the regulation is called, will limit the sulfur content of the fuel used for vessels’ propulsion to 0.5 per cent. The current regulation allows a percentage of 3.5 per cent sulfur in fuel for all vessels sailing in the high seas, outside regulated areas and the residual fuels available in the market usually contain approximately 2.7 per cent sulfur. Therefore, compliance with the regulation in the high seas has not been an issue for the ship owners. This regulation is part of ANNEX VI of the MARPOL convention: Regulations for the Prevention of Air Pollution from Ships (IMO, 1978). As expected, the upcoming global sulfur cap has been for a very long time a much-debated topic in the shipping world that was waiting for IMO’s critical decision regarding the implementation date of the cap. The shipping and refining industry have shown a phenomenal interest in the date the cap would be set in force, as their actions are highly dependent on the timing of the regulations.

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The IMO was set to decide about the implementation date based on the results of the fuel availability study that was conducted by CE Delft (2016). The aim of the study was to assess the ability of the refining industry to produce enough low sulfur fuel for the shipping industry that could cover the demand once the regulations are set in force. In October 2016, the 70th session of IMO’s Marine Environment Protection Committee (MEPC 70) met to examine the results of the fuel availability study and decided that the implementation date should be set to January 1, 2020 rather than wait until 2025. According to the results of CE Delft study, the refining industry has enough time to adapt the production to the new requirements of the global sulfur cap. Alternative methods of compliance were taken into account for the calculations of the expected demand of compliant fuel in 2020. The study examined three scenarios of the fuel demand, a base case, a high-demand case for marine fuels with sulfur content less than 0.5 per cent and a low-demand case in which more ships will be equipped with alternative compliance options and less are going to use low sulfur fuel.

It is interesting to note here that an alternative study conducted by EnSys Energy and Navigistics Consulting was also submitted to the IMO on behalf of various stakeholders, among them BIMCO and IPIECA (Ensys Energy and Navigistics Consulting, 2016). Even though this study estimated a higher number of ships with scrubbers than the original CE Delft study, it claimed that most operators would not have equipped their ships with such systems by 2020 and the only way of compliance would be low sulfur fuel. If that is the case, the refining industry would not have enough time to prepare for the high demand of such fuels that would occur overnight, thus implying shifting the implementation date to 1/1/2025. However, the IMO found these concerns unsubstantiated and after considerable discussion decided to move forward with the 1/1/2020 date as opposed to 1/1/2025. Still, between 2016 and 2018 there was considerable discussion on the subject, as some industry circles voiced concerns on safety issues as regards low sulfur fuels. The latest and perhaps “landmark” decision on this subject was reached by the IMO at MEPC 73 (October 2018), to ban non-compliant fuels from ships that do not use scrubbers, as of March 1, 2020. This is the so-called “carriage ban” policy, which will be discussed later in the paper.

The literature on sulfur regulations and specifically on their possible impacts is worthy of note. For instance, a special issue of Transportation Research Part D was dedicated to discussing Emissions Control Areas (ECAs) and their impact on maritime transport (Cullinane and Bergqvist, 2014). Among other papers in that issue, Panagakos et al. (2014) discussed the possible designation of the Mediterranean as a sulfur emissions control area (SECA), and Jiang et al. (2014) analyzed the costs and benefits of the scrubber solution vis-à-vis low sulfur fuels. Fagerholt et al. (2015), and Fagerholt and Psaraftis (2015), developed models that optimize routes and speeds for ships that sail in and out of ECAs and switch fuel whenever they cross an ECA border. Zis and Psaraftis (2017, 2018) investigated the possible impacts of sulfur regulations on the Ro-Ro sector in Northern Europe, by developing enhanced modal split models that attempt to calculate the possible shifts to other modes. Several measures to mitigate or reverse the negative repercussions of such legislation have also been proposed. Lindstad and Eskeland (2016) showed that the scrubber option gives lowest cost for large vessels even with low fuel prices. A similar and more recent result was shown by Lindstad et al. (2017) in the context of sulfur abatement options for the global sulfur cap. They concluded that scrubbers are a more attractive option for larger vessels whereas low sulfur fuels seem more positive for smaller vessels. Svinland (2018) addressed the environmental effects of ECA regulations on container feeder vessels in Northern Europe.
We note however that none of the above papers, and to our knowledge no papers in the scientific literature on sulfur regulations, have explicitly addressed the enforcement issues associated with the 2020 global sulfur cap. Our paper attempts to contribute to this subject, by examining, inter alia, penalty policies that need to be followed so that potential violations are discouraged. When the global sulfur cap was introduced, penalties were not defined for the non-compliant ships but were left to be decided by the responsible authorities. However, these penalties need to be universal and the fines to the disobeying operators should also work as motivating factors to encourage compliance in the high seas. One of the aims of the paper is to identify and assess the existing and potential methods to monitor and control sulfur emissions in a way that will ensure a level playing field. In addition, the penalty policies that need to be decided before the implementation date are analyzed and a method to calculate fines for ships violating the regulations in the high seas is developed. Port state and flag state control authorities need to have a simple and quick tool to estimate a sufficient fine for the non-compliant ships. The calculation is using data about the ship’s route and average fuel consumption per trip. The distance covered, transit time and speed along with the engine specifications can give us an approximate calculation of the fuel burnt and allow the definition of a penalty that will be a considerable loss for the non-compliant ship operators.

The rest of this paper is organized as follows: Section 2 provides a short explanation of the current and future sulfur regulations. Section 3 examines the compliance options for the ship operators in 2020. Section 4 provides a presentation of the available and potential enforcement schemes. Section 5: presents a model to calculate fines for non-compliant ships based on fuel consumption. Section 6 suggests possible penalties to be imposed for the violations and Section 7 presents the conclusions.

2. Sulfur regulations

The most widely used fuel in the shipping industry is the residual fuel oil, the most popular of which are RMG and RMK with a viscosity of 380 and 700 cSt, respectively, or less. Over the years, all marine engines are able to burn this type of fuel as the low price of HFO (Heavy Fuel Oil) has established it as the main marine fuel. Bunker fuel when burnt releases an important amount of pollutants, the most significant of which are sulfur and nitrogen oxides (SO\textsubscript{x} and NO\textsubscript{x}), carbon monoxide and dioxide (CO and CO\textsubscript{2} respectively), black carbon (BC) and various kinds of particulate matter (PM) (International Transport Forum, 2016), (Molloy, 2016). Carbon and sulfur contained in the bunker fuel oil are oxidized to CO\textsubscript{2} and sulfur oxides, mainly sulfur dioxide, SO\textsubscript{2}. In the engine of the ship, nitrogen (N\textsubscript{2}) is oxidized to nitrogen oxides (NO\textsubscript{x}), which, along with the sulfur oxides, when they reach the atmosphere, are converted into fine particles, sulfate and nitrate aerosols (Press Kristensen et al., 2011). The most dangerous of sulfur oxides is the sulfur dioxide (SO\textsubscript{2}) which is the main cause for acid rain. Ports and areas with heavy industry have higher concentrations of SO\textsubscript{2} and the population is more often suffering from respiratory problems [USA Environmental Protection Agency (EPA), 2016].

The areas designated as ECAs by MARPOL Annex VI are currently the following: the Baltic Sea; the North Sea; the North American area, 200 nautical miles offshore USA and Canada, including Hawaii, St. Lawrence Waterway and the Great Lakes, and the USA Caribbean Sea area. They are often referred to as Sulfur Emission Control areas (SECAs) or Nitrogen Emission Control areas (NECAs) because of the sulfur and nitrogen regulations imposed. According to MARPOL Annex VI, the global limit for the sulfur content since January 1, 2012 (and up to December 31, 2019) is 3.5 per cent. A new global cap will be
imposed as from January 1, 2020 that will limit the sulfur emissions to 0.5 per cent. The current limit for the ECA zones is 0.1 per cent and it is in force since January 1, 2015.

Action on sulfur has been taken by other countries as well. For instance, China including Hong Kong has designated some coastal areas as ECAs. The new regulations were announced in 2015 and designated the areas near the Pearl River Delta, Yangtze River Delta and the Bohai Sea as ECAs. The new requirements oblige all ships sailing inside ECAs or certain ports inside these areas to reduce emissions of sulfur oxides to 0.5 per cent.

3. Compliance options

There are three main compliance options that will allow the vessels to be compliant in the ECA zones and the high seas. The limits differ so it is necessary to pay attention before deciding which method is more efficient in every case. The categories are:

- compliant fuels (other than liquefied natural gas [LNG]);
- LNG; and
- emission abatement methods, also referred to as scrubbers.

Marine fuels with low sulfur content include marine gas oil (MGO) and marine diesel oil (MDO), as well as hybrid fuels, which are usually a mixture of HFO and distillates. Blended fuels, as they are also called, are a cheaper alternative that was developed recently to comply with the 0.1 per cent limit in the ECA zones. The so-called low sulfur fuel oil (LSFO) is a fuel oil variant with maximum 0.5 per cent sulfur. Similar fuels with a maximum sulfur content of 0.5 per cent will be produced to ensure compliance in the high seas. MGO and MDO do not require major alterations in the main engine, which leads to low capital investment and makes it the most appealing option.

Compliant fuels appear to be the most popular method of compliance for 2020 because of the reduced initial investment cost. Their availability in every port is still an open issue. Compliant fuels include also alternative fuels, which are not petroleum products. Most commonly used among these are biofuels, dimethyl ether, ethane and methanol. Alternative fuels might require alterations in the main engine before using them but the main limitation is their unavailability in many ports. Unlike the low sulfur fuels, alternative fuels are harder to find and their market share has never been high.

Another solution for fuel compliance is LNG. LNG offers a reduction of sulfur emissions almost 100 per cent, of CO$_2$ emissions 20-25 per cent, of particulate matter 98-100 per cent and NO$_x$ removal up to 80-90 per cent (Lloyd’s Register, 2012). The number of LNG fueled ships is constantly increasing, with a number of more than 75 operating ships and another 80 expected to be built in the next three years (Ship and Bunker News Team, 2017). LNG provides compliance with all existing regulations without any additional investments, but the original cost of the installation is high with a usually long payback period that may not work in favor of its expansion. The LNG installation may be profitable in some new buildings and usually in vessels with a fixed route that spend a lot of time inside ECA zones. Potential problems with LNG include:

- possible scarcity of bunkering locations;
- price volatility; and
- the so-called “methane slip”, which involves the release of methane emissions because of imperfect burning in the vast majority of marine engines (4-stroke and 2-stroke dual fuel or Otto cycle -spark plug- engines).

Methane (CH$_4$) is a greenhouse gas that is at least 25 times more potent than CO$_2$. 

MABR

4.2

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A popular alternative to low sulfur fuels are the emission abatement systems, commonly known as scrubbers. The scrubber is a device that treats the exhaust gases with a chemical solution through seawater or freshwater aiming in removing part or the total of SO\textsubscript{x} from the gases and reducing PM. The cleaner exhaust is then released to the atmosphere and the neutralized SO\textsubscript{x} and PM along with the solution used are released as waste in the sea. The most common type of scrubber used in marine installations is the wet scrubber.

In wet scrubbers, the sulfurous gases dissolve in the seawater or fresh water enriched with sodium hydroxide, producing sodium sulfate salt, which is a natural salt and can be discharged in the sea. The system comprises of a scrubber unit, usually placed in or around the funnel, a washwater treatment plant, a residue handling facility and an emissions monitoring system as imposed by the IMO for the continuous monitoring of sulfur emissions and other substances. The efficiency of the scrubber, and consequently the amount of SO\textsubscript{x} removed from the flue gas, can be adjusted according to the fuel used and the limitations of the region the ship is sailing. The final percentage of SO\textsubscript{x} emitted depends on the type of scrubber and the alkalinity of the water used. Apparently, the higher the amount of SO\textsubscript{x} removed, the higher the energy consumption of the scrubber.

The installation of a scrubber system is accompanied by the necessary pumps, coolers and tanks and in total it takes up a lot of space on the ship. This space is reserved from cargo space, especially in retrofits where the general arrangement does not facilitate the installation of such a system. The type and size of the scrubber affects highly the overall cost including installation and the lost cargo space.

4. Enforcement of the regulations

The responsible authority for ensuring compliance of the vessels in the high seas rests with the flag state. The flag state duties and jurisdiction over the vessels are mainly laid down under Article 94 of the United Nations Convention on the Law of the Sea (UNCLOS) (1982) and complemented by other articles. Only the flag state has jurisdiction over the registered ship regarding “administrative, technical and social matters” (United Nations, 1982), which includes the control of the ship’s compliance with the regulations referred to marine pollution and ensuring that it is equipped with the necessary certificates that prove compliance. High seas are not strictly regulated and the lack of enforcement allows irresponsible flag states to avoid imposing heavy penalties to their ships, or in fact not imposing anything at all, to attract more ship owners with substandard ships (IMO, 2011). These flag states are called flags of convenience and attract ship owners that attempt to minimize the costs and sacrifice the quality or safety of their vessels.

On the other hand, the coastal state’s jurisdiction is very restricted in case of vessels sailing in their waters without reaching a port. The coastal state has the right to inspect suspicious ships that have reached the port, but cannot stop a passing ship for inspection. If violations are detected, the port state control (PSC) can impose penalties to the operator or detain the ship in the port. The penalty policy of the coastal state very often requires assessment by the police and a court decision about a possible fine. A delegation of duties to the PSC would facilitate the procedure and minimize potential delays and waste of resources. PSC has gained experience in enforcement the past few years in the ECA zones, whereas flag states lack both the equipment and expertise in that field. An exception to this is the flag states that are also port states. A question whether the PSC is more fit to inspect and monitor the emissions is raised and an option to delegate PSC as the responsible authority for enforcement is discussed.
4.1 Port inspection

Port inspection is a standard procedure followed by the PSC for ships at berth and the IMO approved methods for this inspection are the following:

- bunker delivery notes;
- ship’s log books; and
- fuel samples.

The bunker delivery note is a legal document provided by the bunker supplier which indicates the type of fuel bunkered, the quantity, the quality, and its composition and properties. It has to be accompanied by a sealed fuel sample, signed by the supplier’s representative. These documents do not consist a reliable method of inspection because they can be easily falsified as it has been proven in the past with cross checks with fuel samples. The responsibility lies on either the ship operator or the bunker supplier who provided a lower quality fuel that was not thoroughly checked by the master of the ship during bunkering.

One additional document checked in inspections is the ship’s log book. The log book contains information about the fuel and oil handling procedures on board. The changeover from high to low sulfur fuel and the opposite, the volume of low sulfur fuels in each tank and the date, time, and position of the ship during the changeover, before entering or after exiting an ECA, are reported in the Oil Record Book. The log books sometimes do not provide useful information about the ship’s compliance. Records are sometimes not in English, illegible because of handwriting or not recorded in good time, resulting in missing records or valuable information. Falsification of books is sometimes noticed when fuel samples are taken. Samples are either sent to a lab and results are obtained a few days later when the ship has left the port, or portable analyzers can be used to detect the sulfur level on the spot. Because of the reduced accuracy of these devices, the IMO has not approved them as legal evidence of noncompliance. If approved, they could accelerate the procedure of imposing a penalty, as it will become an administrative task, rather than a court order.

The above mentioned methods can be used for ships at berth and they have been proven accurate and reliable. However, they are very time consuming, need a lot of resources and can only be applied to ships in the port and not passing ships. Only a 10 per cent of the ships entering a SECA zone have been inspected using these procedures (CompMon, 2016). Inevitably, these methods cannot be used in the high seas.

It should be noted here that with the recent decision of the IMO to apply a “carriage ban” (of which more is given in Section 4.5), a ship that has no scrubbers will not be allowed to carry non-compliant fuels unless they are cargo; therefore, there can be no changeover of HFO to MGO or MDO, and the only possible changeover when entering an ECA will be from 0.5 per cent to 0.1 per cent fuel. However, this does not prevent operators who deliberately want to cheat to have a secret tank and/or a “magic pipe”, which is used to divert oil to the combustion engine or discharge oil in the sea without using the oil separator, and allows the usage of HFO in the high seas.

4.2 Airborne monitoring

Several innovative systems have been developed lately to monitor the emissions from ships away from the coast. Sulfur emissions have been already successfully measured for ships within a certain distance from the coast by approaching the ship’s plume. Helicopters, unmanned aerial vehicles (UAVs) and special airplanes are able to measure the levels of pollutants directly from the ship’s plume without interfering to the ship’s course and
activities. Airborne monitoring has the advantage of multiple inspections per flight, depending on the autonomy of the system used. The crew does not interfere with the measurements and consequently the results cannot be tampered with. This method has been successfully used by PSC in Denmark, Belgium and The Netherlands to target non-compliant ships. Because of lack of the IMO’s approval for the method, port inspection is still required once the ship reaches a port. If inspection results are legally accepted as proof of guilt, fines will be issued on the spot without the need for a trial and port inspections could be minimized.

Helicopters, UAVs and airplanes with different range and flight duration can be deployed for airborne monitoring. The price of a cheap rotary drone can vary from USD1,523 to USD7,616 approximately. The maximum flight time of a rotary is 2 h, depending on the payload, and covers an area of up to 5 km. Professional drones, that can address more demanding tasks cost about USD1.7m with a maximum flight time of up to 6 h, depending on the payload. Manned vehicles such as helicopters and airplanes have a wider range and flight duration compared to the unmanned vehicles. Their range can reach 200 km away from the coast and autonomy of a few hours. Unmanned vehicles have a more limited range, not only because of their specifications but also because of regulations that state that operators should have visual contact with them during the flight. Therefore, their range is limited to almost 25 km from the coast.

Unmanned vehicles are equipped with sensors, the most popular of which are the so called “sniffers”. Before a measurement, targeting of suspicious ships takes place according to previous history of noncompliance, deviations from the expected route to avoid fixed stations of monitoring or even the color of the plume that could reveal the quality of the fuel if the helicopter is close enough to distinguish it. After targeting, a helicopter or UAV flies over the plume in a distance of approximately 30 to 50 m for a few seconds to obtain a measurement. They are usually equipped with a sniffer box containing electrochemical sensors for the detection of SO$_2$, NO$_2$ and NO and infrared sensors for CO$_2$. The ambient air is pumped towards the sensors through the small tubes attached on the sniffer box and the SO$_2$, NO$_2$ and CO$_2$ levels can be measured with an error of 0.01 per cent to 0.03 per cent. The autonomy of the UAV is limited and it depends on the payload. Therefore, the sniffer box is light-weighted and hard drives are not used, but data is directly stored in the cloud using a satellite connection.

For measurements further away from the coast, optical systems are used in combination with airplanes, as they can operate in higher speeds and bigger distances from the ship. Currently, they are able to detect NO$_2$ and SO$_2$ but the detection of CO$_2$ is harder to implement and still under development. These systems do not reach the accuracy of the sniffers and they are only used as an indication of a gross noncompliance.

The advantages of accuracy and difficulty to tamper with the airborne systems make them a perfect choice for inspecting the emissions in the high seas. However, they have a limited range, are highly dependent on the weather conditions and have a considerable overall cost. The new specifications of UAVs might allow longer, more reliable flights in the ocean. Two types of UAVs are available in the market: the rotary drones and the fixed wing drones.

Fixed wing drones have longer flight time, much greater power capacity and payload. They can operate with sniffers or optical systems depending on the target but improvements are yet to be done before they are deployed in the high seas. A typical drone of this class can fly approximately 20 h without payload, which is satisfying, but any payload will substantially reduce the flight time. The maximum payload is 10 kg including the fuel and it can reach a cruise speed of 70 km/h. A payload of 5 kg is enough to reduce the
flight time in half. The added payload reduces the fuel loaded on the UAV and therefore the flight time. The cost of such a drone can range from USD1.7m to USD3.41m including the necessary equipment. On the contrary, a rotary drone used for inspection in the ECA zones cost around USD150,000, considerably less than a fixed wing drone. In addition, it is still doubtful if the fixed wing drones can be immediately used in the high seas, as many improvements should be done to cope with the difficult conditions of the ocean, but their rapid development gives hope for use in 2020.

4.3 Fixed stations monitoring
Fixed station monitoring is relying on the very high quality of sensors adapted in key locations of the harbors around the world. They are analyzing the composition of the plume by using UV-fluorescence systems. In these systems, SO$_2$ molecules’ excitation by the UV light is used, and the fluorescence, which is a function of the SO$_2$ concentration, is measured. The ambient air and pollution can mislead the measurement, the wind direction can divert the plume away from the sensor and give wrong or inadequate data and the number of ships in the surrounding area can confuse and give wrong results. Consequently, the required high quality of the sensors and the resulting high cost, does not necessarily guarantee an accurate measurement.

In Table I, an example of the costs per method is presented, as applied in Denmark. Costs were given in DKK but converted to USD.

Fixed stations with some important adjustments to withstand the extreme weather conditions, could potentially be used in the middle of the ocean. A floating measurement station installed in the main shipping routes could detect the sulfur emissions of the passing ships. Floating stations need not be fixed in a position, but with a satellite connection, their location can always be determined. If developed, a few considerations need to be taken into account. The sensors that will be used should be durable in extreme weather conditions and possible to maintain on the spot. If the stations are spotted by the ships, there is a possibility they will adjust their route to avoid them as they only have a limited range. For example, an optical measurement system has a maximum range of 5km.

4.4 In situ emissions monitoring
*In situ* emissions monitoring refers to measurements taken directly from the plume of the ship and reporting the information in real-time to the authorities. Hence, an overview of every vessel sailing in the high seas or restricted waters can be obtained at any time. An example of such an application is the regulation imposed for ships using scrubbers to desulfurize their emissions and are legally bound to store relevant data on board for possible subsequent inspections. A similar device that measures the sulfur oxides from the stack of the ship can be designed to control the emissions in the high seas. However, a number of restrictions have delayed the development of such a device.

The main restriction opposed to its development is the sensitivity of the sensors that are used for that purpose. SO$_x$, CO$_2$ and NO$_x$ sensors are sensitive to high temperatures and

<table>
<thead>
<tr>
<th>Surveillance method</th>
<th>Cost per year (USD)</th>
<th>Cost per inspection/ measurement (USD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Port inspection</td>
<td>30,400</td>
<td>55</td>
</tr>
<tr>
<td>Fuel samples</td>
<td>–</td>
<td>91</td>
</tr>
<tr>
<td>Airborne</td>
<td>760,117</td>
<td>380</td>
</tr>
<tr>
<td>Sniffer in Great Belt Bridge</td>
<td>197,627</td>
<td>20</td>
</tr>
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</table>
could be destroyed if applied directly in the stack where the temperatures can be about 400°C. A protective cover for the increased temperatures needs to be invented, and a secure connection to the shore for the transmission of data applied. Even though mandatory scrubber sensors are certified tamper-free, perhaps the safest way to ensure that it will not be possible to tamper with the data is to save the collected data in the cloud by transmitting in real time to shore with a satellite connection. Data are saved in a compressed format where it is impossible to track and edit the content. This compressed output can be transmitted to shore in real time using cloud solutions and satellite connection and can be analyzed quickly to spot any anomalies. The size of the emissions data is small enough to allow transmission without increasing considerably the cost for connection.

An important hinderance to this potential scheme is the party responsible for the initial investment. A device applied in the ship’s stack would be at the cost of a ship owner who has no motive to proceed to such action. A regulation imposed by the IMO that obliges all ship owners to use these devices would be the only solution but it will find all ship owners against it since the overall cost of the new regulation is already burdening enough the shipping industry. The authorities will have to create incentives for the ship operators to install the device at their own cost which renders this scenario highly unlikely to happen in the limited time frame before 2020.

4.5 Carriage ban
In October 2018, MEPC 73 of the IMO adopted the carriage ban as a measure to tackle the possible noncompliance in the high seas in 2020. The measure will be implemented by 1 March 2020, as this is the earliest date possible for implementation because of the processes that need to be followed after the adoption. The carriage ban prohibits the carriage and loading of non-compliant fuel on ships that are not equipped with abatement systems and do not carry such fuel as cargo. In that way, the IMO aims to discourage ship owners to ignore the regulation and bunker HFO instead of low sulfur compliant fuel. Of course, it is still plausible for those who deliberately want to circumvent this rule to devise a method (such as a secret tank, or other) so that HFO is illegally used in the high seas, in the hope that this is not detected.

5. Case studies
Using predictions for the fuel prices in 2020, a method to calculate the profit of the non-compliant ships when burning high sulfur HFO instead of sulfur LSFO in the high seas is developed and used in case studies to present the approximate costs that this regulation introduces. In these case studies we assume that because of stricter enforcement the ship will not try to violate the sulfur regulations within an ECA, and that if a violation is registered it will only be outside the ECA. The main objective is to provide a tool that can be used to decide penalties reflecting the gravity of the violation rather than using uniform penalties that do not actually impose any financial loss to the non-compliant ship operators.

5.1 The marine fuel market
The supply and demand rules can help predict, up to a certain degree, the prices of marine fuels in 2020. The projections have a considerable margin error for the next two years because of political decisions and socio-economic changes that affect the demand and supply. For predicting the fuel prices in 2020, it is necessary to consider the uptake of scrubbers and LNG fueled ships as compliance method. According to the before mentioned study by CE Delft, three scenarios were used for the estimation. These are presented in Table II (CE Delft, 2016), as similar cases will be used in the case studies. Changes in
transport demand, fleet composition and operational efficiency will lead to an overall increase of 8 per cent in the demand of marine fuels between 2012 and 2020. The uptake of scrubbers and LNG is expected to lead to a decrease for HFO from 228 million tonnes per year in 2012 to 36 million tonnes in 2020 in the base case and the new low sulfur fuel with a content of up to 0.5 per cent is expected to reach a demand of 233 million tonnes in the base case. MGO, MDO and Ultra LSFO (ULSFO), which is a maximum 0.1 per cent sulfur variant of LSFO, are expected to drop down to 39 million tonnes per year in 2020, while the demand only for MGO in 2012 was 64 million tonnes. The study by EnSys/Navigistics considered these calculations conservative and estimated a total demand of 342 million tonnes of marine fuels for 2020. Out of these, 195 million tonnes are expected to be marine distillates of 0.5 per cent sulfur or less and 48 million tonnes HFO. The demand for HFO is expected to drop about 44 per cent, from 253 to 48 million tonnes per year in the base case, which is 12 million tonnes more than the prediction of the study by CE Delft. Although the estimations in the studies are different, the conclusion is a drop for the demand of HFO and an increase of marine distillates.

In Figure 1, we can get a view of the behavior of fuel prices for 2016-2018 to help predict the prices in 2020.

Because of the unknown capacity of the refining industry in 2020, the variation of the estimations of the fuel prices is quite wide. The first estimations (IBIA, 2017), (Mattheou, 2018), (Grimmer, 2018), place the HFO price at an average of USD340 for the beginning of 2020 and a price differential with LSFO of approximately USD250. The price of HFO is expected to drop because of the reduced demand and the sudden demand of LSFO will cause a peak in its price the first semester of 2020, but is expected to drop gradually as demand and supply will reach an equilibrium.

5.2 Methodology

As mentioned, three scenarios will be used in the case studies. The low case scenario reflects a situation where the fuel prices are barely affected by the global sulfur cap. In the base case scenario, the market will respond to the new regulation within the expected limits and according to historical data. The high case scenario reflects a situation where the HFO price will plummet because of the very low demand and MGO will have a corresponding increase. Only a rough estimation of the price of the LSFO can be provided, as it is not yet available in the market. The assumed prices in the case studies are presented in the Table III. The fuel consumption of the ship in various engine loads is necessary for the evaluation of the volume of fuel consumed and the cost of fuel. Real fuel consumption was not possible to be obtained for every vessel examined; therefore, nominal fuel consumption for all engine loads is used. Engine loads and the corresponding nominal fuel consumption can be obtained from the data provided by engine manufacturers. Real fuel consumption has to be provided by the

<table>
<thead>
<tr>
<th>Sulfur content (%m/m)</th>
<th>&lt;0.10%</th>
<th>0.10%-0.50%</th>
<th>&gt;0.50%</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Million tonnes per year</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low case</td>
<td>33</td>
<td>198</td>
<td>38</td>
</tr>
<tr>
<td>Base case</td>
<td>39</td>
<td>233</td>
<td>36</td>
</tr>
<tr>
<td>High case</td>
<td>48</td>
<td>290</td>
<td>14</td>
</tr>
</tbody>
</table>

Table II. Global fuel demand  
Source: Assessment of fuel oil availability 2016 by CE Delft (2016)
shipping company owning the vessel but this data is often treated as confidential. Therefore, we used the propeller law (or cubic law) instead (Zis et al., 2016). The engine load is dependent on the engine speed, the weather conditions and the loading condition of the ship. Using the sailing speed, we can estimate the engine load with equation (1):

\[
\frac{EL_1}{EL_2} = \left( \frac{V_1}{V_2} \right)^n
\]

(1)

According to Zis et al. (2016), values from \( n = 3.2 \) or \( n = 3.5 \) can be used for medium-sized vessels, tankers and feeder container ships, and higher exponents up to \( n = 4.5 \) for fast container ships and in extreme weather conditions. In these case studies, cargo load and weather conditions are not taken into account as a general model for average situations is developed. The propeller law is applied with data about the average speed of the vessel from port to port. A drawback of the cubic law is the result returned in very low speeds (Psaraftis and Kontovas, 2013). It cannot be applied in very low or zero speed because it returns zero

<table>
<thead>
<tr>
<th></th>
<th>Low case</th>
<th>Base case</th>
<th>High case</th>
</tr>
</thead>
<tbody>
<tr>
<td>HFO</td>
<td>390</td>
<td>340</td>
<td>300</td>
</tr>
<tr>
<td>MGO</td>
<td>740</td>
<td>790</td>
<td>840</td>
</tr>
<tr>
<td>LSFO &lt; 0.5%</td>
<td>540</td>
<td>590</td>
<td>640</td>
</tr>
</tbody>
</table>

Table III. Projected fuel prices for 2020 used in case studies (USD per tonne)
consumption, ignoring the fuel burnt while at berth. It would be preferable not to use a very low engine load and obtain more realistic results about the fuel consumption. In addition, considering manufacturer’s recommendations for avoiding damage because of wear in the engine in low engine loads (MAN Diesel and Turbo, 2011), a lowest limit of 10 per cent will be used.

Specific fuel oil consumption (SFOC) values are obtained by the engine manufacturer’s websites and the SFOC curves and tables they provide for every type of engine. Fuel consumption of every vessel can then be estimated in equation (2):

$$FC_i = 10^{-3} \times SFOC_i \times EL_i \times EP \times t_i$$  \hspace{0.5cm} (2)

where $i$ is a specific engine loading condition, FC is the fuel consumption in tonnes, SFOC is given in g/kWh, EL$_i$ is the engine load in loading condition $i$, EP expresses the installed engine power and $t_i$ is the sailing time for loading condition $i$ (Zis et al., 2016).

Speed is adjusted according to the engine load by using a minimum value at the minimum engine load and a maximum value at 100 per cent of engine load. The speed inside and outside ECA is optimized with the objective of minimizing the cost of fuel, given that fuel with 0.1 per cent sulfur is more expensive than 0.5 per cent. Consequently, we expect to have higher speeds outside ECA zones and lower speeds in ECAs.

For the specific case of containerships, the schedule imposed by the shipping company is a limiting factor to the speed of the vessel. These schedules are public and can be obtained by the operators’ websites. Containerships were used for these case studies because of the ease of access to data that allow obtaining more accurate calculations. However, the model developed can be applied to any ship not equipped with a compliance method as LNG or scrubber. The model is not dependent on the type of ship but rather on the fuel consumption that depends primarily on the engine type. Distances between ports and distances traveled within ECA zones are acquired by MarineTraffic.

Engine specifications in combination with the vessel’s schedule and speed are used to calculate the cost of fuel per trip in equation (3) and per nautical mile. The cost is calculated separately for both ECA and non-ECA zones assuming that compliant fuel are used in every case, i.e. 0.1 per cent sulfur inside and 0.5 per cent outside ECA zones. The total fuel cost results from the sum of the two independent costs, as shown in equation (4). For noncompliance, the fuel used is assumed to be HFO of 2.7 per cent sulfur:

$$Cost_k = FC_{i,k} \times FP_{j,k}$$  \hspace{0.5cm} (3)

$$Cost_{TOTAL} = Cost_{ECA} + Cost_{NON-ECA}$$  \hspace{0.5cm} (4)

where $FP_j$ is the fuel price for the case scenario $j$, and $k$ characterizes the ECA or non-ECA sailing cost.

The main purpose of this task is the calculation of a minimum amount of fine that should be imposed if a ship gets caught for non-complying, as the fine should be dependent on the profits. A fine that highly exceeds the profits of the ship owner will be a deterrent factor for noncompliance in the future. Therefore, uniformity in the fines for the sulfur cap could lead to high noncompliance rates.

In the following, we examine two case studies to illustrate the method. Both case studies are in the container sector. This causes no loss of generality, as the methodology for other shipping sectors is the same. Both cases are based on realistic data, taken from container...
carriers’ web sites, engine manufacturers’ data and others. Names of ships or shipping companies are not disclosed and there is no implication, direct or indirect, of any intent not to abide by the sulfur regulations. In either case, the calculations are made solely to indicate the magnitude of the potential savings in fuel costs and hence guide relevant authorities on what kinds of fines can be imposed in the event deliberate noncompliance is manifested.

5.3 Case study 1

A large container ship (18,000+ TEU, 59,000+ kW maximum continuous rating [MCR]) is examined in the first case study. Assume the ship is deployed on a route from Asia to Europe and back, with a total of 10 port calls each way, of which 3 are inside the European ECA. At a speed corresponding to 80 per cent of MCR, the whole trip lasts approximately 84 days, of which almost 9 days are spent within European ECAs. The calculated fuel consumption per trip is presented in Table IV.

The SFOC values were retrieved by the engine manufacturer data published online. Using the engine load and SFOC values with the time spent inside and outside ECA, the fuel consumption and fuel cost for the three case scenarios were calculated. The fuel cost per trip and per nautical mile was calculated and the savings per trip and per nautical mile are presented in Table V. We clarify that savings per nautical mile are computed per nautical mile sailed in the high seas (outside ECAs), as this is where potential savings because of inappropriate use of HFO can be realized. The ship spends about 10 per cent of its time inside ECA zones and therefore the fuel cost for the sailing time inside an ECA is not as high as the one in the high seas. The difference in the total cost before and after 2020 is considerably high as the bunker consumption in the high seas is the prevailing value compared to the ECA consumption. To be compliant, the fuel cost for such a ship in 2020 will be 40 per cent more in the high case.

It is clear from this example that a ship of this type will enjoy a great profit by burning non-compliant fuel in the high seas. However, a fine equal to this profit might still be low; the ship owner would rather pay the fine and continue violating the rule. To be a credible deterrent, a multiple of the profit would serve as a better fine. This is of course a policy decision of the enforcement authorities.

5.4 Case study 2

The second container ship is smaller (4,650 TEU, 45,700+ kW MCR). The vessel is deployed on a route from Europe to the USA with 8-port calls roundtrip. Assuming again sailing at a

<table>
<thead>
<tr>
<th>Fuel consumption (tonnes)</th>
<th>ECA zones</th>
<th>High seas</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>323.41</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>5,363.15</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>5,686.55</td>
</tr>
</tbody>
</table>

Table IV. Fuel consumption per trip

<table>
<thead>
<tr>
<th></th>
<th>Cost HFO per trip</th>
<th>Cost LSFO per trip</th>
<th>Savings per trip</th>
<th>Savings per n.m.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low case</td>
<td>1,848.26</td>
<td>3,081.79</td>
<td>1,233.52</td>
<td>0.052</td>
</tr>
<tr>
<td>Base case</td>
<td>2,078.96</td>
<td>3,419.75</td>
<td>1,340.79</td>
<td>0.057</td>
</tr>
<tr>
<td>High case</td>
<td>2,309.66</td>
<td>3,757.71</td>
<td>1,448.05</td>
<td>0.061</td>
</tr>
</tbody>
</table>

Table V. Fuel costs and savings for HFO and LSFO per trip (in thousand USD)
speed corresponding to 80 per cent of MCR, total duration is 35 days. All of the port calls are within the Baltic and North Sea ECA and the North American ECA. As a result, the ship spends almost 50 per cent of its time inside ECA zones.

The cost of fuel during its trip is calculated using data from the engine manufacturer and is presented in Table VI.

The engine load and SFOC values are dependent on the speed of the vessel which was optimized for sailing inside and outside ECAs. The minimum SFOC is provided by the manufacturer as 171 g/kWh.

The fuel costs calculated for the three scenarios using the engine data are presented in Table VII. As before, savings per nautical mile are computed per nautical mile sailed in the high seas (outside ECAs), as this is where savings can be realized.

The size of the ship and the route followed play an important role in the amount of fuel cost per trip. As expected, the second container ship has lower fuel costs compared to the first one, because of not only the size of the ship which is considerably smaller but also the route followed. However, ship 2 spends 50 per cent of the sailing time inside ECA zones where the fuel consumed is considerably more expensive. Sailing with LSFO in spite of HFO will cost approximately 20 per cent more.

6. Penalties

Low fines and relaxed enforcement of the regulations will create a climate of noncompliance where it may be worth taking the risk of getting caught as the penalties will not reach the investment costs for scrubbers, LNG or even switch-over to LSFO. The highest fine for a non-compliant ship in Denmark, where government control is present and environmental regulations are strongly enforced, was USD60,000, by March, 2018 (VPO Global, 2018). However, this value is much lower than even the lowest savings among the two case studies examined (in the second case study a medium-sized container ship could save a minimum of about USD257,000 per trip). Therefore, it is recommended that the fines be higher, and specifically, exceed the profits of the trip to discourage similar behavior. Non-compliant ships should receive higher punishments and the frequency of inspections projected against the chance of a ship getting caught should be examined before deciding a fine, but because of lack of data, it was not possible to assess in this paper.

In Table VIII, fines imposed in European countries for violations inside ECA zones in 2015 are presented. All fines were converted to USD from each country’s currency. It can be observed that there is not a common penalty policy, but it depends on the country and the

<table>
<thead>
<tr>
<th>Table VI.</th>
<th>Fuel consumption (tonnes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ECA zones</td>
<td>919.24</td>
</tr>
<tr>
<td>High seas</td>
<td>1,119.67</td>
</tr>
<tr>
<td>Total</td>
<td>2,038.91</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table VII.</th>
<th>Cost HFO per trip</th>
<th>Cost LSFO per trip</th>
<th>Savings per trip</th>
<th>Savings per n.m.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low case</td>
<td>1,016.14</td>
<td>1,273.66</td>
<td>257.52</td>
<td>0.050</td>
</tr>
<tr>
<td>Base case</td>
<td>1,106.88</td>
<td>1,386.80</td>
<td>279.92</td>
<td>0.055</td>
</tr>
<tr>
<td>High case</td>
<td>1,197.63</td>
<td>1,499.95</td>
<td>302.31</td>
<td>0.059</td>
</tr>
</tbody>
</table>
court decision in every case. This variety of the level of fines can create the impression that it
is possible to get away with a violation paying a very low price.

An alternative but very effective penalty is detention in port. Currently, detention of a
ship is possible when violations regarding the structural safety of the ship or the safety and
health of the crew are found on board during the inspection of the PSC. Detention is a very
costly penalty for ship owners, as a delay in schedule may result to loss of sensitive cargo
that needs fast transportation. Failing to deliver the cargo on time could imply a fine to the
operator because the terms of the contract were violated. In addition, the operative costs of
the ship have to be covered immediately, despite the fact that it is not operating at the time,
leading to considerable losses for the operator. An appeal for the fine imposed is not going to
save any of the costs that the ship owner will be charged with. Detention has not been used
so far for these violations, but it could be considered as a potential measure for special cases.

Other negative reinforcement methods could be the loss of insurance coverage if a ship is
captured violating the regulation.

Fines are an inevitable measure but positive reinforcement can prove more effective in
the long term.

Shipping companies will become more condescending and willing to carry the burden of
the additional cost of the compliant fuel, if rewards to compliant ships are awarded by ports
or port states. Advantages to law-abiding companies, lower port fees and taxes are some
measures that can be used to call the shipping world to comply with the new regulation. The
occasional controls by PSC can verify if ships comply. It is up to the port state and the port
administration to decide whether such incentives will be applied or not, and what kind of
incentives are possible to apply in every port.

### 7. Conclusion
The global sulfur cap imposing a new limit of 0.5 per cent sulfur content in the fuel consumed
in the high seas has raised concern in the shipping world because of the high fuel costs that it
implies but also the level of compliance in an area difficult to regulate and monitor like the
high seas. The enforcement methods that can be used in the high seas are still under research
as there are not any suggested methods by the IMO. All methods are analyzed, their
advantages and limitations, as well as their feasibility and possible improvements. The
enforcement schemes that are possible to use can be grouped in five categories:

1. port inspection;
2. airborne monitoring;
3. fixed stations monitoring;

<table>
<thead>
<tr>
<th>Country</th>
<th>Maximum fine (USD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Belgium</td>
<td>6,823,240</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>3,828,506</td>
</tr>
<tr>
<td>United States</td>
<td>25,000 per day</td>
</tr>
<tr>
<td>Denmark</td>
<td>57,424</td>
</tr>
<tr>
<td>Germany</td>
<td>25,018</td>
</tr>
<tr>
<td>Lithuania</td>
<td>16,467</td>
</tr>
<tr>
<td>Latvia</td>
<td>3,288</td>
</tr>
<tr>
<td>Sweden</td>
<td>1,111,233</td>
</tr>
<tr>
<td>Netherlands</td>
<td>92,120 + economic gains</td>
</tr>
</tbody>
</table>

Table VIII.
Fines in Europe, Adapted from International Transport Forum (ITF, 2016)
Port inspection is conducted in the port and therefore ineffective in the case of enforcement in the high seas. The carriage ban is a measure in the right direction, but cannot address the full scale of the problem and will need to be implemented in parallel with other measures. On the other hand, airborne solutions are very promising but need further development. Investment in the development of in situ emissions monitoring solutions could prove very useful for the future as it will be the most effective and low cost solution, if the consequences of such a decision for the ship owners are anticipated.

The long procedure of definition of penalties could be standardized and accelerated with a model which calculates the profits of any ship, given the route and duration of the trip. This could help estimate the minimum amount of fine and there would be no need for the authorities to waste time and resources for court decisions about the violations. A model that calculates the profits for burning non-compliant fuel in the high seas was developed and was applied in two case studies. The calculations are based on the route followed, the amount and type of fuel burnt and the approximate fuel consumption. Inside the ECA zones, the vessels are considered to be compliant because of the strict enforcement and the speed of the vessels is optimized accordingly for the ECA areas. It was noticed that ships spending most of their time inside ECA zones have higher costs because of the higher price of the 0.1 per cent sulfur fuels, MGO and MDO. However, the profits in case of noncompliance are considerably smaller in this case of a reduced time sailing with HFO. The potential savings in the two case studies examined reached a maximum value of USD61 per (high seas) nautical mile, but even higher values are conceivable, depending on the scenario. It will be very profitable for ships sailing a long time in the high seas to risk noncompliance, given the level of the fines that have been imposed so far, unless a very strict enforcement takes place. In addition, this does not refer only to monitoring but also to the penalty system applied and its effectiveness.

A further study of the subject could lead to a calculation of fines that takes into account the probability of getting caught for noncompliance and the corresponding time a ship could be sailing in the high seas burning HFO.

Needless to say, a global harmonization of the system of fine calculation and imposition is considered of paramount importance for the overall effectiveness of enforcement of the global cap. The legal issues associated with this may be non-trivial but will need to be addressed all the same.

**Note**

1. Given the definition of LFSO, HFO in this paper is meant to be the standard, high-sulfur (typically 3.5 per cent) variant of fuel oil.

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Sulfur cap in maritime transport


Lloyd’s Register (2012), LNG-Fuelled Deep Sea Shipping, Lloyd’s Register, August.


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China–Pakistan economic corridor and maritime security collaboration
A growing bilateral interests
Yen-Chiang Chang
School of Law, Dalian Maritime University, Dalian, Liaoning, China, and
Mehran Idris Khan
School of Law, Shandong University, Qingdao, Shandong, China

Abstract

Purpose – This study aims to explore why marine development and maritime security in Pakistan are significant and what the Chinese concerns are. Therefore, the objective of this research is to analyse a growing Pak–China bilateral interests, particularly at Gwadar, to achieve the geostrategic objectives of China–Pakistan Economic Corridor (CPEC).

Design/methodology/approach – The study adopts a qualitative means to discuss the significance of China’s ambitions towards the CPEC project concerning strategic deep-sea management and maritime regulations in the region, with a particular focus on the Gwadar Port.

Findings – The paper concludes that the Gwadar Port is a critical element for maritime security in the whole region. The study also provides an analysis of national and international, security and legal challenges associated with CPEC.

Originality/value – Most of the potential outcomes have already been discussed in public, though a limited academic discussion is available on the legal aspects. It is particularly so with regard to the development and capacity building in the maritime sector of Pakistan under this project. This study aims to explore why marine development and maritime security in Pakistan is significant and what the Chinese concerns are.

Keywords China–Pakistan Economic Corridor, China’s interests, Maritime security collaborations, Pakistan’s marine development

Paper type Case study

1. Introduction

China’s gigantic strategy of “Belt and Road Initiative” (hereinafter BRI) interconnects the South East Asia, Eurasia, South Asia and Africa in a way that attracts partners working towards long-term benefits by using its unique design of roadways, railway lines, energy infrastructure and maritime routes. A research report released by Hong Kong and Shanghai Banking Corporation (HSBC) shows that states alongside the BRI comprise 63 per cent of the

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world’s population and 29 per cent of the Gross Domestic Product (GDP) (Global Capital, 2015). Two main components of BRI can be regarded as the land-based “Silk Road Economic Belt” (hereinafter SREB) and the oceangoing “21st Century Maritime Silk Road” (hereinafter MSR). The China–Pakistan Economic Corridor (hereinafter CPEC) is that portion of a land-based constituent of BRI strategy which connects its oceanic routes at the point of Gwadar Port in southern Pakistan. It is situated at a strategic location where the 21st Century MSR and SREB connect. Therefore, it may be regarded as a key project of the BRI (MFA, 2015). Some of the international analysts regarded CPEC as a “game changer” for the region. Under this multi-billion project, China has been connected with Pakistan from the western province of Xinjiang, with the northern areas of Pakistan through the Khunjerab Pass that leads to southern Pakistan (Gwadar Port), framing a communication network as well as energy infrastructure of approximately 2,500 miles (Ali, 2016).

It is a pertinent fact that maritime security is connected with the economic development of any state. The importance of maritime trade has always been vital throughout history because the majority of the world trade passes through maritime routes. The commercial phase of this development contributes to additional revenue given the significance of offshore resources as well as coastline tourism. However, this strategic rationale is a noteworthy challenge for Pakistan and China. Since then, Pakistan Navy has initiated its strategic missions such as its Special Task Force-88 (The CPEC Bulletin, 2017). As maritime traffic-flow through the Gwadar Port is anticipated to increase significantly, eventually maritime security is a dependent variable for the success of CPEC project. A multidimensional approach necessitates encountering the security challenges to ensure the security of Gwadar Port, including leading security guards, littoral exercises and fetching law enforcement agencies to enhance growing maritime awareness in the region. Human trafficking and piracy issues are the main challenges besides the challenges raised by India’s mounting concerns in the Indian Ocean. Consequently, Pakistan Navy, with China’s support and cooperation, is working on three key extents: the Gwadar Port security, the security of sea lanes and vessel security (The Value Walk, 2017). Pakistan is expected to advance its independent maritime security doctrine to accomplish all these objectives for the capable functioning of CPEC (Maqsood, 2017).

The developments in the Gwadar Port would carry new hopes for economic and trade growth. Therefore, Pakistan has taken numerous steps to improve ocean governance with the collaboration of China to secure projects under CPEC. Pakistan has conducted a transnational naval exercise in Karachi and the northern Arabian Sea in which 37 states have taken part in a five-day exercise that includes military vessels, aircraft and special marine force teams (The Value Walk, 2017). The war on terror has brought some limitations in the way of foreign aid to Pakistan. Therefore, this CPEC-Gwadar Port joint venture would promote the sustainable image of Pakistan through investments, and it might also be the centre of global debate to capture the world’s attention. Eventually, CPEC may be regarded as an emerging architecture of economic development. At the same time, it has various challenges including poverty, the terrorism-security threat for the Chinese labour force in Pakistan, ethnonationalism and growing radicalisation (Qasim, 2016). The Chinese vision for the developments of its friendly neighbour states such as Pakistan through infrastructure developments concerning trade and industry would bring Pakistan in a cable position to face these challenges. Subsequently, international crimes including human trafficking, piracy, maritime terrorism and other cyber-related crimes around the Indian Ocean, which may mess up international commercial transactions leading to economic failure, can be coped with up to sufficient extent. The aforementioned has led Pakistan’s priorities to strengthen its maritime security governance to tackle these problems.
CPEC includes a large number of development projects within Pakistan (Bhattacharjee, 2017). Since the official announcement of the mega project of CPEC, China is greatly assisting Pakistan for sustainable usage of its marine resources. China is proposing to approach the Middle East oil resources effectively and safely, which not only reduces the freight charges but also serves to save supply time for China’s energy and production requirements. It also reflects the Chinese vision to secure sea lanes in the Indian Ocean starting from the Chinese mainland via the South China Sea that may range up to the Port Sudan, where China would construct commercial ports and shipping amenities (Hamilton, 2004). It advocates Chinese concerns to enhance the maritime capacity building of Pakistan Navy, which can be traced in ongoing and recently completed projects (listed in Section 3).

The significance of the maritime security is vital in a sense that all the economic activities under CPEC are going to be placed through a unique route connecting China to the Arabian Sea, the Middle East and opening it to the Indian Ocean. Therefore, the marine development, as well as maritime security of Pakistan, is the topmost priority for both the Chinese officials and Pakistan Maritime Security Agency (hereinafter PMSA) to ensure the safety of international trade through the Gwadar Port. The challenges include not only human trafficking and piracy issues but also to accord CPEC regulations both at the national and the international levels. It can be said that if fuel is life for the industry and economy, then CPEC along with its strategic exposure to the Middle East as well as the Indian Ocean may be regarded as the blood to Chinese economic growth in the future.

2. The magnitude of this maritime collaboration
2.1 China will approach the Indian Ocean and the Middle East through a unique maritime route under China–Pakistan Economic Corridor project

The Middle East comprises nearly 50 per cent of global oil reserves and 25 per cent of oil production worldwide (OPEC, 2017). China, with growing oil consumption as per its economic development, is likely to be a major oil importer from the Middle Eastern oil enriched states, hence, a key stakeholder of the Gwadar Port. The Gwadar Port, the world’s largest deep sea-port situated at a distance of nearly 250 km as of the Persian Gulf, can serve as a gateway and will come out as a strategic location for the forthcoming Chinese interests in the region (Naseem, 2017). Approximately 52 per cent of China’s oil demands are being met and imported from the Middle Eastern states. The world top exporters released a report revealing the fact that from its total oil imports of $134.3bn, China imported US$69bn from the Middle East during the year 2015 (Figure 1) (Rahman and Shurong, 2017).

The Gwadar Port will link western Chinese province, Xinjiang, to the Indian Ocean over oil and gas pipelines as well as scheduled highways and a network of high-speed railways. That is how China will approach the Middle Eastern oil with a shortcut route. It will take only six days to approach energy supplies to Chinese boundary through CPEC, which is the shortest time frame as compared to its current sea-route in 32 days and 19 days through the suggested Bangladesh-China-India-Myanmar Economic Corridor (BCIMEC) (Shaikh et al., 2016). The Middle Eastern oil reserves will only be around 2,295 miles (of which 545 miles via Oceanic routes and 1,750 miles through roadways) away from China through CEPC route as compared to its present 12,537 miles long distance comprising 9,912 miles through oceanic ways and 2,625 miles via the land-based route (Figure 4). Similarly, the transportation cost (from Abu Dhabi to Shanghai) will also be reduced to US$200-250 (Figure 2) per 40 feet container with a time frame of two-three days (Figure 3) as compared to its current transportation cost of US$2,000 which takes a long period of 16 days to reach its destination (The Gulf Today, 2017). Research reports signify the effectiveness of CPEC as declaring it a cost-effective project that will take shortest possible time for transferring
energy supplies to China and environmental friendly at the same time as it will cause less greenhouse gases emission (Collins and Erickson, 2010; Sharan and Thiher, 2011) (Figure 4).

2.2 Safeguarding sea lanes of communications within the Indian Ocean region
The USA, Japan and India have set their priority to ensure maritime security in the Indian Ocean Region (Wang, 2015). The USA has played a vital role in launching anti-piracy operations in this region securing the international trade, whereas India has already built its naval bases in the Nicobar and Adman Islands. Whereas, China became the world’s largest maritime trader even deprived of adding sufficiently to its maritime security of international trade in the region comparatively (The Guardian, 2016). Almost 90 per cent trade of the USA
and China is being made via oceanic routes which represent about 25 per cent of the trade worldwide. However, it may not be feasible to continue this free ride for a longer time by availing important port amenities under BRI to project Chinese Navy’s assets abroad.

As compared to its economic and military strengths, China has embraced quite a narrow and careful attitude to enhance its naval bases outside the country. There is only a naval post in Djibouti where People’s Liberation Army Navy (hereinafter PLAN) of China operates anti-piracy activities, collaborating with the Japanese, US and French naval forces (Aljazeera, 2017). Therefore, the Gwadar Port may provide a warm platform to the Chinese

Source: The gulf today

Figure 3.
Proposed timeframe to reach the consignment at the destination

Figure 4.
Comparison of mileage between the current route and proposed route under CPEC project (Abu Dhabi to Shanghai; in miles)

Source: The gulf today
Navy to enhance its maritime security in the Indian Ocean. In 2004, the US Department of Defence reported a notion named as “String of Pearls” concerning China’s apprehensions in the Indian Ocean to build its blue water navy (Hamilton, 2004). This theory hypothesises China’s concerns to strengthen its chain of seaports and naval amenities in the Indian Ocean ranging from the South China Sea to Port Sudan. Safeguarding sea lanes of communications in this region from both traditional and non-traditional threats is vulnerable to China’s future maritime security. In the scenario mentioned above, the Gwadar Port which is situated only 250 km of distance from the Strait of Hormuz, may be a most suitable platform for Chinese naval forces that can open a gate to keep international trading lanes safe and secure (Rahman and Shurong, 2017).

2.3 Sea channel safety

It is important to ensure the sea channel stayed opened instead of cutting off, which is inevitable for smooth implementation of Chinese BRI. Ocean shipping comprises almost 90 per cent of global trade and 60 per cent of oil volume worldwide, whereas the Indian Ocean contributes world’s 50 per cent of container shipments and 70 per cent of the shipping of oil products from the Middle East to the Pacific (Haiquan, 2017). Nearly 40 per cent of world’s trade via the Strait of Malacca and almost 40 per cent of crude oil trade passages via the Hormuz Strait, signify strategic importance of the Indian Ocean routes for international trade (Kaplan, 2009). It is also of huge importance for China because most of the Chinese oceanic oil trade is passing through the Straits of Malacca, the Indian Ocean to North Africa and the Middle East. The channels that connect the Middle East to the Indian Ocean through the Malacca Straits can be regarded as the lifeline for China’s future economic growth that will prove as the blood to the veins of Chinese industry as far as their needs of petroleum products are concerned. Hence, the importance to ensure the safety and security of passage of the Malacca Strait, the Strait of Hormuz and the Mande Strait around the “One Road” is vital. The challenges, however, coming across it can never be ignored, as the USA also has concerns to control over these straits (Haiquan, 2017).

2.4 Why is the maritime security of Pakistan so important?

While advocating the effectiveness of sea power, Admiral Alfred Thayer Mahan stated that control of the sea by maritime trade activities and naval supremacy means predominant influence in the world (Kok Giok, 2013). It suggests that becoming a sea power within a particular region is essential to a nation’s long-term prosperity and its ignorance can put a nation at risk. CPEC has enough potential to transmute Pakistan into a trade hub that would categorically induce some sentiments in the regional enemies and competitors, particularly in India to halt it. Indian experts have been focussing on two imperative political and military ideas since long. The first one is, whoever commands the Indian Ocean will also command entire Asia. Secondly, extra-regional influences should be kept out as Indian Ocean lies around its backyard (The Value Walk, 2017).

The Strait of Hormuz is the channel for about one-third of the global oil trade, which makes the role of the Gwadar Port in this region vigorous to ensure energy security for China. The proposed naval base for China in this region would counter the USA’s influence (Waedlich, 2017). The potential of the Gwadar Port is not limited to Pakistan and China, but its scope is wider enough that promises to bid gigantic and potential dividends beyond the instant region. Therefore, the maritime security of Pakistan is identically important but a mere attended matter that needs to be considered with due attention by the policymakers. China and Pakistan are to be placed in an exceptionally advantageous strategic situation with the deep sea Gwadar Port that will also lead a drift of passionate competition among the contending states (Kazmi, 2016). Besides offering an utmost economical path for trade connectivity concerning China,
Pakistan and rest of the world, CPEC along with the Gwadar Port likely to create fruitful opportunity to enhance connectivity to the energy enriched Central Asian Republics. Another edging point of the Gwadar Port with the future perspective of this region is that it may also be used as a hub port for the Gulf states in the future (Khan, 2016a).

The challenges raised under the dominion of maritime security cannot be faced by any state of the world alone owing to the certain nature of contemporary maritime challenges. Therefore, the Pakistan Navy is in continuous collaboration with the Chinese Navy and navies of different states since a time followed by numerous activities in advancing its grip and interoperability over maritime crimes, for instance, joining 2004 USA-led multinational Task Force-150 (Khan, 2016a). Several prominent initiatives have been taken by Pakistan military to guarantee onshore as well as a float security of the Gwadar Port. It includes the security of the Gwadar Port and China’s engineers and other workers along with the relevant infrastructure. Besides, a separate force named as “Force Protection Battalion” has been created by the Pakistan Navy solely for the protection and security of the Gwadar Port as well as Chinese people working on CPEC project (Kamran, 2017).

3. Current developments of Pakistan’s maritime capacity building

Chinese sustenance for Pakistan’s struggles in strengthening its maritime competencies has significantly expanded from the perspective of equipment, logistics and training support as well as technology transfer. During an official visit of the PLAN chief to Pakistan, tremendous concerns towards broadening the scope of present maritime exercises aimed to enhance interoperability have been shown by both the navies (Collin, 2016; The Dawn, 2016a, 2016b). Pakistan and China have entered into a contract to build six patrol vessels for PMSA in June 2015. According to this agreement, out of these six, four were to be built in China and the other two at Karachi’s Shipyard and Engineering Works (hereinafter KS and EW) under Transfer of Technology (Haider, 2015). The endorsement by the China Shipbuilding Industry Corporation for its participation in a project with the Pakistan Navy to deliver eight attack submarines symbols yet another milestone in this collaboration (Naval Today, 2016). The acquirement of these new ships is an important phase concerning to the capacity building of PMSA by the government that will definitely improve the agency’s operational capabilities, which will on the one side help to defend and safeguard the resources in Pakistan’s exclusive economic zone (hereinafter EEZ) and fishery protection and, on the other hand, offer to curb the issues of human trafficking, piracy, maritime terrorism and other cyber-related crimes around the Indian Ocean.

The latest progress and a key landmark of this bilateral arrangement (CPEC) is the construction of a Chinese-built deepwater port at Gwadar on the Arabian Sea, which is situated at an ideal geographical location near to the Iranian border. The six vessels as mentioned earlier will greatly assist Pakistani Navy and prove as a “force multiplier” to safeguard the maritime frontiers of Pakistan. China’s growing interests in the Gwadar Port is obvious and justified as it links China to the Arabian Sea and the Middle East resulting in many benefits to the trade and energy requirements of China. The situation above is a contemporary instance of China–Pakistan maritime security collaboration. There are many latest maritime-related projects launched in Pakistan which are building up Pakistan’s maritime capacity. Some of these are recently completed, and many are still in progress.

3.1 Recently completed maritime projects by Pakistan Navy

Various maritime projects of Pakistan Navy have been recently completed and are functioning in their full capacity to secure and safeguard the maritime zone of the country. These projects include:
- 32 Tons Bollard Pull Tug: 34 m of total length with a displacement of 481 tons, having a top speed of 12 knots and bollard pull of 32 tons;
- F22P Frigate (Zulfiqar Class Frigate): the frigate transmits Harbin Z-9 helicopter, armed with a 76 mm gun, 30 mm Type 730B close-in weapons systems, FM-90N surface-to-air missiles, C-802 surface-to-surface missiles, ET-52C torpedoes and RDC-32 anti-submarine rockets;
- 10 Tons Bollard Pull Tug: 16.89 m in length and a displacement of 55 ton, divided into five watertight compartments, a modern twin screw tug for inland water, harbour and coastal facilities;
- Fast Attack Craft (Missile) – FAC (M): 63 m in length, having a range of 1,000 nautical miles, with a maximum speed of 30 knots. A 560-ton fast attack craft features surface-to-surface missiles;
- Dredge Tender: 19.11 m in length, 8.46 m in breadth and 2.75 m in depth with a displacement capability of 125 tons with draught aft of 1.7 m;
- Small Tanker cum Utility Ship (STUS): a robust, thick design to administrate several roles, including the transfer of workforces to and from coastal ports, which can also perform as an attendant vessel throughout diving operations, towed array transportation, mine laying, mine recovery and torpedo recovery;
- Harbour Utility Vessels: harbour and ocean-going tugs as well as utility vessels in several configurations built to meet the specific needs and requirements;
- Multi-Purpose Auxiliary Craft – Missile (MPAC): constructed with a speed of 32 knots, having a maximum displacement of 250 tons, fitted with state-of-the-art anti-ship missile system;
- Coastal Oil Tanker: an 885 TDW coastal tanker (fuel, water and dry cargo);
- Floating Dock: offers many benefits comprising onboard repair workshops and cranes, with lifting capacity ranging from 1,000 to 5,000 tons.
- Midget Submarines: a very useful submarine having several purposes such as attacking enemy units in the harbour with frogmen/chariots, at sea with torpedoes, at shore installations by commandos, mine laying, a defensive barrier in shallow waters, advance pickets’ duties, intelligence gathering, etc.;
- Multipurpose Barge: 30 m in length, furnished with pumps, ventilation system, fire pumps, generator and oily water separators. It is being used to collect compensated water from submarine fuel tanks and remove fuel contents to avoid pollution in the harbour, diesel storage and supply and assist in harbour pollution control; and
- Split Hopper Barges: intended to arrange with cutter suction dredgers. (KS&EW, 2019a, 2019b)

3.2 Series of major ongoing projects

There are some major projects still ongoing underneath of Pakistan Navy, which are very important to ensure the maritime security of oceanic borders. Some of the key ongoing projects are mentioned hereunder:

- **17,000 Tons Fleet Tanker**: The construction of Pakistan Navy Fleet Tanker (PNFT) is propelled by two diesel controlled engines with manageable pitch propeller and can reach a maximum speed of 20 knots at full load, the ship is of double hull
configuration equipped with 4x DGs for electrical power generation with general length of 158.4 m and maximum width of 22.0 m, the ship has scantling displacement of over 17,000 tons. PNFT is the largest ship which is going to be built in the country to date.

- **Fast Attack Craft (Missile):** A state of the art, multi-mission corvette, 63 m long and having a breadth of 8.8 m. The design draught of the ship is 2.46 m having a displacement of 560 tons with a top speed of 30 knots ranging 1,000 nautical miles. It is an enhanced form of vessels than the previous vessels which can transport an indigenous weapon system. The ship is being constructed underneath the Chinese Classification Society Rules.

- **Maritime Patrol Vessels:** Two Maritime Patrol Vessels (MPVs) are also underway to be constructed for PMSA, which are 600 and 1,500 tons of displacements. The 600 tons MPV is having a length of 68 m and a determined breath of 8.7 m. with a maximum speed of 27 Knots was propelled on 5 December 2017 and it will be brought until April 2018. Whereas the 1,500 tons MPV is 95 m long, having a determined breath of 11m. with the highest speed of 26 knots, scheduled to be constructed before February 2019. It will have the aptitude to function autonomously as well as a part of a combined force in coastal and deep-sea zones. MPVs will be used for many roles comprising patrolling and policing operations against asymmetric threats, pollution control, surveillance of EEZ, disaster relief, intelligence gathering and maritime security operations.

- **32 Tons Bollard Pull Tugs:** A 34 m of general length having a displacement of 481 tons with a top speed of 12 knots, Bollard Pull of 32 tons and fitted with an identically robust fandering preparation.

- **Bridge Erection Boats:** A 22x Boats Bridge Erection, prepared with Aluminium Alloy, driven by Cummins Marine Diesel Engine of 205 HP, capable of impulsing it at a maximum speed of 13 knots. This 5.85-m-long boat has a vigorous design to endure fast river currents. (KS&EW, 2019a, 2019b).

4. Gwadar Port development project and China’s commitments
Owing to its proximity to the Strait of Hormuz, Gwadar will turn into a trade hub and key shipping point to connect China, Pakistan, Afghanistan and the other Central Asian states once connected with air, rail and roadways alongside a shortest available route. It will also then serve as an energy corridor between these states. Eventually, these developments will bring much employment opportunities and create significant revenue sources to the national economy, particularly for the local people (Khan, 2017). China Overseas Port Holdings Limited took charge of the Gwadar Port in 2003 (The Express Tribune, 2013). China’s interest in Gwadar Port is significant owing to various reasons such as to meet its energy demands more efficiently, addressing the economic issues in western China and its overall unprecedented economic growth. Also, China is planning to build an oil refinery at Gwadar coupled with a long pipeline from Gwadar to Xinjiang for transporting oil from Africa and the Persian Gulf (The News, 2018).

4.1 Military perspectives of Gwadar Port
As Gwadar will open China to the Arabian Sea as well as the Indian Ocean, therefore, it will strategically serve China with numerous military benefits such as monitoring eastern rival Indian nautical operations in the region (Azeemi, 2007). Its geo-strategic location could assist
in monitoring electronic surveillance of the naval operations in the Indian Ocean as well as the Arabian Sea, which will further provide a crucial Maritime base remote from Indian frontiers to Pakistan. On the other hand, China will create a maritime encirclement by engaging with other nearby ports such as Chittagong in Bangladesh, Hambantota in Sri Lanka and Sittwe in Myanmar (Kalim, 2016).

China is upgrading Gwadar Port and will allow heavy ship-docking together with deadweight size, e.g. 70,000. To this end, around 80 per cent of soft loans as well as grants are provided for the development of Gwadar Port and other nearby areas. It is an important fact that the US Navy executes security in the Strait of Malacca and stretches coastal areas of Indonesia and Malaysia (Song, 2007). So, China’s existence in the region may work as a matter of political pressure and military strength to balance any possible maritime conflict in the future.

4.2 Development projects in Gwadar and their progress
CPEC project can also be regarded as another significant extension to the Chinese BRI and the game changer in this region. However, the success of CPEC is mainly based upon the development and successful running of the Gwadar Port, which is a mix-up of Chinese Government Concessional Loans and Grants as well as loans from the domestic financiers. The details of numerous projects at Gwadar with their updated progress are mentioned hereunder (MPDR, 2019) (Table I):

5. Discussion and analysis
5.1 Legal issues on China–Pakistan Economic Corridor, Chinese Silk Road Economic Belt and 21st Century Maritime Silk Road vision
The 21st Century MSR is adjunct to the Chinese SREB programme following up the BRI. Later on 28 March 2015, China’s National Development and Reform Commission issued an action plan for the BRI, in collaboration with China’s Commerce Ministry and Foreign Ministry that indicated Chinese concerns in the Indian Ocean connecting the Persian Gulf with the Mediterranean Sea through Central and West Asia (NDRC, 2015). However, some fundamental legal questions about international economic law’s perspective rise with this arrangement that deserves to be addressed by or to the stakeholders. This development approach of Chinese vision is envisioned as a new model of global cooperation and universal governance. Therefore, the nature of this additional development model demands some analysis (IAB&R, 2016). Secondly, the governing principles of the BRI, as well as CPEC, are the point of significance that serve to shed more light on the nature of the Chinese Vision. Thirdly, to formulate and accord the overall regulations of the project with national and international laws. Finally, the legal nature of the underlying apparatus within which CPEC is framed is important to notify the legitimate privileges and responsibilities of the concerned parties.

5.2 National and international law issues
Article 14 of the 1969 Vienna Convention on the Law of Treaties states that any agreement governed by international law between the countries those intend to commit themselves qualifies as an enforceable treaty when it is expressed in writing (Vienna Convention on the Law of Treaties, Article 14). It means memorandums of understating signed between China and Pakistan, for the sake of arguments, are supposed to be enforceable agreements under the definition of the Vienna Convention. Furthermore, it also needs to be incorporated by the domestic legal system through national legislation.
<table>
<thead>
<tr>
<th>Name of the project</th>
<th>Estimated cost (US$ in millions)</th>
<th>Project progress update</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gwadar East-Bay Expressway</td>
<td>140.60</td>
<td>Minutes under the Economic Affairs Division (EAD) with the Ministry of Foreign Trade and Commerce (hereinafter MOFCOM) have been signed</td>
</tr>
<tr>
<td>New Gwadar International Airport</td>
<td>230.00</td>
<td>Minutes of EAD-MOFCOM have been signed, The Chinese side has also proceeded with the grant request</td>
</tr>
<tr>
<td>Construction of Breakwaters</td>
<td>123</td>
<td>The Chinese company named China Overseas Port Holding Company Limited (hereinafter COPHCL) has provided the draft business plan Under review by Gwadar Port Authority (hereinafter GPA) and Ministry of Ports and Shipping (MoP and S), Government of Pakistan</td>
</tr>
<tr>
<td>Dredging of berthing areas and channels</td>
<td>27</td>
<td>COPHCL has provided the draft business plan</td>
</tr>
<tr>
<td>Development of Free Zone</td>
<td>32</td>
<td>Under review by GPA and MoP and S, Finance Bill 2016 notification included the tax exemptions for port and Free Zone Groundbreaking has been done by the prime minister of Pakistan</td>
</tr>
<tr>
<td>Necessary facilities regarding fresh water treatment, water supply and distribution</td>
<td>130.00</td>
<td>The investment inside the free zone is 100% private and to be operated by COPHCL, Signiﬁcant progress has attracted and responded to a large number of investors, Gwadar Free Zone investment guideline is published to assist all the stakeholders</td>
</tr>
<tr>
<td>Pak–China Friendship Hospital</td>
<td>100</td>
<td>Legal assistance may be sought keeping in view the aforementioned ofﬁcial documents Grant request sent by EAD to MOFCOM</td>
</tr>
<tr>
<td>Technical and Vocational Institute at Gwadar</td>
<td>10.00</td>
<td>A visit by a Chinese technical team expected soon to conduct a feasibility study MoU in this regard is also likely to be signed soon MoU was signed in November 2015 Letter of Exchange was signed in August 2016</td>
</tr>
<tr>
<td>Gwadar Smart Port City Master Plan</td>
<td>4</td>
<td>EAD has provided the name of one consultant in this regard. The case has been processed on the fast track, making sure its completion before/within 12 months positively</td>
</tr>
<tr>
<td>Bao Steel Park, petrochemicals, stainless steel and other industries in Gwadar</td>
<td></td>
<td>The essential approval procedure would be completed at the earliest for inclusion as new CPEC project under Gwadar – Joint Working Group</td>
</tr>
<tr>
<td>Development of Gwadar University under Social Sector Development Program</td>
<td></td>
<td>A leading Chinese university will be identiﬁed by the Chinese side for collaboration with the University of Gwadar on marine and maritime-related subjects, along with other disciplines</td>
</tr>
<tr>
<td>Upgradation and development of ﬁshing, boat making and maintenance services to protect and promote livelihoods of the local population</td>
<td></td>
<td>Effective measures would be taken by COPHCL for social sector development in Gwadar</td>
</tr>
</tbody>
</table>

Source: www.cpec.gov.pk/gwader; last visited on 28 November 2018

Table I. Gwadar Port and city development projects under CPEC
Pakistan has signed around 50 bilateral investment agreements with China, Japan, South Korea and some European as well as other states of the world (Investment Policy Hub, 2019). Apart from this, Pakistan has countersigned Pakistan–USA Trade and Investment Framework Agreement (2003), EC-Cooperation Agreement (2004) and the China–Pakistan Free Trade Agreement (FTA 2007) (IPH-Pakistan, 2019). The agreements with the USA and EC do not comprise enough to be regarded legally significant whereas, the China–Pakistan FTA is relatively an elaborative FTA which also include rules about international investment as a complete chapter (IAB&R, 2016).

The normative regimes that CPEC and its execution comprise various soft and hard nature of disciplines. The primary disciplines include: Pakistani major law and its Constitution, the MoUs signed between China and Pakistan along with different organs of the Chinese and Pakistani states, bilateral investment agreements signed between Pakistan and third states as well as between China and Pakistan, WTO Agreements, international environmental law, IMF disciplines that also includes any conditions under Pakistan’s IMF Extended Fund Facility, international law on territories and the law governing the investment arrangements between Pakistan and Chinese investors (Shapiee and Idrees, 2017). In the case of national laws, an obvious point to be noted is that the implementation of CPEC project necessitates conforming numerous pertinent domestic laws of Pakistan, for instance, the Pakistan Environmental Protection Act, 1997.

5.3 Security challenges: regional and internal
Regional and internal security is one of the biggest challenges to CPEC (Small, 2015). In spite of various military operations, Pakistan is still facing some security constraints in certain areas such as militants and extremist groups target government officials, religious or ethnic minority groups, security forces, gas pipelines and power pylons and in some cases, Chinese workers and engineers have been kidnapped and killed, which has caused significant economic as well as human damage to the country (Shah, 2013; Syed et al., 2016; Arifeen, 2017).

The security agencies in Pakistan have taken pertinent measures and rendered a great job to ensure the better security conditions in these areas. To this end, a Special Security Division including 12,000 troops has been established by the Pakistan Army to safeguard and look after the security issues in CPEC projects (Gishkori, 2015; Khan, 2016b). The various military operations have significantly brought down the violence in Pakistan (Human Rights Watch, 2018). Also, Chinese and Pakistan’s Navy ships will jointly protect and safeguard the maritime corridor. The Pakistan Navy has launched a special task force “TF-88” in December 2016, which makes sure the security measures for maritime trade; China will provide four ships to PMSA for this purpose (Gady, 2017).

5.4 Political concerns in China–Pakistan Economic Corridor routes
There are some political challenges over CPEC projects concerning the competing demands and claims by the provinces of Pakistan (Ramay, 2016). According to a study by Zhaoli (2013), security concerns are linked with political bias, which may lead to change any route within Pakistan. In 2015, the Chinese Government showed their concerns to the political parties in Pakistan as well as Pakistan Army to bringing various stakeholders at one page over this project (Lain and Pantucci, 2016). A former official from China’s Foreign Ministry, Victor Gao has observed uncertainty concerning the claim over the ownership of this mega project by either the government or the military (Bokhari et al., 2016). There is no doubt that the Pakistan Army is the guarantor for the security of CPEC routes due to its extraordinary diplomatic interdependency with Chinese officials (Wolf, 2016).
In addition to local or regional politics, some international political norms are also involved and need to be addressed through this venture such as the collection of hydrographic intelligence in foreign EEZs (Rehman, 2017). Some Chinese legal experts stated that US intelligence is violating the “peaceful purpose cause” clause of the United Nations Convention on the Law of the Sea (UNCLOS) and conducting illegal operations in foreign EEZs (Dutton, 2010). Although, maritime rivalries in the Indian Ocean may be a premature signal for the great competition or power politics at the international level (Sweijs et al., 2010). However, PLAN along with PMSA will have to consider these provisions while conducting various operations concerning maritime security and intelligence gathering in the Arabian Sea or the Indian Ocean through Gwadar Port in the future (Mizokami, 2016; Gupta, 2016).

5.5 Disputes concerning exclusive economic zones

China has dispute particularly with the USA concerning the right to regulate foreign military operations within EEZs under the arena of international law. To this end, the USA’s position is that UNCLOS establishes and gives a right to the coastal states to regulate economic activities, e.g. oil exploration and fishing, as part of their EEZs but not to constrain foreign military operations within EEZs (Marex, 2014). Whereas, China’s and some other state’s stances is that UNCLOS interprets the rights including economic activities as well as foreign military operations in their EEZs at the same time (Geng, 2012).

Some observed numbers have been provided in a research that highlights the number of coastal states taking position to exercise right for economic as well as foreign military activities in EEZ under UNCLOS; 18 coastal states seek to regulate activities by foreign military in their EEZs, and three states, including North Korea, Peru and China, have regulated foreign military operations in EEZs (O’Rourke, 2018). Keeping in view the scenario, it is important to consider and address how China will conduct and actively participate in maritime operations under CPEC and avoid any EEZ-related dispute in future.

5.6 Pakistan Maritime Security Agency and China–Pakistan Economic Corridor: ensuring maritime security

Since launching the BRI, the protection of Pakistan’s maritime zones has become a major priority for both China and Pakistan (Saleem, 2017). CPEC is regarded as the flagship venture of BRI, and both states are functioning amicably to guarantee its smooth execution. The PMSA was established in 1987 under the provisions of 1982 UNCLOS (UNCLOS, 1998) to protect its maritime interests. The major tasks assigned to the agency under PMSA Act 1994 include to: assist as well as coordinate in Search and Rescue of the vessels, secure property and lives in distress at sea, implement national as well as international laws including agreements and conventions in the maritime zones, provide required help and cooperate with other departments and agencies at sea to perform their duties and functions, protect the fishing vessels and crew against any possible threat within the maritime zones, execute such other operations as may be assigned by the government to protect the maritime interests of the country. (PMSA, 2019)

China, under an agreement signed in 2015, has already supplied Pakistan with a third 600-ton maritime patrol ship. Pakistan’s Ministry of Defence Production (MoDP) signed an agreement with China Shipbuilding and Trading Company, which included construction of four 600 tons and two 1,500 tons patrol ships for the PMSA. These ships
have been attained to improve PMSA’s capacity to safeguard Pakistan’s maritime resources in its EEZ and to carry out operations against drug trafficking and illegal immigration under the international maritime law (Haider, 2015). The collaboration between both states on the developments of these ships witnesses their mutual strategic interests reflecting long-term benefits. Consequently, Pakistan’s capabilities to safeguard its maritime security and economic interests are significantly bolstered with China’s helping hand to PMSA that would also support for accelerating Chinese determinations in the region.

5.7 Pakistan Maritime Security Agency–People’s Liberation Army Navy cooperation in maritime security

Gwadar stands as a hub of CPEC projects. Therefore, Seaward and Sea lanes security are of much significance. The history of this area is replete with some illegal incidents concerning maritime terrorism, piracy, gun running and drug trafficking, which increase the economic risks and threats to seafarers at the same time (Azmie, 2017). It demands teamwork in the area of maritime security of the region. For this purpose, Pakistan Navy has been actively participating in maritime operations with the collaboration of international navies, e.g. the Annual International Maritime Conference, the AMAN series of biennial multinational naval exercises, the Joint Maritime Information Coordination Centre and institutionalisation of Coastal Command are some examples (Wilk, 2014). However, the proposed future scenario of increased commercial activities in this region will demand additional measures. To this end, Pakistan Navy, PMSA and PLAN are working on the joint venture in this regard.

The Chinese naval support to Pakistan Navy has been significantly increased in the recent years. PLAN and Pakistan Navy along with PMSA have endorsed to enhance the scope of bilateral cooperation in the dominion of maritime security such as exercises, joint shipbuilding projects, port calls, maritime security dialogues, training visits or courses, agreement regarding Yuan-class submarines, Azmat and Jalalat class fast attack craft (missile) and construction of the F-22P frigate for the Pakistan Navy (The Dawn, 2016a). Pakistan Navy became the first foreign navy which has conducted a naval exercise with PLAN in 2003. In 2007, PLAN also participated in AMAN Exercise Maritime Operation with Pakistan Navy; PLAN’s first participation in a transnational maritime operation (Kaufman, 2009). The concept of joint ventures would offer the basis of maritime cooperation in the Indian Ocean concerning maritime safety and security for the shared interests of the regional stakeholders (Saeed, 2016).

5.8 Chinese naval interests in the Indian Ocean

China’s naval interests together with maritime trade are growing across the Indian Ocean, which also indicates to establish a naval presence at various ports in the Indian Ocean including an increased number of maritime security cooperation in Indo-pacific region. All these facts may make China a resident power in the Indian Ocean in future (Palgrave Studies, 2018). Chinese companies have been engaging in the expansion, construction and operation of various commercial port facilities in the region since the turn of this century, which include Gwadar (Pakistan), Bagamoyo (Tanzania), Lamu (Kenya), Kyaukpyu (Myanmar) and Colombo and Hambantota (Sri Lanka) (Suri, 2017). Besides, Chinese state-owned companies have acquired key stakes in the ports of Djibouti, Hambantota, Suez, Lome, Chittagong, Piraeus, Zeebrugge, Antwerp, Kyaukpyu, Karachi, Colombo, Gwadar, Karachi, Colombo and Singapore (The New Masters and Commanders, 2013). The extensive naval acquisition of Chinese Navy around the Indian Ocean
Ocean will strengthen its maritime security scope and also make China one of the key players in the maritime domain of the Indian Ocean. Eventually, China might come up with a regional power having a strong grip over four sides of the Oceanic sphere in the region.

5.9 China’s second overseas naval base
Chinese strategic designs regarding Baluchistan have lately been in the news, and it was reported that China was eyeing the nearby “Jiwani” port as a military base (located between Gwadar and Chabahar port in Iran) and had been in secret talks with Baloch separatists for stabilising the region (Gupta, 2018). According to a report by Marex in early 2018, PLAN is going to set up a second Chinese overseas naval base after Djibouti, around the Chinese-built Gwadar Port of Pakistan (Marex, 2018). Retired US Army Col. Lawrence Sellin has also endorsed the news that Chinese officials are in negotiations to build a naval base at a small fishing port of “Jiwani” on a peninsula west of Gwadar (Chan, 2018). Another academic evidence for this initiative may be a research study conducted by Roshan Khanijo, in which he stated that acquisition of Gwadar Port by China might also be regarded as to construct a base facility at “Jiwani” (Khanijo, 2018). In addition to its own naval bases, building another foreign naval base at Jiwani will have a significant impact on the sphere of maritime security of this region. This Sino–Pak maritime security collaboration will not only serve China with international energy sources at the next door but also strengthen its naval capacity more strategically.

6. Conclusion
Maritime security collaboration between China and Pakistan is important not only for regional peace and political stability but even beyond. Given these objectives, China’s intention of building a partnership through the “China Pakistan Economic Corridor” demonstrates achieving its larger goal of securing its foothold in maritime and economic growth at large. To this end, building ports and coastal facilities is an important step forward to extend China’s maritime approach across the Indian Ocean via the Suez Canal, into the Mediterranean basin. The core objectives include securing its sea lanes of communications, which carry almost 90 per cent of trade and energy supplies for China. More importantly, a secured maritime position will not only result in strong regional power and a prosperous economy but also strengthen Chinese naval military motivations in the region coupled with increased territorial coverage opening it to the Arabian Sea as well as the Indian Ocean.

The capacity enhancement of PMSA is pertinent to secure the area of Gwadar owing to enhanced responsibilities under CPEC project. The Pakistan Navy and PMSA have already established a comprehensive apparatus to ensure the security of the Gwadar Port and surrounding sea areas. Pakistan’s collaboration with China on the developments of these projects serves as a testimony of combined strategic interests of both states. One thing is quite obvious that the success of CPEC and the Gwadar Port project is linked to a safe and secure maritime environment in the Indian Ocean region and the Arabian Sea, which merits PLAN–PMSA cooperation to understand and encounter the foremost maritime security challenges with due care to get the maximum out of this long-lasting economic as well as a diplomatic initiative to capture the regional powers in hands.
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