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DEVELOPING SHORT SEA SHIPPING TRANSPORTATION CHAINS AT HELSINKI-TALLINN ROUTE

Master´s thesis

Supervisor: Professor Olli-Pekka Hilmola

ABSTRACT

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Master´s Thesis. Lappeenranta University of Technology School of Business and Management Global Management of Innovation and Technology 114 pages, 21 figures, 20 tables and 6 appendices **1st Supervisor:** Olli-Pekka Hilmola
Keywords: CONRO ships, emissions, Helsinki-Tallinn route, short sea shipping, shipping cost, utilization.
Short sea shipping is an important part of the European economy and an alternative to road transport of goods in Europe. It represents an intermodal transport combination of sea and land on a Door-to-Door basis, and it aims to develop more sustainable transport network with the least negative impacts by the transport modes. This Master's thesis addresses the development of short sea shipping transportation chains at Helsinki-Tallinn route. The Master´s thesis explores the development of short sea shipping at Helsinki-Tallinn route by analyzing the shipping costs per unit transported by different ship types and sizes between port of Helsinki-Vuosaari harbour and port of Tallinn-Muuga harbour, and examining the possibility of Ro-Ro traffic as well. The study is qualitative-quantitative method and it is based on a case study, data is collected from secondary and primary sources, and mixed methods analysis is used to implement the interviews and observations results with the databases analysis. In the thesis factors affecting on short sea shipping are explored and analyzed, also the possibility of Ro-Ro shipping is examined, by comparing the shipping cost and the environmental impact of different ships like container ships, Ropax, and CONRO ships. The finding of this research shows the importance of time at port and utilization as a shipping cost determinants, the relationship between ship type and costing, and the possibility of Ro-Ro shipping.

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Lappeenranta, February 2015

Ahmad Alkhatib

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CONRO	container and rolling on-rolling off ship
DSS	deep sea shipping
FEU	forty-foot equivalent unit
IMO	International Maritime Organization
LOLO	lift on-lift off
M/S	motor ship
MOS	motorways of the sea
RORO	roll on-roll off
SSS	short sea shipping
TEN-T	trans-European transport networks
TEU	twenty-foot equivalent unit

1. INTRODUCTION

This chapter consists from 3 subchapters, background of the research is presented in the first part, meanwhile, the research gap, objectives and research questions are introduced in the part two, and in the last subchapter an overview of the research is presented.

1.1. Background of the research

In the white paper on “The Future Development of the Common Transport Policy” of December 1992, the European commission defined future priorities based on the need to harmonize the demand for mobility with the environmental requirements, in line with the principle of sustainable mobility. Additionally, the communication examines the potential of short sea shipping (henceforth SSS) to the achievement of sustainable mobility, by shifting the cargo from land modes to the sea. This shifting of cargo is for environmental and economic reasons, and also a policy choice. Moreover, the European parliament and the council of the European Union established and develop the Trans-European Transport Networks (TEN-T) to organize the road, rail, air and water transport in Europe (European Commission, 1993).

Following, in the white paper of September 2001, the commission suggested the development of the Motorways of the Sea (MoS) as a dominated competitive alternative to land transport, and these MoS should be part of (TEN-T). The goals of MoS concept as explained in article 12a of (TEN-T) are; increasing cohesion, reducing road congestion through modal shift, and freight flow concentration on sea-based logistical routes (European Commission, 2001).

Among other MoS routes, there is the Helsinki-Tallinn route, which is among the MoS of the Baltic Sea, and currently, there is a running project between ports of Tallinn and Helsinki under the name TWIN-PORT (project code: 2012-EU-21011-P**)** with TEN-T funding, and administered and managed by Port of Tallinn (European Commission, 2012). The idea in the project is to develop a Roll on-Roll off (RORO) shipping further and more efficient between these capitals. Currently, competition between sea ports within Estonian general cargo traffic is made between sea port of Helsinki and Hanko, although Helsinki is clearly dominant player and leader. According to the Eurostat (2012) the total transported goods in Helsinki was 10.832 million tonnes and only 3.234 in Hanko. SSS will grow in its importance within near future, mostly due to sulphur regulation change (in 2015), also due to planned nitrogen directive (earliest to be implemented in 2016, but was very recently postponed). Challenge in SSS operations, and particularly between Helsinki and Tallinn, is that it is implemented nearly solely with trucks and semi-trailers, but these are not optimal or cost efficient for longer distance movement from Tallinn onwards to Central Europe by railways.

Another innovative solution for SSS route of Helsinki-Tallinn route is the use of a ship that can meet both trailer and container segments (CONRO). In these ships trucks with semi-trailers are placed inside the vessel and containers in turn on deck (e.g. with lift-on lift-off, LOLO). Strength of this concept is the versatile combination of different freight types to one ship, but as weakness this ship requires significant amount of ballast water to keep the balance (Dunn, 2012). CONRO concept would sound like a reasonable alternative for Helsinki-Tallinn route, if fuel consumption is lower than before and loading as well as unloading could be done in flexible fashion. As hindering factor for this extremely short distance shipping route is the relative expensive cost for loading and unloading.

1.2. Research gap, objectives, research questions and delimitations

Among other conventions issued by the International Maritime Organization (IMO), there is the International Convention for the Prevention of Pollution from Ships (MARPOL), for the prevention of pollution of the marine environment by ships from operational or accidental causes. In this convention, a new limitation (regulation 14) for the sulphur oxide emissions from ship exhausts entered into force starting from 1st of January 2015 (IMO, 2014), which will consequently increase the bunker fuel prices, and as a result the shipping costs as well.

Helsinki-Tallinn sea route is among the routes that adopted the new emission regulations, and due to the shortage of researches on the effects of the new changes, the need for such researches was created. So, this research studies the development of SSS on Helsinki-

Tallinn route from cost perspective, taking into consideration the rise in bunker fuel prices, which is not well documented yet in the literature. Additionally, this research is part of the sixth and last activity in the TWIN-PORT project, which consists from six activities started in January 2012 to December 2015. The last activity in this project studies the Ro-Ro traffic scenarios for Helsinki-Tallinn route (Port of Tallinn, 2014a), and this research is one of the first researches investigating the possibility of Ro-Ro traffic between these two capitals.

The objective of the research is to develop SSS transportation chains at Helsinki-Tallinn route, by analysing the competitiveness of cargo transportation between port of Helsinki - Vuosaari Harbour and port of Tallinn - Muuga Harbour. The competitiveness of cargo transportation is analysed from shipping cost perspective, and the possibility of developing RoRo traffic at the route.

The research is carried out by presenting the current literature and analyze the data collected from databases (secondary data) and interviews (primary data). Thus, to achieve the objective of this study, the following research questions are elaborated:

1. *What are the main factors affecting on short sea shipping costs?*
2. *How to improve the cost per unit transported in short sea shipping?*
3. *What is the optimum ship type suitable for the development of Helsinki-Tallinn route?*
4. *What is the optimum ship size for the development of Helsinki-Tallinn route?*

The research questions, goals of the questions, and methods and data used for getting the answers to the research questions are presented in Table 1.

Table 1 Research questions, goals, and method and data

Research questions	Research goal	Method and Data used
1. What are the main factors affecting on short sea shipping costs?	Determining the main factors affecting on short sea shipping costs	Desk research; academic literature, secondary and primary data
2. How to improve the cost per unit transported in short sea shipping?	Suggesting methods for improving the cost per unit transported	Desk research, case study, interview; academic literature and secondary data
3. What is the optimum ship type suitable for the development of Helsinki-Tallinn route?	Finding the optimum ship type suitable for the development Helsinki-Tallinn route	Desk research, case study, interview; secondary and primary data
4. What is the optimum ship size for the development of Helsinki-Tallinn route?	Finding the optimum ship size suitable for the development Helsinki-Tallinn route	Desk research, case study, interview; academic literature and secondary data

The delimitations of this research can be summarized as following: Firstly, the geographical focus on Helsinki-Tallinn sea route case, and specifically between Vuosaari and Muuga harbours. Secondly, the analysis will be focused on the shipping costs.

1.3. Overview of the research

The research consists from the following main parts: introduction, literature review, data collection and methodology, data analysis, results, discussion and conclusions. These parts are distributed in 10 chapters as following (Figure 1): The introduction is represented in chapter one, where it discusses the research background, objective of the research and an overview of the research. Then, chapter 2 describes the data collection and methodology. Meanwhile the literature review is retrieved in chapters 3, 4, and 5. Starting by chapter 3 which discusses the intermodality, then chapter 4 discusses the short sea shipping, and the shipping cost in chapter 5. The reasons behind conducting this literature review in this manner are: Increase the breadth of knowledge, identify seminal work and help in analyzing and interpret the result of the research (Gabbott, 2004). Following, chapter 6 provides information about the research environment, then data analysis is illustrated in chapter 7. Meanwhile, the results are expressed in chapter 8, while chapter 9 is devoted for the discussion, and the conclusions are summarized in chapter 10.

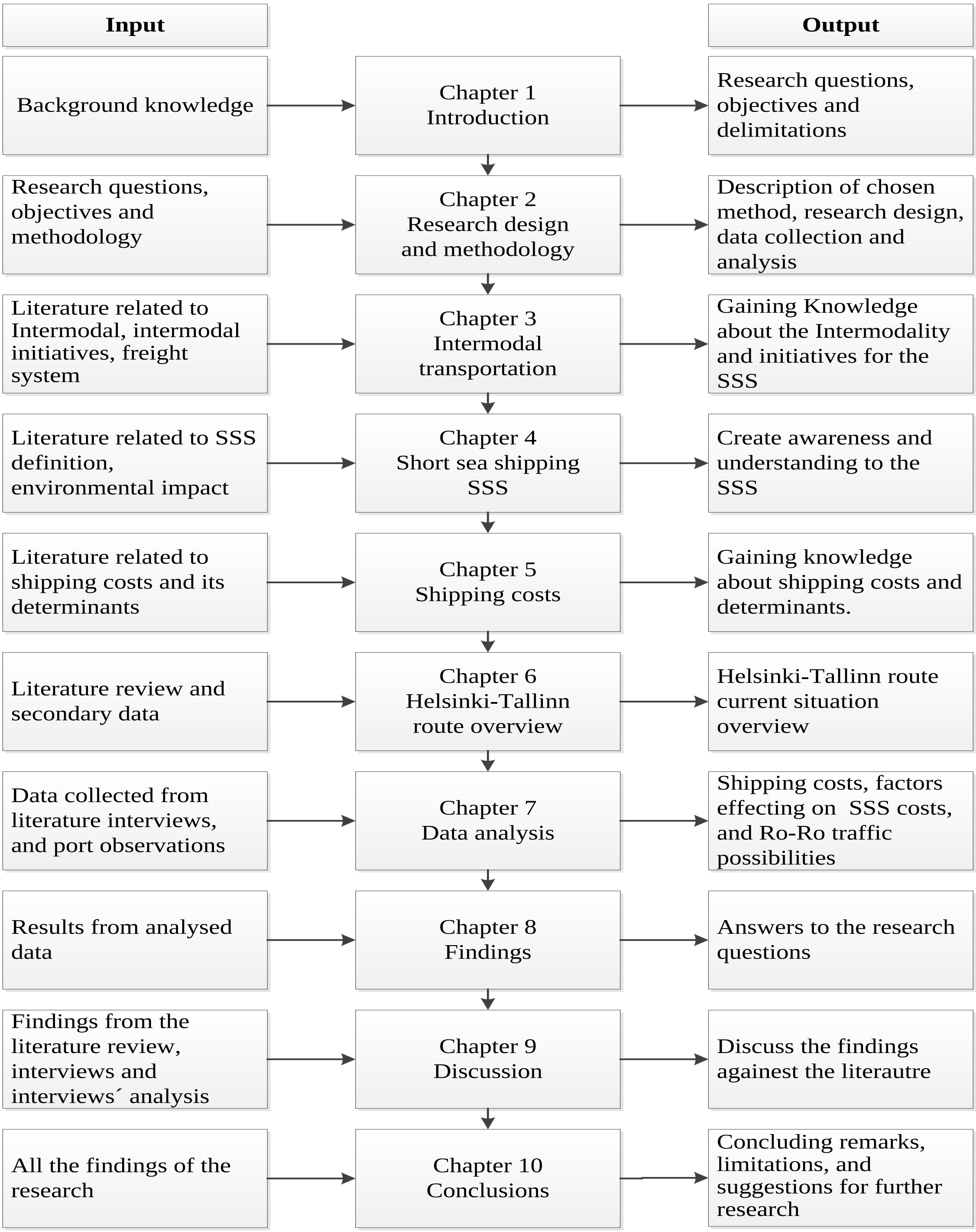

Figure 1 Research structure

2. RESEARCH DESIGN AND METHODOLOGY

"Case studies are the preferred method when 1) "how" or "why" questions are being posed, 2) the investigator has little control over events, and 3) the focus of the study is a contemporary phenomenon within a real-life context." (Yin, 2014, p 2).

The methodology used in this research is a qualitative one, due to the nature of the research -investigating on a case study-, objectives, and the type of research questions. Jonson and Christensen (2012) described the research to be a qualitative one if it is characterized by the following features: Firstly, research objectives aim to obtain insights into a situation, identify related trends, gain rich and complex understanding of the problem. Secondly, consideration of various thoughts and opinions defines subjective nature of the study. Additionally, research questions are qualitative by nature (starting by "what", "how" and "who") and aim to gather the qualitative results requiring collection of textual rather than numerical data. Finally, the results of the research provide specific and narrow information which forms the base for decision making.

However, following the classification of research methods given by Saunders et al. (2009), this research should be identified as quantitative, because it is partly based on analysis of numbers (gathered from databases) and this analysis is conducted by using diagrams and statistics (Saunders et al. 2009). Nevertheless, this master thesis uses mixed methods in order to fulfill the research objectives.

2.1. Research framework

There are many well-known case study researchers (Yin, 2014; Stake, 1994; Miles & Huberman, 1994), all of whom have written extensively about case study research, and have suggested techniques for organizing and conducting the case study research successfully. For the purpose of this research, the framework of Yin (2014) has been chosen (see Figure 2).

Yin suggested that doing a case study research is a linear, but an iterative process as well. Whereas, the design, prepare, collect and analysis phases can be repeated (as a spiral of activities) after each data collected and analysed, and the design will be adjusted accordingly, until the last data has been collected and analysed.

Additionally, Yin (2014) listed five components of of effective case study research design:

- Research questions, the suggested form of questions for a qualitative case study research-in terms of “who,” “what,” “where,” “how,” and “why”-provides an important clue regarding the most relevant research method to be used.
- Propositions or purpose of study, each proposition directs attention to something that should be examined within the scope of study;
- Unit analysis, which refers to the area of focus that a case study analyses;
- Logic that links data to propositions, and this connection is made following the data collection phase as themes emerge;
- Criteria for interpreting findings, interpretation a strategy to identify and address rival explanations for the findings.

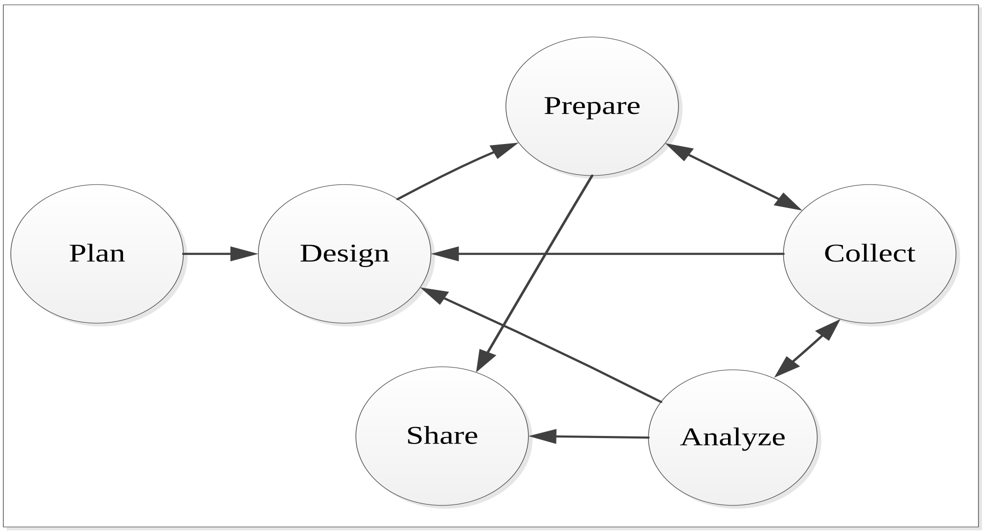

Figure 2 Case study framework (Yin 2014, P2)

2.2. Research design

Yin (2014) emphasized that the research design can be described as a plan that guides the investigator in the process of collecting, analyzing, and interpreting observations. The overall picture of research design is presented in Figure 3, whereas the literature review represent the preparing phase of the research, in which the research questions are formulated and the boundaries of the case study are sat. Following, the data collected via secondary and primary sources will be analyzed separately, and jointly in order to be linked to the objectives of the research, and finally interpreting the findings.

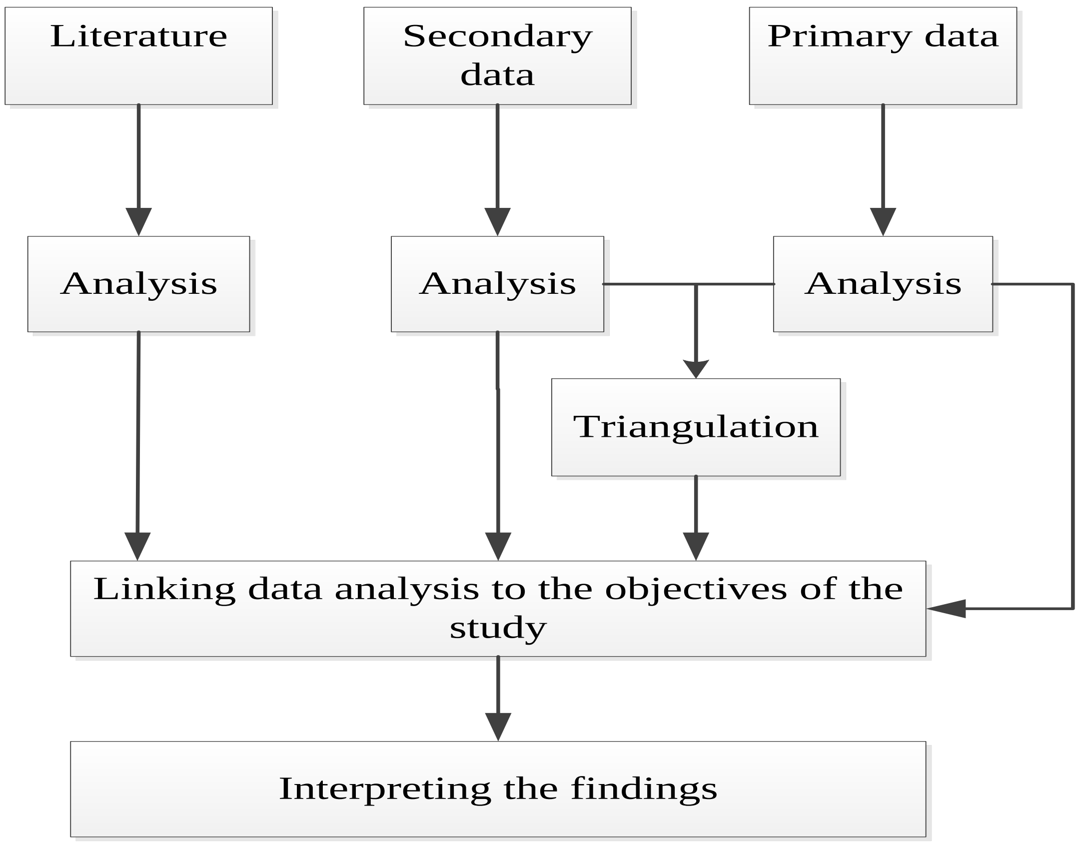

Figure 3 Research design

2.3. Data collection and analysis

In this research the data sources used can be classified into primary and secondary sources. The primary sources consists from interviews and observations, meanwhile the secondary sources consists from publications and databases (see Figure 4).

The purpose of this research is an exploratory research for the case study of development of short sea shipping transportation chains at Helsinki-Tallinn route. According to Robson (2002) the exploratory study tries to find what happened, what is happening, seek new insights, ask questions and assess phenomena in a new light. Furthermore, the main principle ways to conduct an exploratory study are: literature search, interviewing experts and conducting focus group interviews (Saunders et al. 2009). Therefore, due to the research nature, and in order to conduct an exploratory study, the research adapts both inductive and deductive approaches. According to Creswell (2002), the inductive approach emphasis on a number of practical criteria, among others the close understanding of the research context, the collection of qualitative data, a more flexible structure to permit changes of research emphasis as the research progresses, a realization that the researcher is part of the research process and less concern with the need to generalize. The inductive approach can be conducted through collecting data to develop a theory after analysing the results. Meanwhile, the deductive approach begins with theories to be tested against new data. For instance, data related to research questions 1 and 2 will be analysed deductively, meanwhile, for research questions 3 and 4 the data will analysed inductively.

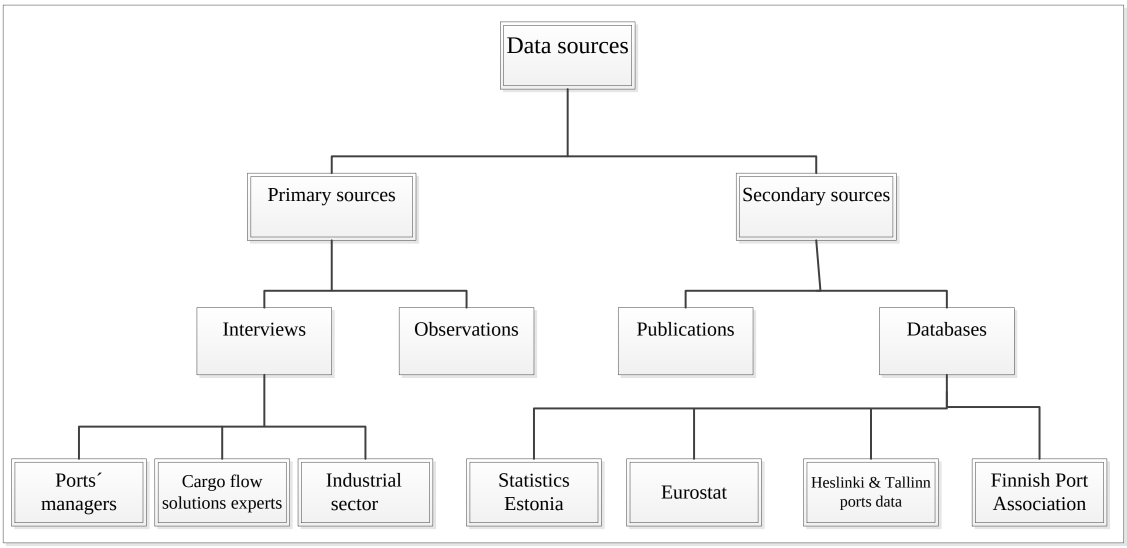

Figure 4 Data sources (Adapted from Saunders et al. 2009, p 69)

2.3.1. Secondary data

The secondary data forms a strong foundation for the whole research and helps in gaining better understanding of the research field developing the context of the problem (Smith & Albaum, 2012). The secondary sources were mainly from publications and databases providing statistical information about the transported volumes via Helsinki-Tallinn route, in addition to general statistics of both ports.

The main statistical databases used in this research are: Statistics Estonia, Eurostat, Finnish Port Association and both Helsinki and Tallinn ports´ data. Additionally, Secondary data sources used for the purposes of this research can be summarized in the following list:

- Ports' web pages (Port of Helsinki and Port of Tallinn);
- Publications (leading transportation journals);
- Reports (Shipping companies´ annual report, European Commissions reports;
- International Maritime organization reports and others);
- State statistics services (Eurostat, statistics Estonia; Finnish Port Association and others);

- Transportation analytical reviews.

2.3.2. Primary data

The interviews and observations (at both ports) represents the sources of the primary data in this research, and a total of 14 interviews (Table 2) were conducted. The listed interviewees represents the stakeholders of the project of development of short sea shipping transportation chains at Helsinki-Tallinn route, which can be categorized into three categories (Figure 5) as following:

- The internal stakeholders, which includes both ports of Helsinki and Tallinn

- Connected stakeholders, which includes shipping companies, and customers using the Helsinki-Tallinn route (Industrial companies using Helsinki-Tallinn route)

- External stakeholders, which includes, cargo flow solutions experts and port operations companies.

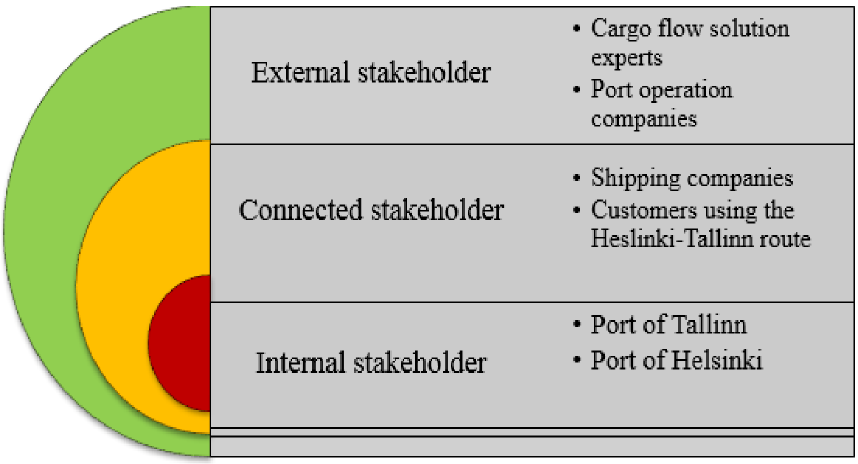

Figure 5 Stakeholders map

Interview

According to the classification of Saunders et al. (2009) for interviews, the interviews conducted in this research can be classified as non-standardized one-to-one type of interviews. Additionally, these one-to-one interviews can be face to face, telephone or Internet and intranet-mediated (electronic) interviews. Moreover, the non-standardized interviews could be either semi-structured interviews, where a list of themes and questions are covered, although these may vary from one interview to another, or unstructured (informative) interviews, which could be used to explore in depth a general area of interest (Saunders et al. 2009). Accordingly, the non-standardized interviews conducted in this research are classified as: Firstly, unstructured interviews with internal stakeholders (ports of Helsinki and Tallinn), and secondly semi-structured interviews with the connected and the external stakeholders.

Additionally, the semi-structured one-to-one interviews with cargo flow solutions expert, where done via personal visits to their work location, except for expert 3, the interview was conducted in an agreed public place, since this particular expert is working as a freelancer. Moreover, all the interviews were recorded and transcribed, then a copy was sent to each correspondent interviewee for approval, to validate the data collected from the interview. A summary of the conducted semi-structured interviews with the cargo flow solutions experts can be seen in Appendix 2.

Meanwhile, the interviews with industrial companies interested in Helsinki-Tallinn route development, were executed via personal visits to company premises, Skype interview and emails. The interviewed companies where chosen for two main reasons: Firstly, the company must be using the Helsinki-Tallinn route for transporting finished/semi-finished products in almost daily bases. Secondly, the possibility of conducting an interview within the time limit of the project. A summary of the conducted interviews with the industrial sector, the semi-structured interviews and a summary of the answers can be seen can in Appendix 3.

Table 2 List of the conducted interviews

Interview	Title	Place	Date	Type	Meeting duration
Shipping company	Managing Director	Turku	17.6.2014	One-to-one	1.5 hours
Estonian Maritime Academy	Dean	Tallinn	1.8.2014	Email	-
Shipping expert	Former crewing manager	Nottingham	6.8.2014	Email	-
Port of Tallinn	CCO	Tallinn	11.8.2014	Email	-
Industrial company 1	Logistics manager	Pärnu	20.8.2014	Email	-
Cargo flow solutions expert 1	Terminal development manager	Turku	20.8.2014	One-to-one	1.50 hours
Industrial company 2	Transportation manager	Finland	27.8.2014	Email	-
Port of Tallinn	Port business manager	Tallinn	17.9.2014	One-to-one	45 min
Port of Tallinn	Port operational Director	Tallinn	17.9.2014	One-to-one	45 min
Industrial company 3	Factory manager	Tallinn	18.9.2014	One-to-one	1 hour
Cargo flow solutions expert 2	Terminal development manager	Helsinki	19.9.2014	One-to-one	1 hour
Industrial company 4	Logistics manager	Tallinn	1.10.2014	Skype	45 min
Port of Vuosaari	Port manager	Helsinki	15.10.2014	One-to-one	1 hour
Cargo flow solutions expert 3	Container operations manager	Kotka	16.10.2014	One-to-one	1 hour

Observation

Observation is an empirical data collection technique, which aims to record actual behavioral patterns of people, objects, and events as they happen in their own context (Zikmund & Babin, 2013). The objective of observation process, which took place in Vuosaari and Muuga harbours, was to observe the loading/unloading equipment, quays, and ramps. The primary goal was to support the suggested development methods for the short sea shipping at Helsinki-Tallinn route and increase the validity and reliability of the research. According to DeWalt & DeWalt (2011) implementation of observations in research process maximizes validity and reliability of research.

During both port visits, the interview was recorded, and a report has been sent to the interviewee, to have his approval on the collected information for the purpose of the validation of the data collected. Additionally, the ports visits were documented with pictures of the loading/unloading equipment, quays and ramps.

2.4. Data triangulation

Triangulation is defined as the combination of methodologies in the study of the same phenomena (Denzin, 1970), and it can be considered as a strategy (test) for improving the validity and reliability of research or evaluation of findings (Mathison, 1988). According to Denzin (1970) Triangulation can be classified into four types: data triangulation, investigator triangulation, theoretical triangulation, and methodological triangulation.

In this research data triangulation was used, and according to Saunders et al. (2009) data triangulation is the use of two or more independent sources of data or data collection methods to corroborate research findings within a study. Table 3 shows the use of primary and secondary data sources with reference to research findings.

Table 3 Data triangulation with reference to research findings

Primary data			**Secondary Data**	**Research findings**
Interviewee/ place	Type	collected data		
Estonian Maritime Academy	Interview (Email)	port of Tallinn dues	Databases and web pages for Port of Tallinn costs	Shipping costs at Helsinki-Tallinn route(RQ1)
Shipping expert		Ship crew size	Salary costs	
Port of Tallinn CCO		Port of Tallinn costs	Databases and web pages for port of Tallinn costs	Improving cost per unit transported (RQ2)
Port of Helsinki manager		Port of Helsinki costs	Data bases and web pages for ports of Helsinki costs and dues	
Industrial companies	Interview (email, Skype and one-to-one)	Lead time Type of preferred freight transportation model	Cargo transportation at Helsinki-Tallinn route	Optimum ship type and size (RQ3) & (RQ)
Port of Helsinki (Vuosaari harbour visit)	Observation	suitability of the port for implementing new modes of SSS transportation	Freight transportation system	
Port of Tallinn (Muuga harbour visit)		suitability of the port for implementing new modes of SSS transportation	Freight transportation system	
Cargo flow experts	Interview (one-to-one)	Suitable Loading/unloading methods Vuosaari and Muuga harbours	Publications for loading/unloading methods	Optimum ship type and size (RQ3) &(RQ4)

2.5. Assessing the quality of the research

Generally, there are four tests used to establish the quality of any empirical social research, and these testes can also be applied on the case study research as well, since case study research is one form of such research. The four tests are: First, the construct validity, which identify the correct operational measures for the concepts being studied. Second, the internal validity, which seeks to establish a causal relationship, whereby certain conditions are believed to lead to other conditions, as distinguished from spurious relationships. Third, the external validity, which defines the domain to which the study´s findings can be generalized. Fourth, the reliability, which demonstrates that the operations of a study can be repeated, with the same results (Yin, 2014). Accordingly, Yin (2014) suggested some tactics to be applied to each quality test, with the phase of the research in which the tactics occurs (see Table 4).

Table 4 Case study tactics for research quality tests

Tests	**Case study tactic**	**Phase of research in which tactic occurs**
Construct validity	Use multiple sources of evidence	Data collection
	Establish chain of evidence	Data collection
	Have key informants review draft case study report	Composition
Internal validity	Do pattern matching	Data analysis
	Do explanation building	Data analysis
	Address rival explanations	Data analysis
	Use logic models	Data analysis
External validity	Use theory in single-case studies	Research design
	Use replication logic in multiple-case studies	Research design
Reliability	Use case study protocol	Data collection
	Develop case study database	Data collection

(Source: Yin, 2014, p 41)

In this research, multiple data source were used, and reporting was done on regular bases to stakeholders of the project (see chapter 7) and to the research supervisor as well. Additionally, rival explanations were addressed and a case study database was developed

3. INTERMODAL TRANSPORTATION

In this chapter, intermodal transportation is discussed as an introduction to SSS. This chapter consist of five subchapters, starting with intermodal definition in subchapter 1, to the Intermodal transport initiatives in Europe in subchapter 2, while subchapter 3 discuss the freight transportation system and loading units. Meanwhile, subchapter 4 introduces the shipping type services, and subchapter 5 gives a brief description for the different modes of transport for the new development.

3.1. Definition

The concept of intermodality has been promoted by the European transport policy and many other national authorities essentially during the last 22 years (European commission 1993). In the beginning of the promotion, the main emphasis was on the development of rail-road transport corridors, in order to alleviate the road infrastructure network, reduce external transport costs and environmental concerns (OECD, 1997), without neglecting the importance of SSS, which was also promoted as another intermodal (sea-road or sea-rail-road) and listed in an action programme and in ongoing projects (European Commission, 1995).

Currently, there are many definitions for the intermodal transportation, and each definition reflects the scope of the research that introduced it. Bontekoning et al. (2004) thinks that the definition should reflect the distinguishing characteristics of intermodal transport and serves as a framework for the whole intermodal research field. Among other definitions, the European Conference of Ministries of Transport (2001) defined the intermodal transportation as the movement of goods in one and the same loading unit or vehicle, which uses successfully two or more modes of transport without handling the goods themselves in changing modes. Meanwhile, Crainic and Kim (2007) stated that, intermodal transportation can be defined generally as "*the transportation of a person or load from its origin to its destination by sequence of at least two transportation modes, the transfer from one mode to the next being performed at international terminal*". From the previous definitions intermodal can be applied for both; people and freight, but the focus in this chapter will be on freight. In addition to the term intermodal, different terminologies appear in the literature over the years like multimodal, co-modal, and recently synchromodal transportation (Steadieseift et al. 2014).

One of the most widely accepted meaning for intermodal freight transportation, is the multimodal freight transportation (Crainic & Kim, 2007), which is defined as the transportation of goods by a sequence of at least two different modes of transportation The goods can be in a unit of container, a swap body, a road/rail vehicle, or a vessel (UNECE, 2009).

3.2. Intermodal transport initiatives in Europe

The focus on improving the competitive position of intermodal transport has always been mainly on the supply side of the intermodal transport market by the financial support to the development of multi-annual framework programmes and to selected research and technology demonstration (RTD) activates and networking that are proposed by the international associations (European Commission, 1997).

Among the most important multi-annual framework programme are: PACT (1997-2001) "Pilot Actions for Combined Transport", which aimed to increase the competitiveness of combined transport by promoting the use of advanced technology in the combined transport sector. TRILOG (1999) "Trilateral Logistics-Europe", which aimed to provide an overall vision on global supply chain management and the role EU can play in terms of policy actions. RECORDIT (2001) "Real Cost Reduction of Door-to-Door intermodal transport" which proposed measures to improve the competitiveness of intermodal freight transport in Europe through the reduction of cost and price barriers, which currently hinder its development, while respecting the principle of sustainable mobility. SULOGTRA (2001) "Supply Chain Management, Logistics and Transport", which has analysed the relationship between supply chain trends and freight transport operations and proposed ways to facilitate supply chain integration at a European level. MARCO POLO I (2003-2006), and MARCO POLO II (2007-2013), which aimed to ease road congestion and its attendant pollution by promoting a switch to greener transport modes for European freight traffic. Lastly, TEN-T (2007-2013), and TEN-T (2014-2020), which aim to close the gaps between Member States' transport networks, remove bottlenecks that still hinder the smooth functioning of the internal market and overcome technical barriers.

Meanwhile, there are few approaches and programmes that examine the modal shift from the demand side, like the programme LOGIQ (2000), which aimed to identify the actors in the decision-making process and has provided information on underlining criteria and constraints in the use of intermodal transport.

3.3. Freight transportation system and loading units

Freight transportation is a key component of the supply chain for ensuring the efficient flow and timely availability of raw materials and finished products (Crainic, 2003). The demand for freight transportation is created between a producers and consumers, and due to the economic globalization, international trade continues to grow rabidly (UNCTAD, 2011) and the geographical separation between the producers and consumers increases as well, which will consequently increase the demand on the freight transportation and more demand for intermodal transportation system. In 2013, about 45.3 % of total transportation in the European countries was transported by road, 36.8 % via sea, 11.0 % via rail and 3.7 % via inland waterways (Eurostat, 2013).

Containers and semi-trailers are widely used in freight transport system. Containers are large metal boxes with standardized sizes (ISO 668 standard), they were first introduced more than half a century ago (Guerrero & Rodrigue, 2013). The size of a container refers to its metrics in terms of length, width and height which are usually expressed in feet and inches. The length of a freight container typically is 20, 40, or 45 feet. A standardized ISO-container is always 8 feet wide and 9.6 feet high. Sizes and capacities of vessels and container terminals are generally measured in terms of TEU, which refer to the length of a 20 feet container. Consequently, a 40 feet container accounts for two TEUs. The tare weight of a 20 feet container is around 2250 kg and its maximum payload is 22750 kg (Kemme, 2013). Meanwhile, semi-trailer can be described as a loading platform with rear wheels, designed for road transport, but also moveable by rail and sea. Some semi-trailers are equipped for vertical handling but port handling utilises the Roll-on/Roll off (RoRo) principle. Additionally, semi-trailers can be assumed (conservatively) to correspond to two TEUs (Woxenius & Bergqvist, 2011).

Container transportation is a major component in intermodal transportation due to the following reasons: safety of cargo, reduction of handling costs, standardization, and accessibility (Crainic & Kim, 2007). Therefore, container trade expanded at an average of 8.2% between 1990 and 2010 (UNCTAD, 2011). Moreover, container-related activities have grown also remarkably over the last decade for instance, in 2011 a total of 253 container ships with a combined capacity of 1.8 million TEU were ordered worldwide, compared to 0.7 million TEU from 2010 (ISL, 2012).

The main transport market for maritime containers is the trans-ocean trade, meanwhile semi-trailers serve intra-regional flows. Woxenius & Bergqvist (2011) argued that the characteristics of the geographic transport market for these segments, is not a sharp one due to the following: The design of the latter transport system allows for co-production with intra-regional container services and the RoRo ships transporting semi-trailers, which can also take containers on mafi trailers or semi-trailer chassis. Additionally, the shorter intra-European Ro-Ro shipping routes also serve accompanied trucks and passengers. This implies that the demand compromise is wider than for transport of unitised cargo alone, and adds a certain degree of production in the ports by the customers.

3.4. Freight transportation modal choice

The decisions on how to convey the goods are often taken by a logistics service provider (LSP), which sometimes played by freight forwarders or agents and sometimes by transport operators directly (Sommar & Woxenius, 2007). Modal choice may depend on many variables like: transport cost of the available modes (including loading and unloading cost), transport time, the number of transshipments, reliability, flexibility, probability of damage during transport, tracking and tracing of the cargo, the harmful emissions and transport frequency offered (de Jong, 2014). Woxenius & Bergqvist (2011) compared between the contexts of containers and semi-trailers transportation from many aspects like: geographic transport market, modal competition, business priority, port geography, hinterland depth, transport time/speed, precision, order time, frequency, transport service, cargo dwell time in port, empty unit dwell time, port work content, rail technology, road technology, and road–rail transhipment technology (see Table 5).

Table 5 Comparison between container and semi-trailer shipping segments

	Container	**Semi-trailer**
Geographic transport market	Transocean/deep sea/short sea	Intra-European/short sea
Modal competition	Air for deep sea leg/Rail and road for	Feeder leg Rail and road + fixed connections
Business priority	Utilizing economies of scale	Providing customer convenience
Port geography	Few large hub ports + feeder ports	Many ports -partly bridge substitute
Hinterland depth	Deep	Shallow
Transport time/speed	Fast	Fast
Precision	Day	Hour
Order time	Week	Day/minute
Frequency	Weekly	Daily/hourly
Transport service	Coordinator shipping line, line agent or sea forwarder	Shipper, road haulier or general forwarder
Cargo dwell time in port	Days	Accompanied – minutes or none/Unaccompanied - hours
Empty unit dwell time	Days/weeks	Hours/days
Port work content	Substantial	Limited
Rail technology	Very simple – flat wagon/twist locks	Complicated – pocket wagon/king-pin box
Road technology	Awkward at end points	Simple and accessible
Road–rail transhipment technology	Fairly simple – automation possible	Dimension factor in weight and handling

(Source: Woxenius & Bergqvist, 2011)

3.5. Types of shipping services

There are three basic modes of operation of commercial ships: Firstly, liner which operates according to published schedules and the demand for their services depends among other things on their schedules. Liner operators usually control container and general cargo vessels. Secondly, tramp ships follow the available cargoes, similar to a taxicab. Often tramp ships engage in contracts, where specified quantities of cargo have to be carried between specified ports within a specific time frame for an agreed upon payment per unit of cargo. Tramp operators usually control tankers and dry bulk carriers. Thirdly, industrial operators, which usually own the cargoes shipped and control the vessels used to ship them. These vessels may be their own or on a time charter. Such operations abound in high volume liquid and dry bulk trades of vertically integrated companies, such as: oil, chemicals, and ores (Christiansen et al. 2006).

According to Eyres (2007), marine ships can be classified into transport and non-transport ships. Transport ships include cargo, container and passenger ships and non-transport including fishing vessels, service craft such tugs and supply vessels and warships, an overview of the wide range of the ship types in given in Appendix 1.

3.6. Modes of transport for the new development

3.6.1. Ro-Ro ferry traffic

Roll on - Roll off ships are designed for wheeled cargo, sometimes in the form of trailers, and the cargo can be loaded and unloaded quickly through a stern and bow doors or sometimes side ports for small vehicles. The cargo can be driven by their own power (in case of trailers with cabin) or by straddle carriers or forklift trucks (in case of trailers without cabin or containers), into an internal ramps or lifts leading from the loading deck to upper decks or hold below (Molland, 2008, p 49). Ro-Ro ships may be fitted with various patent ramps for loading through the shell doors, when not trading to regular ports, where link span and other shore-side facilities that are designed to suit are available (Eyres & Bruce, 2012, p 21).

3.6.2. Passenger ferry traffic

Passenger ships can be classified into two categories: cruise ships and passenger ferries. In cruise ships it is provided with high standard of accommodation and leisure facilities located in the many tiers of decks the passenger ship has. Meanwhile, the passenger ferry ships are a combination of Ro-Ro and passenger ship. Passenger ferry ships are steel-framed ships, which consist from three layers, the lower for the machinery space, the vehicle decks and the passenger accommodation. Additionally, ferry ships have a large stern door or bow door, which provide access for the wheeled cargo to the various decks, which are connected by ramps. Ship sizes vary according to the route requirements and speed is usually around 20-22 knots (Molland, 2008, p 58). Additionally, passenger ferry ships are suitable for short and busy routes, such as traffic between Helsinki and Tallinn, where the journey takes 2 to 4 hours depending on the ship and its sailing schedule, additionally the ferries are reliable during the winter as well. A large number of daily departures and precise schedules maintain the excellent level of service. The versatility of the ships' facilities (for passengers, vehicles and cargo) makes the ship type very competitive and enables a seasonal variation of the cargo.

One of the main disadvantages of this type of ship is that the increased traffic causes congestion in the harbour area and in the harbour entry and exit routes (Port of Helsinki, 2014b).

3.6.3. Container ship traffic

Container ship represents an integrated approach for transporting the goods from the factory to the final destination in a secure way, since the containers need not to be opened until they reach their destination (Molland 2008, p 45). One important feature of the container ship is the stowage of the rectangular container units within the fuller rectangular portion of the hull and their arrangement in tiers above the main deck level, which facilitate removal and placing of the container units (Eyres & Bruce 2012, p 21).
Cargo holds are separated by a deep web-framed structure to provide the ship with transverse strength. Additionally, the structure outboard of the container holds as a box-like arrangement of wing tanks providing longitudinal and torsional strength (Molland, 2008, p49). Moreover, the narrow deck width outboard of the hatch opening forms the crown of a double shell space containing wing ballast tanks and passageways (Eyres & Bruce 2012, p 21). The wing tank may be used for water ballast and can be used to counter the heeling of the ship when discharging containers, a double bottom is fitted, which adds to the longitudinal strength and provides additional ballast space (Molland, 2008, p 49).

The overall capacity of a container ship is expressed in terms of the number of TEUs it can carry, and container ships are of ever increasing size to take advantage of the economies of scale. The larger ships can use only the largest ports, but as these are fitted out to unload and load containers, the ship itself does not need handling gear. Smaller ships are used to distribute containers from large to smaller ports. Since the smaller ports may not have suitable handling gear, these ships can load and offload their own cargoes (Tupper, 2013). Loading and unloading container ship in container terminals can be achieved by terminal transport equipment like cranes and horizontal transport vehicles. Cranes can be quay or gantry, and in both cases Lo-Lo system is used (containers are lift on during loading operation and lift off the ship during the unloading). Meanwhile, horizontal transport vehicles can be classified into two categories: vehicles that can't lift containers like trucks with trailers, multi-trailers and automatic guided vehicles (AGV), and vehicles that can lift containers like reach stacker and straddle carriers (SC) (Steenken et al. 2004).

3.6.4. CONRO ships

Conro ship is a Ro-Ro ship that combines the features of both a traditional container ship and a Ro-Ro ship. Such ships' interiors are distributed in such a way that both their loads are evenly distributed and balanced. The maximum load that is transited by these vessels is between 20,000 to over 50,000 dead weight tonnes (DWT) (Marine insight, 2014). These vessels are design for both: wheeled cargo (trailers with or without a cabin, and smaller vehicles) and general cargo like containers. Conro vessels are built as cargo vessels with fixed or movable inner ramps between the different decks. They have one or more cargo ramps at the stern, the bow or even along the side. Wheeled cargo is secured with chains and cables to prevent it from shifting at sea. The wheeled cargo can be loaded or unloaded through stern, bow doors, or side ports for smaller vehicles. By its own power or straddle carriers or forklift trucks, into an internal ramps leading from the loading deck. Meanwhile, containers are loaded and discharged by cranes to a large open deck (Molland, 2008).

Conro ships have many advantages, including: cargo mixture of wheeled and general cargo enhances the trades by creating more opportunities with "small" clients with vibrant manufacturing. Fast and independent cargo operations especially for the wheeled cargo, which can be driven by its own power, and also the use of cassettes for containers for fast loading (Dunn, 2012).

4. SHORT SEA SHIPPING (SSS)

The focus of this research is on the SSS at Helsinki-Tallinn route, so this chapter is dedicated to SSS as an introduction to the shipping costs in the following chapter. This consists from the following six subchapters: subchapter 1 introduces and define the SSS, then subchapter 2 provides background information for the SSS, meanwhile subchapter 3 describes the current situation of SSS in Europe. Following, subchapter 4 lists the main strengths and weakness for SSS, while subchapter 5 discusses the environmental impact of SSS.

4.1. SSS importance and definition

SSS is an important part of the European economy and an alternative to road transport of goods in Europe. Although, SSS is considered to be global, but it is much more related to Europe, for the reason that it operates in a large-scale in the European borders and by European shipping companies. According to the European Commission (2002) it represents an efficient and environmentally-friendly transport mode, often the most cost-effective alternative to avoid long-distance traffic at Europe´s roads, and an essential link to islands and outlying region. Despite that, ships' emissions are a major contributor to the concentration of atmospheric pollutants and greenhouse emissions over most of the world's oceans (Dalsøren et al. 2008). The world's merchant fleet has already reached 1.12 billion tonnes of CO_2, or nearly 4.5% of all global emissions of the main greenhouse gas (Vidal, 2008). Before the 1980s the emissions from ships were not considered to be a crucial issue, because the main actors that were forming the maritime sector were focusing more on developing reliable and economic solutions for the transportation of freight cargo. Consequently, in 2013 in the EU (EU28) an approximate of 3.73 billion tonnes of goods was handled through sea (Eurostat, 2013).

Defining the SSS is a difficult task, since there is no academic agreement that has reached yet among several experts on the concept. The lack of a conceptual definition for the SSS has been acknowledged since the 1990s (Douet & Cappuccilli, 2011). Although there are a lot of attempts in the literature to specify a common definition of SSS (Bjornald, 1993; Bagchups & Kuipers, 1993; Stopford, 1997; Papadimitriou 2001; Paixao & Marlow, 2002). Marlow et al. (1997) explained this difficulty when they stated that SSS can include variety of different ships, cargo-handling techniques, ports, networks and information systems in their definition for SSS as: "A seaborne flows of all kinds of freight performed by vessels of any flag from the EU Member States to whichever destination within the territory embracing Europe, the Mediterranean and Black Sea non-European countries". Therefore, it is not easy to carry out a universal analysis for SSS for the purpose of developing public policy initiatives and the essential market conditions for commercial success (Lombardo, 2004).

However, in 1999 the European Commission identifies SSS as: "*The movement of cargo and passengers by sea between ports situated in geographical Europe or between those ports and ports situated in non-European countries having a coastline on the enclosed seas boarding Europe*". Additionally, the concept of SSS also extends to maritime transport between the member states of the union, Norway, Iceland and other states of the Baltic Sea, the Black sea and the Mediterranean (European Commission, 1999).

In 2005, the US Maritime Administration (MARAD) defined SSS as: "*A commercial waterborne transportation that does not transit an ocean. It is an alternative form of commercial transportation that utilizes inland and coastal waterways to move commercial freight from major domestic ports to its destination*." (US department of Transportation, 2008). In the same year, Yonge and Henesey provided the following elements to the previous SSS definitions: Intermodals, feedering, door-to-door, floating stock, inter-regional cargo, an alternative to road transport for containers or trailers, border crossing, transhipment, and the hub and spoke networks (Yonge & Henesey, 2005).

4.2. SSS background

According to Musso et al. (2010), the main idea of SSS is based on the development of a more sustainable transport network with the least negative impacts by the transport modes. At European policy level, in 1992 the European Commission (EC) references SSS for the first time in the European Common Transport Policy as a potential mean of attracting freight from the already congested roads, and in 1997 EC started to promote SSS. According to Medda and Trujillo (2010) SSS was delayed to receive an equal public support compared to roadway and railway, due to the mistaken assumption by policy makers that the sea way is a free highway. Congested road networks, environmental impacts and external costs - which amount to 80 billion Euros per year, almost 1% of EU's GDP- are the reasons that highlighted the need for a more energy efficient and environmentally friendly model of transport.

Globalization, management strategies like just-in-time, door-to-door deliveries and divided production chains, enhanced environmental negative impacts of freight transport, because of the boost that land transport received thanks to its superior flexibility and low prices. In the EU, transport sector has the fastest growth of energy consumption (Medda & Trujillo, 2010). It is argued that the enhancement of SSS is critical for environmental and economic reasons. This kind of transport mode is characterized by high energy efficiency and environmental performance. Developed and developing economies depend on the efficient flow of freight by transport modes. SSS is considered by the European Commission as a unique option of transport modes, which is able to respond to the rapid economic growth of the EU. In addition, it has the potential to reduce road congestion and to improve competitiveness of transport mode. Almost 90% of the EU external freight trade is conducted through sea (European Commission, 2011). SSS in 2011 forms 40% of intra-EU exchanges in terms of ton-kilometres, but there are still issues left to tackle.

4.3. Current situation of SSS in Europe

According to the European commission database from 2005 to 2013, SSS represented almost 60% of total EU-28 maritime transport of goods. The total amount of goods transported to or from the main ports by SSS and Deep Sea Shipping (DSS) was the highest in 2008 (Figure 6).

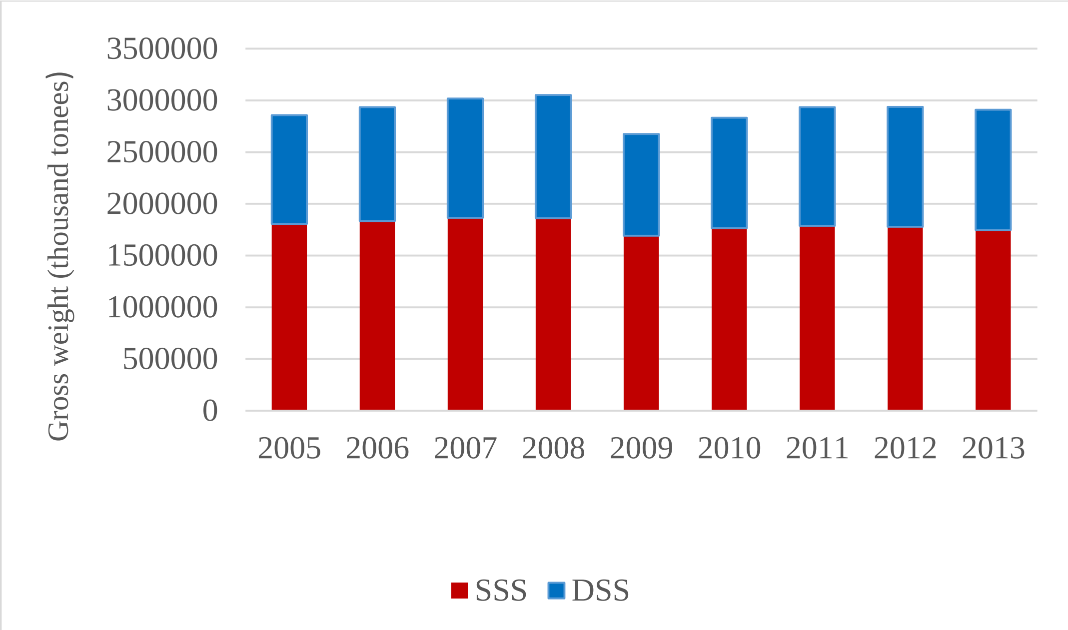

Figure 6 Share of SSS of goods in total sea transport for EU-28 (Eurostat, 2014b).

Figure 7 demonstrates the distribution of cargos by sea region for the year 2013. The shown percentage is based on the gross weight of goods, and it has been almost constant in the period from 2005-2012. Cargo types transported are liquid bulk, large container, dry bulk, and Ro-Ro, mobile self-propelled units (Eurostat, 2014c).

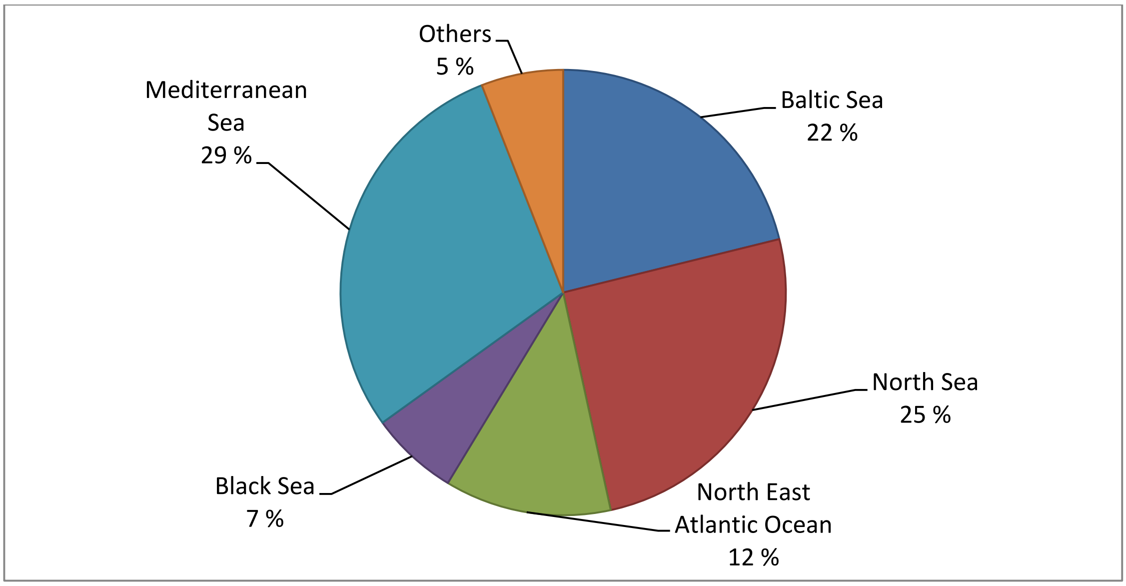

Figure 7 EU level- SSS of goods by sea region (Eurostat, 2014c).

4.4. Strengths and weakness of SSS

4.4.1. The strengths of SSS

The geographical advantages of SSS are based on the long coastline of Europe which is more than 67,000 kilometres of coastline, from 60 % to 70% of its industry and production centres located within 150–200 kilometre of the coast and a network of inland water of 25,000 kilometres of which are part of the combined transport road network. This advantage can provide huge economic impacts such SSS can contribute to the integration, cohesion and economic development of the area and might also to the SSS companies (Paixão & Marlow, 2002).

Additionally, the economies of scale and distance, which can allow low freight rate offering, despite the enormous capital investment, still SSS companies already possess the most expensive assets involved in the intermodal freight transport, which entitled them to a good position to develop transport system. Moreover, the sea is virtually free, does not require as much maintenance as land infrastructure. Additionally, the unlimited capacity of the sea, allow free movement for ships almost all year time with less congestion (Baird, 2007). Nevertheless, financial advantages occur by the lower port maintenance and investment costs, compared to rail and road infrastructure, whose external costs are increasing (Paixão & Marlow, 2002).

According to some studies, SSS can be considered an environmental friendly in terms of energy efficiency and less harmful emissions. SSS produce less carbon dioxide (CO_2) per tonne-kilometre than other modes of transportation, however improvement on the emissions level need to be made to the nitrogen oxide (NO_x), sulphur dioxide (SO_x) and the Particular Matters (PM) emissions in order to comply with the international standards limiting through the Annex VI convection established by the IMO (see subsection 4.5.2.). Another reason, which makes SSS environmentally friendlier than the other modes is the less intervention in the natural environment. Rail and road networks require expensive investments for railway lines, roads, tunnels and bridges. This of course does not mean that further improvements are not required in terms of vessels' engines to reduce the harmful emissions (Paixão & Marlow, 2002).

4.4.2. The weaknesses for SSS

Despite the previously discussed advantages and potentials for SSS, the sector needs to overcome several weaknesses and obstacles whose significance exceeds the positive qualitative characteristics of SSS (European commission, 2003; Paixão & Marlow, 2002). For instance, The SSS did not reach yet the full integration of logistical chains; door-to-door services. Paixão and Marlow (2002) described SSS as being part of a broken chain, because to complete a door-to-door service, SSS requires a collaboration of other modes of transportation such as train and road modes in order to collect and deliver the freight before and after the sea leg. Additionally, SSS requires support by dedicated terminals and a well-established network of inland terminals. Thus, in most of the cases SSS is unable to provide individually door-to-door services. Despite the important steps towards the integration of SSS have been done by the EC (especially through developing policies for necessary infrastructure), but still it has not been enough. The integration of seaborne and surface modes of transport in general but also in terms of information technology and information system is required. This lack makes SSS lagging behind road modes of transport in terms of flexibility (European commission, 2003).

Additionally, The SSS involves complex administrative procedures. SSS needs amount of paper work. Paper work or the so called documentation procedures for SSS are considerably more than for road transport (five categories of documentation that a vessel needs every time that enters or exits from a port), in addition to the heterogeneity in the documentation process between different trade sea routes in Europe, which enhances the amount of bureaucracy (Paixão & Marlow, 2002).

Moreover, The SSS requires higher port efficiency and good hinterland accessibility. Ports need planning for their operations and activities is such way that all operations are handled in a smooth and efficient way. Double handling due to inefficient operation, lack of capacity in terms of quay length or number of berths, lack of adequate cargo handling equipment or misuse and complex hierarchical structure of ports result in lower performance of SSS (Paixão & Marlow, 2002). Thus, the aforementioned weaknesses, from a marketing point of view, undermine the reliability and the image of shipping operations in the eyes of the customers.

4.5. Environmental impact of shipping

It is generally accepted that shipping possesses environmental advantages compared with other transport modes (Ng & Song, 2010; Hjelle & Fridell, 2012). Additionally, Hjelle & Fridell (2012) argued that shipping is efficient regarding fuel consumption, when calculated per deadweight tonne along routes of similar length, and in terms CO_2 emissions, but they also mentioned the high percentage of other emissions like Sulpur and Nitrogen oxides. Moreover, problems in air quality related to emissions from shipping have been reported globally (Corbett et al. 2007; Dalsøren et al. 2007; Endresen et al. 2003; Corbett et al. 1999; Capaldo et al. 1999).

Gases emitted from ships can be classified into several categories, among others; Green House Gases (GHGs) and Non-Green House Gases. GHGs include carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O). Meanwhile; Non-Green House Gases include mainly sulphur oxides (SO_x) and nitrogen oxides (NO_x). The effects of all of the above gases on global climate are diverse and most are considered negative, if not kept under control. Among other effects, GHGs contribute to global warming, SO_x cause acid rain and deforestation, and NO_x cause undesirable health effects (Psaraftis & Kontovas, 2013).

4.5.1. Carbon emissions

According to a GHG study by the International Maritime Organization in 2009 international shipping contributes 2.7% of the CO_2 emitted globally, meanwhile road transport contribute 21.3 %, and the highest contribution with (35%) was from producing electricity and heat. Figure 8 illustrates the global CO_2 emissions (IMO, 2009). The same study was done again in 2014 to estimate the CO_2 emissions by the international shipping, and the estimation was built based on two approaches; fuel sales data and ship activity data. Accordingly, the CO_2 contribution by the international shipping to the global CO_2 emissions was 2.2% and 2.1 % correspondingly to the two approaches (IMO, 2014).

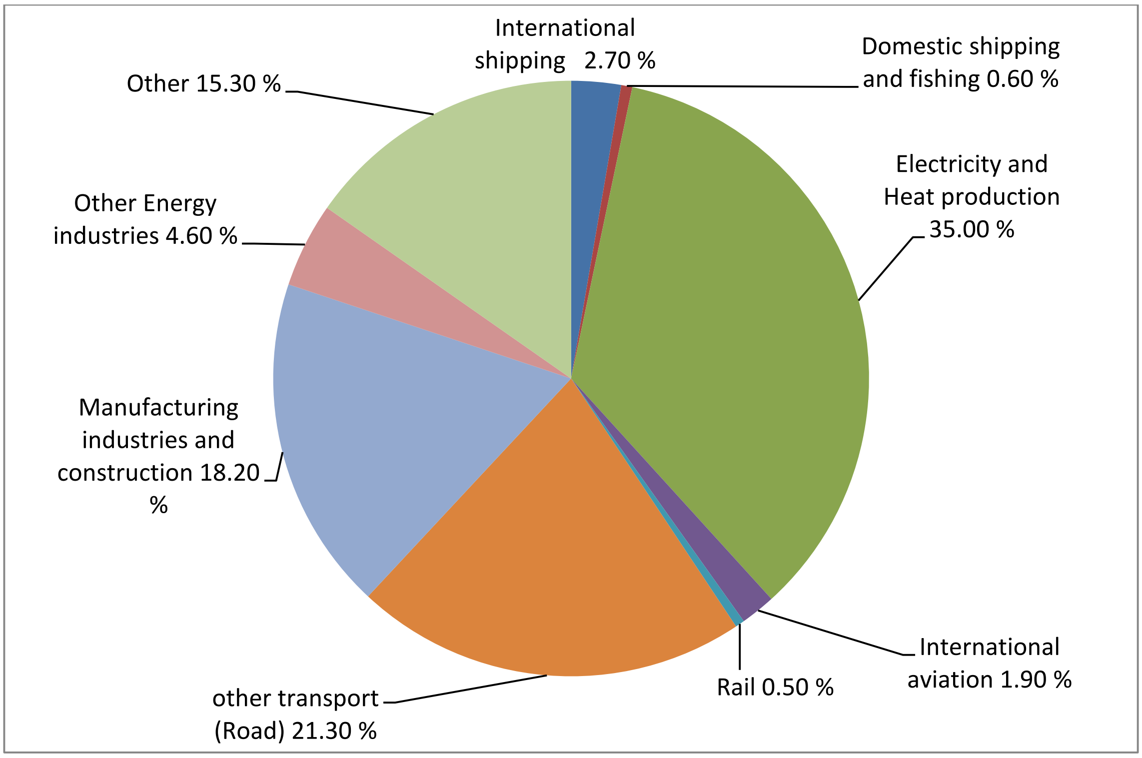

Figure 8 Global CO2 emissions (IMO, 2009).

4.5.2. Sulphur and nitrogen oxides emissions

Sulphur emission is directly proportional to the sulphur content of the bunker oil, while nitrogen oxide is produced when nitrogen and air, oxidises in the combustion chamber of the ship's engine due to high temperature and pressure. Figure 8 shows the amount of both sulphur oxides and nitrogen oxides in the European Union countries, from the figure a general decrease can be noticed on these gases amounts and this decrease is due to the awareness of the disadvantages of such emissions on the health and climate. The awareness started in 1973 with the international convection for the prevention of pollution from ships (MARPOL), which was modified and entered into action in 1983 (Annexes I and II) the convention included regulations aimed to prevent and minimize pollution from ships (IMO, 2014).

In 2005, the EU initiated a Directive, which was adopted by the European Parliament and the Council, which would enforce the maximum sulphur limits at 1.5% for marine fuels in the Baltic Sea (from August 2006), the North Sea and the English Channel (from autumn

2007) and these areas are called Sulphur Emissions Control Areas (SECA). The Directive is also responsible to ensure that vessels running inland waterway and coastal routes are in line with the EU's environmental policies and CO_2 targets (European Commission 2006). On 10th of October 2008 the Marine Environment Protection Committee (MEPC) of the IMO unanimously adopted the revised Annex VI, Prevention of Air Pollution from Ships, to the MARPOL 73/78 Convention. The Annex sets limits on nitrogen oxide and sulphur oxide emissions from ship exhausts. The new Annex entered into force on 1 July 2010, and the highest sulphur content allowed in ship fuel reduced globally as of 1st January 2012 from 4.5% to 3.5% and as of 1st January 2020 to be 0.5%. Meanwhile, Sulphur content allowed in SECA decreased as of 1 July 2010 to 1.0% and as of 1 January 2015 to be 0.1%. These regulations are mandatory for ships over than 400 tonnes gross weight (IMO, 2008).

The use of exhaust gas cleaning systems will continue to be allowed, which means that ships equipped with scrubbers may also run on types of fuel that are currently in use. With the use of low sulphur bunker fuels, which can immediately decrease sulphur emissions, while requiring no modifications in the engine. The problem is that, low sulphur bunker oil is significantly more expensive (Kalli et al. 2009).

Additionally, the revised Annex VI set regulations to control the NO_x emissions from ships producing more than 130KW installed on ships built (defined as date of keel laying or similar stage of construction) on or after January 1, 2000 and different levels (Tiers) of NO_x control apply based on the ship construction date. The NO_x emissions limit is expressed as dependent on engine speed. The control of diesel engine NO_x emissions is achieved through the survey and certification requirements leading to the issue of an Engine International Air Pollution Prevention (EIAPP) Certificate and the subsequent demonstration of in service compliance in accordance with the requirements of the mandatory, regulations 13.8 and 5.3.2 respectively, NO_x Technical Code 2008 (resolution MEPC.177 (58))(IMO, 2008). Reducing NOx emissions can be achieved by technical improvements of engines or abatement techniques. For instance, Kågesson (1999) discussed many alternatives techniques for reducing the NO_x emissions by engine improvements. Meanwhile, Jalkanen et al. (2009) listed some various abatement techniques and their evaluated emission reduction efficiencies in case of NO_x and SO_x.

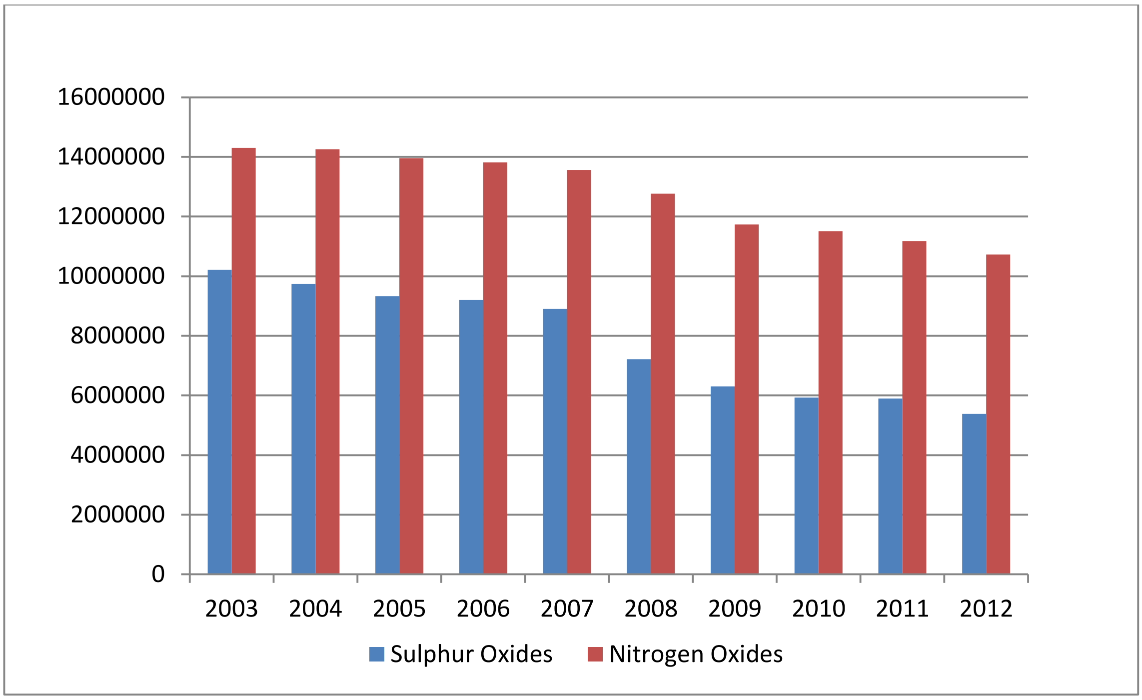

Figure 9 Sulphur and Nitrogen Oxide amounts in thousands tonnes from 2003 to 2012 in EU 28 (Eurostat, 2014d).

4.6. Can intermodality reduce emissions?

The Marco polo II programme had the objective of shifting the equivalent of the forecast increase in cross-border road tonne-kilometres (20.5 billion) between 2007 and 2013 onto rail or water (Millan de la Lastra, 2007). According to the results published by the European Commission (2014), there was a 2.86 million tonne of CO_2 emissions saved. In addition, a recent study has revealed that in the case of door-to-door transport between the port of Le Havre and the Paris region, combined waterway-road transport is responsible for between 20% and 50% less carbon dioxide emissions (CO_2) than road transport (Franc and Fremont, 2009). In other hand, finding of Kreutzberger et al. (2003) indicated that, generally intermodal has more advantage over the uni-modal transport in case of short pre- and end-haulage, and when the origin and destination locations don't involve backward move distances. Nevertheless, environmental improvements are needed in short sea shipping intermodal, particularly in the areas of SO_x, NO_x and particulates (Vanherle & Delhaye, 2010).

4.6.1. Lowering the emissions by slow steaming

Slow steaming is the sailing of maritime vessels with low speed (lower than 20 knots). The practice of slow steaming emerged during the financial crisis of 2008-2009, and it has become increasingly common practice in container liner shipping due to the increase in the amount and unit size of available vessel capacity, and also due to the increase of fuel prices (Notteboom & Cariou, 2013). The same authors found that "slow steaming practices are not implemented on all trade routes, but depend on operational aspects such as distances covered and the characteristics of the ships deployed".

Additionally, slow steaming is claimed to reduce environmental emissions by vessels at sea (Buhaug et al. 2009; Corbett et al. 2009; Faber et al. 2010; Cariou, 2011). For instance, reducing a vessel's speed by 10% decreases CO_2 emissions by at least 10 –15%, but also creates substantial losses in revenues (Psaraftis & Kontovas, 2010). CO_2 emission reduction can be achieved without the adoption of any new technology (except the case of very low speed; exhaust design and safety issues will rise), if bunker prices remain high. Meanwhile, if fuel prices fall, while freight rates and inventory costs rise, the profit motives for operating a vessel at full speed are likely to rise (Cariou, 2011). So from the above discussion we can conclude that, rational energy use, speed reduction, and revenues are closely related in the shipping sector. The next section discusses the shipping cost.

5. SHIPPING COSTS

This chapter provides a review to the shipping costs literature, and it is divided into two subchapters: the first one introduces shipping cost models, meanwhile the second subchapter introduces the ports as shipping cost determinant, and it is presented in two subsections, the first one discusses port pricing, and the second one provides an introduction to time at ports.

5.1. Shipping cost models

There are many ways to calculate the shipping costs (Ryder & Chappell, 1979), and in the literature there are many models for calculating the costs (e.g. Radelet & Sachs, 1998; Jansson & Shneerson, 1985; Pawellek & Schönknecht, 2011; Cullinane & Khanna, 2000; Stopford, 2004; Morales-Fusco, 2012). For instance, Cullinane and Khanna (2000) adopted an approach, which involves the specification and calibration of three submodels which yield the following consecutive outputs:

1. Daily Fixed Cost per TEU, which analyses cost variability (daily capital costs and daily operational costs) in response to changes in time to derive a standard cost per TEU per time unit.

2. Cost per TEU-Mile, The output from the first sub-model is used as an input for the second sub-model, which assesses cost variability (fuel consumption) in relation to distance travelled.

3. Total Shipping Cost per TEU combines the output from both the previous submodels.

Figure 10 represent the aggregate model for calculating shipping cost, where (y) is the cost component, (x) is the ship size in NTEU (Net Twenty Feet Unit), and (e) is the elasticity and (k) is a constant. In their model, Cullinane and Khanna quantifies the economies of scale in operating large containerships by taking into consideration the effect of port time, speed, and route distance. They noted, as widely recognized, that costs at sea per tonne or per TEU will decrease as ship size increases. However, the overall efficiency of a ship depends ultimately on the total time the ship takes to complete a voyage, because the time spent in port is unavoidable in the sense that cargo will need to be loaded and unloaded (Gkonis & Psaraftis, 2010).

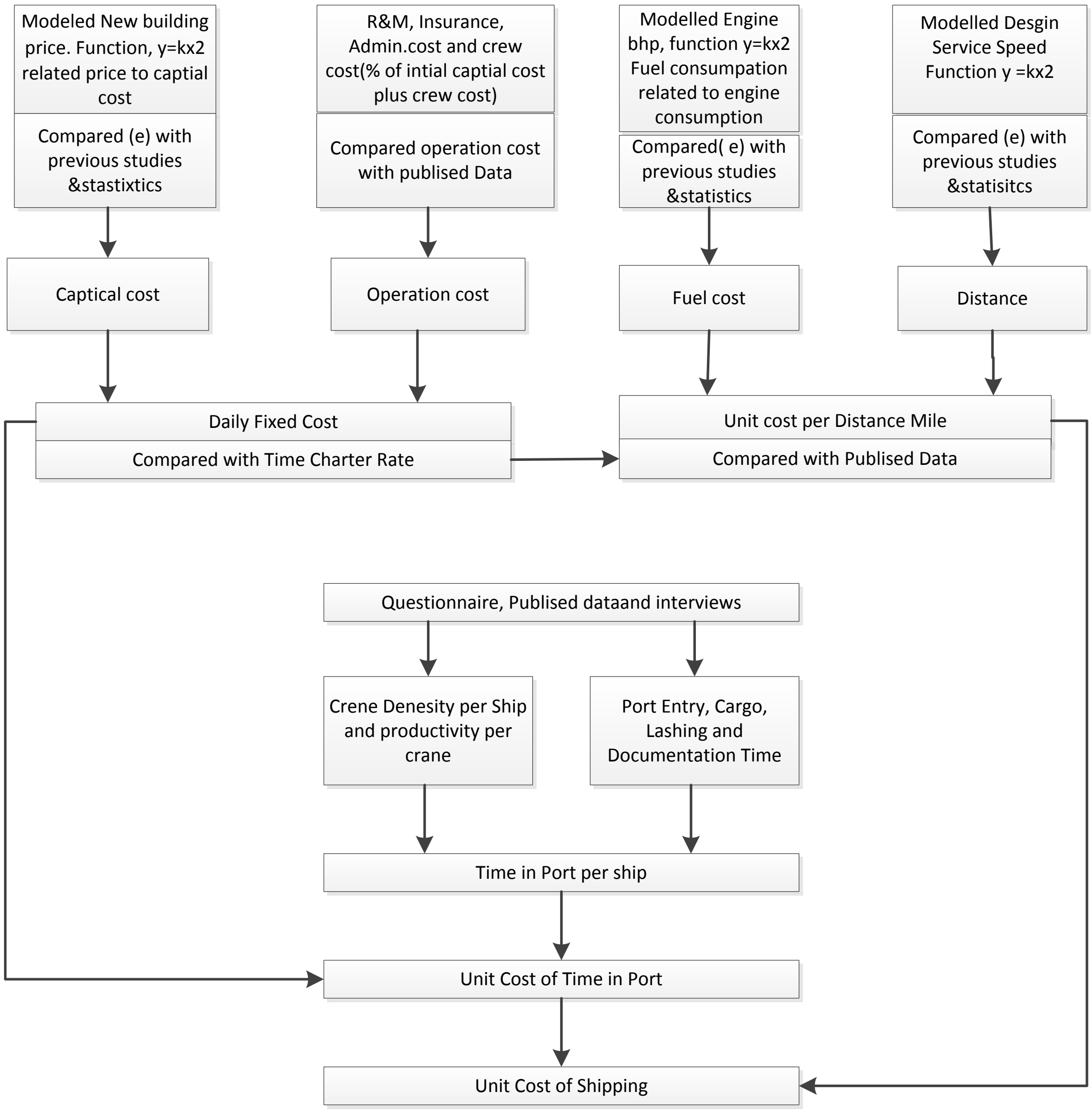

Figure 10 Representation of the aggregate cost model (adapted from Cullinane & Khanna, 2000).

5.2. Port as shipping cost determinants

The sea port or port (according to the European Commission, 1997a) can be defined as the area of land and water made up of such improvement works and equipment as to permit, principally, the reception of ships, their loading and unloading, the storage of goods, the receipt and delivery of these goods by inland transport, the embarkation and disembarkation of passengers.

Following, from the previous definition, the services provided by the port can be listed as follows: Firstly, technical-nautical services, which includes pilotage, towage and mooring. Secondly; cargo handling, and it include stevedoring, stowage, transhipment and other intra-terminal transport, in addition to storage, depot and warehousing (depending on cargo categories), and cargo consolidation. Finally, passenger services including embarkation and disembarkation (European Commission, 1997a).

Additionally, port pricing can be defined as multi-output enterprises where a chain of interlinked services defines the main activity of commercial ports. These services in practice are often charged individually and by different parties (Meersman et al. 2010). Port pricing is well documented in the literature, and there are many articles reviewing that the topic is important and academically relevant (e.g. Pettersen & Marlow, 2000; Heaver, 2006; Pallis et al. 2011; Acciaro, 2013).

5.2.1. Port pricing

As discussed in Cullinane and Khanna modal, port time is one of the factors effecting the shipping cost, additionally, According to Pettersen & Marlow (2000) port charges make up only 5 - 10 per cent of overall transit costs for deep-sea shipping compared to 40 - 60 percent for vessels engaged in short-sea trades. And they also cleared the reason behind high percentage of ports costs to short sea shipping, due to the relatively low tariffs charged to coastal traders, which merely compensate coastal shipping somewhat for their more frequent port calls for loading and discharging compared to deep-sea shipping. Hence, any preferential treatment inherent in such charges is intra-modal rather than inter-modal in nature.

The main pricing principles discussed in the literature may be classified as cost based pricing, methods for cost recovery, congestion pricing and strategic port pricing. In addition the price structures used in privatised ports can be classed as "commercial" port pricing (Pettersen & Marlow, 2000). Meanwhile, Acciaro (2013) classified them into strategic pricing, pricing and market conditions, pricing and infrastructure cost recovery, pricing and external costs and empirical studies (recently highlighted in the literature). Additionally, Pettersen & Marlow (2000) suggested a method for calculating port costs based on the expected time in port (the time or duration of the port stay, which depends on the time for handling vessels and cargoes) and the punctuality in port operations (the total handling time for the vessels and the total time needed for the goods to pass through the port), in addition to the different port dues or payable port costs. The method is illustrated by the following equation:

$$\boldsymbol{C} = \boldsymbol{d} + \boldsymbol{f}\,(\boldsymbol{t} + \boldsymbol{p})$$

Where **d** is the tonnage and goods dues, **t** duration of port stay, **p** waiting time reflecting punctuality, and f costs per unit of time.

Another factor effecting port pricing is ship sizes, for example Gilman and Williams (1976) discussed the issue of how ship size affected the network of ports at which ships might call and the need for efficient port turnaround times. Meersman et al. (2014) provide a generic overview of the current port pricing structure. It distinguishes between the various activities, who is setting the price level, and who is paying, and the variable(s) determining the price level. The overview can be seen in the following Tables 6, 7 and 8.

Table 6 Port of calling pricing

Activity	**Who is pricing?**	**How is paying?**	**Variable(s) applied**
Port dues	Port authority	Shipping line	
· Tonnage dues			Gross tonnage (vessel)
· Mooring dues			Load (ton)
Pilotage		Shipping line	
· Sea pilotage	Government		Draught (entering and leaving)
· River pilotage	Government		Draught (entering and leaving), and distance
· Dock pilotage	Port authority (plus ship owners association(s))		Length of the vessel plus distance
Towage			
· River tugboat	Private company	Shipping line	Length of the vessel plus distance
· Port tugboat	Port authority		Gross tonnage plus distance
Agency costs	Shipping agents	Shipping line	Job-by-job fee in case of independent agent; lump sum in case of ship owner´s agent
Other costs			
·Berthing/ unberthing	Private company (can be linked to port authority)	Shipping line	Per port call
· ship reporting	Private company (or port authority)		
Port state control	N/A	government	condition of the vessel
Waste reception facilities	Service company	Shipping line	Quantity and type of waste
Bunkering	Bunker supplier	Shipping line	Quotation international markets; quantity supplied; number of bunkers a year
Supplies (water and electricity)	Supplier (may be private company, port authority, or government)	Shipping line	Quantity Supplied

(Source: Meersman et al. 2014)

Table 7 Handling pricing

Activity	Who is pricing?	Who is paying?	Variable(s)applied
Cargo handling on quay	TOC (Terminal Operating Company or stevedore)	Shipping line through its agent if terms of sale are liner terms. Recipient depends on the contract (free out)	Per weight (tons) or movements (containers)
Transport to/from storage	TOC Carrier if cargo is transported to storage area outside the terminal premises	Shipping line or receiver depending on the terms of the sale (see above) owner	Per weight (tons) or movements (containers)
Storage	TOC	Recipient of the goods	Per unit of weight (ton of TEU) and time cf.dwell time)
Delivery/ receiving	TOC	Recipient of the goods	Per unit weight or TEU
Cargo moving inland	Inland transport operator (rail operator, barge, truck)	If carrier haulage: shipping line; if merchant haulage: the recipient of the goods	Per TEU unit or per ton
Customs	Customs authority	Owner of the goods via customs broker	According to value of goods and customs clarification
Handling of empty boxes	TOC	Shipping line	Per box
Storing of empty boxes	TOC	Shipping line or leasing company if boxes out of lease	per box and dwell time

(Source: Meersman et al. 2014)

Table 8 Concession Pricing

Activity	Who is pricing?	Who is paying?	Variable(s)applied
Granting concession	Port authority (i.e. market-based, after tendering)	Concessionaire (stevedore, industry, etc.)	Size of the area, location, facilities, etc.

(Source: Meersman et al. 2014)

5.2.2. Time at port

Time at port not only includes the loading/unloading operation, but also includes the additional time for manoeuvring, mooring and paperwork. In a congested port, the ship may also have to queue for crane service or wait for the cargo (Laine & Vepsäläinen, 1994). The annual operating time is almost all the times of the year, but practically it is reduced by the number of days the ship is out of service for repair, maintenance, or other reasons. According to Finnish system, the working days are 252 days per year. Of course, it is possible to operate all the time around the year, but a trade-offs needs to be done between fulfilling the trips schedule and the extra costs for the working in holidays and night shifts.

Laine & Vepsäläinen (1994) suggested a model for calculating the time needed for round trips between two ports, the model is illustrated in the following equation:

$$t = 2\left(\frac{d}{s} + \frac{2q}{r}\right)$$

Where **t** represents the round trip time measured in hours, **d** distance between the two ports, **s** ship speed, **q** capacity measured in TEUs and **r** is the rate of cargo handling TEUs per hour. Though, Laine & Vepsäläinen model is a practical model to calculate the time needed to make around trip between two ports, but still it does not take into the consideration other factors than loading/unloading time at port.

6. RESEARCH ENVIRONMENT

The research investigates the development of Helsinki-Tallinn route, and in this chapter there are two subchapters; The first one introduces the Helsinki-Tallinn route, and it consist of two subsections; the first one provides some details and key figures about port of Helsinki, the second one provides details and key figures about port of Tallinn. Meanwhile, the second subchapter provides some statistical details about both ports of Helsinki and Tallinn.

6.1. Helsinki-Tallinn route

The distance between Helsinki and Tallinn is around 82 kilometres by fairways from the west harbour in Helsinki to old Harbour in Tallinn (Google Maps, 2014), meanwhile the distance by cargo ships from Vuosaari Harbour in Helsinki to Muuga harbour in Tallinn is about 86 kilometres (Port of Tallinn, 2014a). The Gulf of Finland is a sea area, where the maritime traffic is one of the heaviest in the whole Europe. Therefore, a mandatory ship reporting system GOFREP has been established in the Gulf of Finland, which covers the international waters in the Gulf of Finland including Helsinki-Tallinn route. Therefore, any 300 gross tonnage or upward vessels, must give a report to the GOFREP system, when it departures from the ports in the Gulf of Finland or at the latest when it enters the GOFREP area, less than 300 gross tonnage, they have to report in special cases (Finnish Transport Agency, 2014a).

The main ferry companies operating on the Helsinki-Tallinn sea route carrying both cargo and passengers are: Eckerö Line, Tallink Silja and Viking Line (Table 9). The traffic is based on Ropax/car ferry concept, where passengers and cargo are transported in the same vessels. In addition to one RoRo cargo shipping which recently (January 2015) has started by Tallink Silja between Vuosaari harbour in port of Helsinki and old city harbour in port of Tallinn (Navigator, 2015). Moreover, there is another company called Linda line, which operates only in summer time for passengers only (Linda line, 2014).

Depending on a vessel and its sailing schedule the journey from Helsinki to Tallinn and vice versa takes two to four hours. Eckerö Line has two daily departures in both directions, and Viking Line has 3 daily departures in summer and two in winter in both directions (Eckerö Line, 2014; Viking Line, 2014). Meanwhile Tallink Silja has 8 daily departures in both directions in summer and 8 daily departures from Helsinki and 7 from Tallinn in winter (Tallink Silja, 2014).

Table 9 Ferry companies carry on the Helsinki-Tallinn sea route

Ferry company	**Vessels**			
	Name	**Type**	**Lane meters**	**Speed (knots)**
Eckerö line	M/S Finlandia	Ropax	1900	27
Tallink Silja	M/S Star	Ropax	2000	27
	M/S Superstar	Ropax	1930	29
	M/S Europa	Ropax	932	21.5
Viking Line	M/S Viking XPPS	Ropax	1000	25
	M/S Mariella*	Ropax	980	20.5
	M/S Gabriella*	Ropax	900	20.5

(Source: Eckerö Line, 2014; Tallink Silja, 2014; Viking Line, 2014)

* *Only in summer time*

6.1.1. The Port of Helsinki

The port of Helsinki is located in Southern side of Finland on the northern shores of the Gulf of Finland. Around 300 kilometres to the west from St. Petersburg in Russia, and around 80 kilometres to the north from the port of Tallinn in Estonia (World Port Source, 2014a). The port of Helsinki is Finland’s main, specialized in unitized cargo services for Finnish companies engaged in foreign trade due to its location in the core of production, trade and consumption. Moreover, it is considered to be the highest frequency of scheduled departures to all major Western, Central and Northern European ports. It is specialized mainly in line passenger traffic and cruise traffic as well as in unitized cargo traffic including containers, trucks, trailers and similar units. In the passenger traffic, Helsinki is Finland's busiest port by handling over 11.1 million passengers (liner and international cruise traffic) in the year 2013. The port of Helsinki has connections, for example, to

Gdynia, Rostock, St. Petersburg, Stockholm, Tallinn and Travemünde. Cargo traffic in the port of Helsinki is composed mainly of Finnish foreign trade imports and exports. Import transports consist primarily of consumer goods and food stuff, beside raw materials and semi-finished products for industry, while export transports include especially products from forestry and metal industries (Port of Helsinki, 2014a).

The Port of Helsinki consists of three harbour sections leaded by three fairways: 11 metres deep channel to West Harbour section, 9.6 metres channel to South Harbour and Katajanokka section and 11 meter channel to Vuosaari section. Channels to these harbours are long, and they start from open sea and go through an archipelago (Finnish Transport Agency, 2012b).

South Harbour and West Harbour serve Ro-Ro traffic that is transported by passenger vessels. They serve regular scheduled passenger ferry traffic. The passenger harbours are important ports for unitised goods as well, since most of 28 vessels carry significant number of trucks and trailers besides passengers. South Harbour is Finland's largest passenger port – approximately five million passengers pass through it annually. Through its three terminals (Olympia, Makasiini and Katajanokka) it has regular scheduled sailings to both Stockholm and Tallinn twice a day. In summertime, there are also many connections with high-speed vessels to Tallinn.

The West Harbour, in turn, serves Tallinn passenger traffic. It has 8-9 daily departures to Tallinn and three times a week to St. Petersburg and one departure to Stockholm. Some six million passengers pass through the West Terminal every year (Port of Helsinki, 2014a).

6.1.2. The Port of Tallinn

The Port of Tallinn is public limited company owned by the state, the largest cargo and passenger port complex in Estonia and the biggest on the Baltic Sea coast (from cargo and passengers traffic perspective). The port consists of five constituent harbours: Old City Harbour (Old City Marina part of it), Muuga Harbour, Paldiski South Harbour, Paljassaare Harbour and Saaremaa Harbour (Port of Tallinn, 2014b). The first four mentioned harbours are located on the northern coast of Estonia, on the shores of the Gulf of Finland around

80–100 kilometres from Helsinki. Meanwhile, Saaremaa Harbour located in the north-western coast of Estonia's biggest island Saaremaa, about 180 kilometres from Tallinn to southwest. All of the harbours are open all year-round (World Port Source, 2014b). Muuga, Paljassaare and Paldiski are focused on cargo handling, Old city harbour handles both passengers and Ro-Ro cargo, and Saaremaa is a pure passenger harbour. Table 10 compares the main key features between port of Tallinn´s harbours.

In Tallinn, the approaches to the port are deep and clear and the channels to the harbours are short. Strong northern winds may effect on the vessels. From mid-January through March, the port is kept open by icebreakers. In traffic to the Old City Harbour a traffic-management route-system, the Traffic Separation Schemes (TSS), is used (National geospatial-intelligence agency, 2014, p11 -12). In the system the traffic-lanes indicate the general direction of the ships in that zone. The westbound traffic to Muuga intersects with dense north-southbound traffic to Tallinn. Additionally, the depth of the channel to the Muuga Harbour allows all the vessels that can pass through the Danish Straits to call in the harbour (World Port Source, 2014b).

Table 10 Tallinn´s Harbours main key features

	The old city Harbour(Inc. old city Marine)	The Paldiski south harbour	Paljassaare Harbour	Saaremaa Harbour	Muuga Harbour
Territory in Hectare	52.9 ha	138.6 ha	46.6 ha	13.6 ha	524.2 ha
Aquatory	79.9 ha	137.2 ha	33.5 ha	44.3 ha	752 ha
Number of berths	23	8	11	3 and one floating for small crafts	28
Total length of berths	4.2 km	1.4 km	1.9km	460m	5.9km
Max. depth	10.7 m	13.5 m	9m	10m	18m
Max. length of the vessel	320m	230m	190m	200m	300m
Max. width of vessel	40 m	35m	30m	30m	48 m
Terminals	4 passengers terminals (incl. Ro-Ro facilities), mixed terminal	8 terminals one each for: passenger, petroleum, Ro-Ro, general cargo, timber, wood ballets, peat and biodiesel. 2 car terminals. 2 Metal terminals.	7 terminals one each for: Oil, cooking oil, timber, coal, general cargo (incl. reefer terminal) and dry bulk.		6 liquid bulk terminals 2 multipurpose terminals (one of them with a reefer complex) 5 terminals, one each for: container and Ro-Ro , dry bulk, grain, steel, and coal
Storage area:	Covered area: 10.400 m² opened area: 95000 m²	Covered area: 15,000m². Opened area: 500000 m² Oil tank capacity: 357900 m³	Covered area: 16000 m² Opened area: 105000 m² Oil tank capacity: 42000 m3 Reefer warehouse area: 15,000 m2		Covered area: 151000 m² opened area: 670000 m² Reefer warehouse area: 11 500 m². Oil tank capacity: 1550150m³ Grain silo: 300000 t

(Source: Port of Tallinn, 2014a)

6.2. Statistical analysis for transportation at port of Helsinki and port Tallinn

In 2013, the total transported goods (Liquid bulk, dry bulk, large containers and RO-RO, mobile self-propelled unites) by the main ports in Finland was 102,195 thousand tonnes and for Estonia 39,453 thousand tonnes (Eurostat, 2014a). Whereas, 7% of the Finnish total maritime transport from the previous mentioned goods type was with Estonia, with 3514.4 thousand tonnes as import and 3195.5 thousand tonnes as export. In the same year, the share of Helsinki port from the total Finnish maritime transport was about 11% (Finnish transport agency, 2014c). Meanwhile, Tallinn port handled 28,247 thousand tonnes (port of Tallinn, 2014d), which represent almost a share of 72% from the Estonian total maritime transported goods.

Regarding passengers travelling from Helsinki to Tallinn and vice versa, it has been continuously growing; Figure 11 shows the volumes of passengers travelling in both ways from 2003 to 2013 in all ships on the Helsinki-Tallinn route. Passenger volumes are almost similar in both ways from Helsinki to Tallinn and vice versa specially after the year 2003, Estonian passenger volumes started to grow slightly more than the Finnish passengers to Estonia, after Estonia has joined the European union in 2004.

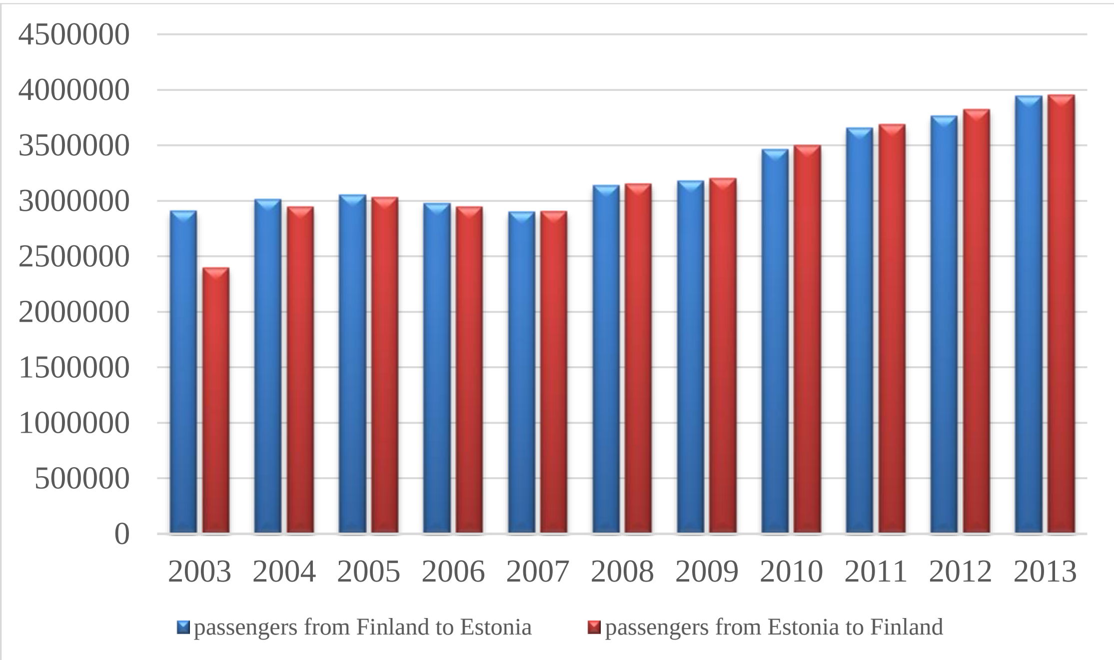

Figure 11 Passenger volumes between Helsinki and Tallinn (Statistics Estonia, 2014).

Figure 12 shows the total unitized cargo in trucks and trailers in thousand tonnes transported in both ports Helsinki and Tallinn by Ro-Ro shipping from the year 2003 to the year 2013. Helsinki port represent the biggest port in Finland regarding the amount of trucks and trailers transported in all Finnish ports. In 2013, port of Helsinki transported a total of 6065 thousand tonnes of unitized cargo in trucks and trailers, which represents almost half of the total volumes transported by all Finnish ports (Finnish port Association 2014c). Meanwhile, port of Tallinn´s transported unitized cargo is showing recovery after the economic crisis in 2008, but still a decline in 2013, which might be due to the slowdown in the economic growth of port of Tallinn (port of Tallinn 2014c).

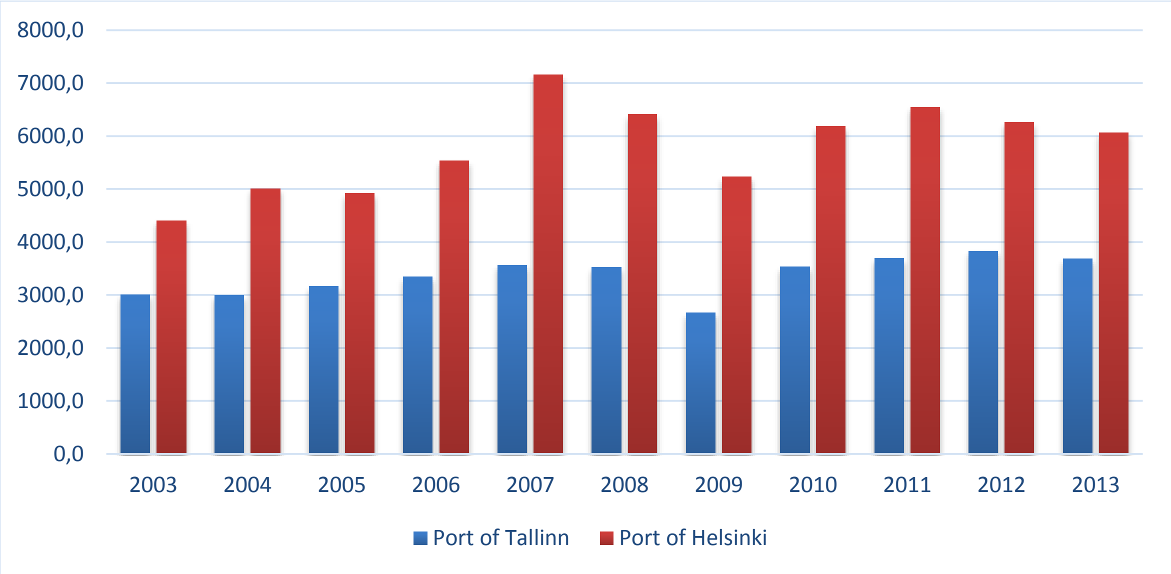

Figure 12 Comparison between the volumes of Ro-Ro, mobile self-propelled units in both ports of Helsinki and Tallinn (source: port of Tallinn, 2014c; Finnish port Association, 2014a).

Figure 13 compares the container volumes in both ports of Helsinki and Tallinn in the units of TEU from the year 2003 to the year 2013. Port of Helsinki is showing a slow recovery after the 2008 crisis, with a decline in 2013. Meanwhile, port of Tallinn is showing a steady increase after the 2008 crisis. The increase could be related to the growing trend in the trade sector to deliver goods in containers on the east coast of the Baltic Sea and the area beyond (port of Tallinn, 2014d), due to the implementation of container trains to the eastern destinations (Hilmola & Henttu 2014).

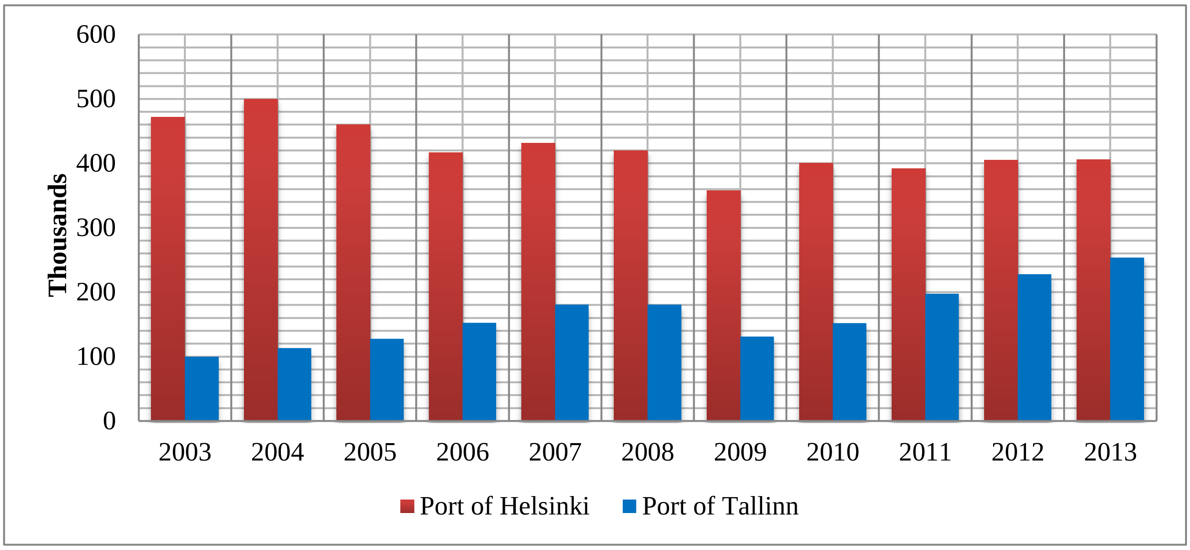

Figure 13 Container volumes handled in both port of Helsinki and port of Tallinn (Source: Finnish port Association, 2014b; Port of Tallinn, 2014d).

7. DATA ANALYSIS

As mentioned in chapter two, this research uses the triangulation for data collection and analysis. Therefore, the primary data collected via interviews and observations will be implemented in the data analysis. Additionally, since this research is part of a project work, research progress, data collection and stage findings were presented to the main stakeholders described in Figure 5. The presentations took place in port of Helsinki at the following date: the first meeting in 28.08.2014, a presentation for the basic shipping cost calculations, and the collected data and findings until that time. Second meeting in 26.09.2014, which presented findings from the shipping cost calculations and the collected data and data analysis regarding loading/unloading methods. Meanwhile, the last meeting was in 27.11.2014, in which a presentation for the CONRO calculations was presented, and the data collection and findings.

This chapter consists from seven subchapters, starting by the SSS cost calculations, then the shipping cost calculations will be analyzed in subchapter two, and the factors affecting on SSS will be discussed in subchapter three. Ropax shipping cost will be analyzed in subchapter four, and CO_2 emissions due to SSS at Helsinki-Tallinn route will be illustrated in subchapter 5. Subchapter 6 discusses Ro-Ro traffic possibilities, meanwhile the last subchapter demonstrate the CONRO shipping possibilities at Helsinki-Tallinn route.

7.1. SSS cost calculations for transportation at Helsinki-Tallinn route

The chosen ships for the SSS cost calculations

For the purpose of calculating the shipping costs at Helsinki-Tallinn route, the ships in Table 11 has been chosen. The ship sizes ranging between 100-1,000 FEUs. The reason behind choosing such range of containership sizes, is due to the characteristics of Helsinki-Tallinn route (e.g. the short distance between the two capitals, available container volumes for transportation, port sea draught, etc.). Additionally, the containership sizes is expressed in terms of “FEU”, so it could represent both the forty-foot container and semi-trailer units.

Table 11 represents a comparison between a range of ships according to their: size (measured in FEUs), age (or built year), Estimated service time, price, net tonnage[1], gross tonnage[2], and fuel consumption.

Table 11 The group of chosen ships and their key features

Size (FEU)	**Age/built year**	**Estimated service time (years)**	**Price (million €)**	**Net tonnage**	**Gross tonnage**	**Fuel consumption (per trip in €)**
120	2012	20	25.00	1008	3000	2500.00
110 II	2011	20	2.97	1491	3739	2500.00
110 I	2005	18	1.15	2978	1314	2500.00
233	10 years old*	7	5.19	2625	5239	2 273.51
481	2013	20	14.68	5464	10288	3 247.87
800	10 years old*	7	5.93	8222	16145	2 560.89
981	10 years old*	7	11.12	9251	21842	4 366.65

**mentioned in "built year" due to data source.*

Finding statistical data about ships, including prices and fuel consumption, was quite a hard task, since shipping companies don't reveal such information due to many reasons (e.g. competition in the market, indemnity insurance, etc.), so to obtain ship prices and age/ built year, the following source was used: Firstly, the months report of April and June 2014 from the international ship and offshore brokers and investment bank (PLATOU, 2014). Secondly, the report of 2013 from the maritime transport published by the United Nations (UNCTAD, 2013).Meanwhile, the fuel consumptions for the 120 FEUs was obtained from the shipping company interview, meanwhile the 233 FEUs, 481 FEUs, 800 FEUs and 981 FEUs is based on LIPASTO traffic emissions (LIPASTO, 2009).

[1] Net tonnage is a non-dimensional unit, refer to the volume of cargo spaces in the ship (ISL, 2006).
[2] Gross tonnage is a non-dimensional unit, refer to the total volume of enclosed spaces in the ship (ISL, 2006).

Shipping cost calculation model

In order to calculate the shipping costs for different ships, it was necessary to use a specific pattern and apply it on all the ship examples used, and for this purpose a model was created is it can be seen in Figure 15.

The shipping costs data, is based on secondary (databases) and primary sources (data collected from interviews) as illustrated earlier in Table 3. Meanwhile, the cost calculations method is derived from the process of adding all the costs generated from transporting one FEU at Helsinki-Tallinn route, including the ship fixed costs. Consequently, the process of calculating the shipping cost per FEU is summarised in the following steps:

1. Calculating the port costs per annum including port dues (Helsinki and Tallinn) and the loading/unloading costs.

In step one, port dues in port of Helsinki depends on the ship net tonnage, meanwhile in Tallinn it depends on the ship gross tonnage. Additionally, the loading/unloading costs is not part of port dues, because in both ports it's managed by private companies. But they are added here, because time of loading/unloading determines the possible number of visits per day and consequently per year, which influence the port dues (a discount is given by ports for the increase number of ship visit per year). Table 12 below demonstrates the port costs in addition to container handling costs in port of Helsinki and port of Tallinn ports.

Table 12 Costs in port of Helsinki and port of Tallinn

Port of Helsinki	**Port of Tallinn**
Waterway dues	Waterway dues
Pilotage payment (once a year)	Lighthouse dues
General cargo payment in sea port	Navigation dues
Sea vessel payment in sea port	Pilotage payment
Waste payment in sea port	Tonnage payment at sea port
Mooring and unmooring	Waste payment in sea port
Handling of units in terminal area	Mooring payment in sea port
Gate fee, units arriving / departing to / from terminal	Handling of units in terminal area

(Source: Port of Helsinki, 2014a; port of Tallinn, 2014b)

2. Adding the ships costs per annum which includes:
    a. Fixed costs and fuel costs;
    b. Salary costs;
    c. Overhead costs (50% of the total salaries);
    d. Maintenance costs (10% of the total annual capital costs).

In step two, fixed costs are taken as yearly payment to cover the loan and the interest costs. Additionally, when calculating the fuel costs it was taken into consideration the use of Marine gas oil (MGO) with low sulphur content (0.1%), in order to cope with the new sulphur regulations starting from the 1st of January 2015. Meanwhile, salaries can be calculated by first knowing the crew size, and in the research, the crew size was determined based on the interview with the shipping expert (see Table 3), and then calculating the salaries according to Finnish payroll system (Konepäällystöliitto). Following, the overhead costs was calculated as 50% of the salaries. Lastly, the maintenance costs were taken as 10% from the yearly fixed costs.

3. Adding a marginal profit of 10% from the sum of 1 & 2.

4. Dividing the result form step 3 over the amount of trips performed per year, which yields to the costs per one trip.

5. Finally, dividing the result from step 4 over the amount of FEUs per trip, which gives the shipping costs per FEU.

In the last step, the sum of the above mentioned costs gives the ship costs per year, and in order to find the ship costs per visit, it is important to know the time needed for one visit, which includes the loading/unloading time at port, and the time at sea. Loading/unloading time depends on the loading method, in the calculations the normal loading method by the gantry crane was taken, which performs an average of 30 moves/hour (cargo flow solutions expert 3 interview), meanwhile the time at sea depends mainly on the ship sailing speed, which was taken as 10 knots per hour[3] (based on the shipping company interview). Figure 14 represents the shipping costs model used to calculate the shipping cost per FEU for different ships with different sizes/capacity (in FEUs).

[3] 10 knots per hour is equal to around 18.5 km per hour (Metric conversion, 2014).

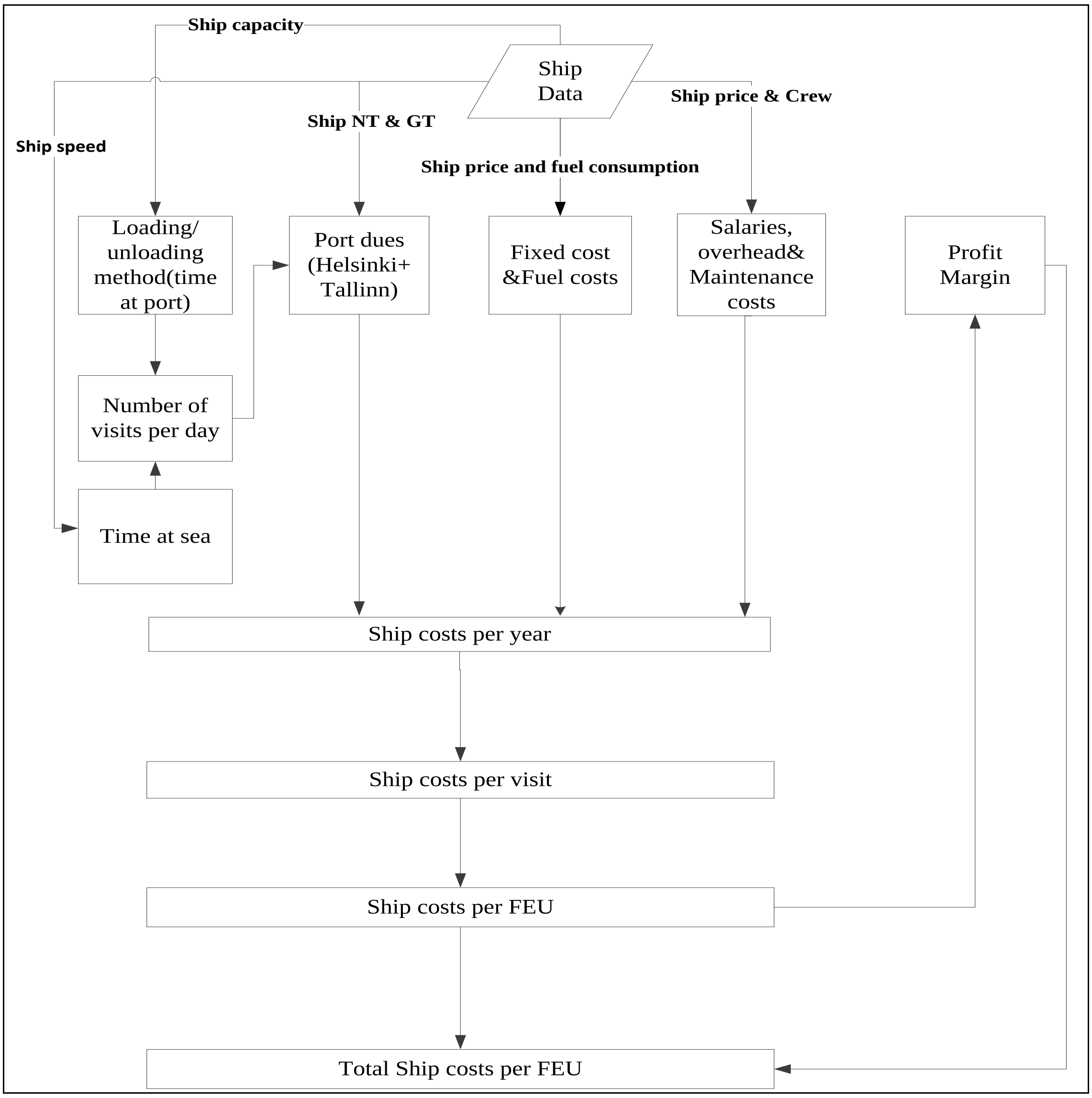

Figure 14 Shipping cost calculation model

The size of the ships in Table 11 represent the maximum capacity of each ship measured in FEUs, but practically the ship does not always sail with full capacity, so in order to determine the shipping costs per FEU variation with changing capacity, four utilization scenarios were considered as percentage from the full capacity. The utilization scenarios are: 85%, 65%, 50% and 25%, and Figure 15 represents the shipping costs per FEU for the chosen ships with the different utilization scenarios (See Appendix 4 for the cost per FEU calculations for the ships illustrated in Table 11).

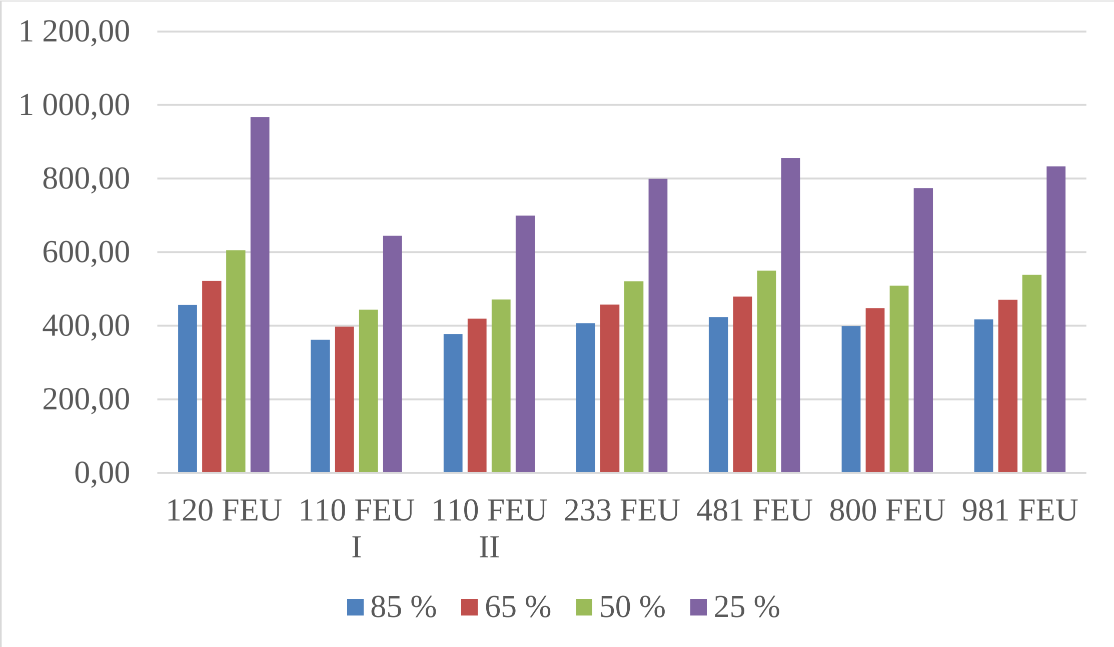

Figure 15 ship costs per FEU in Euros for different ship sizes and different utilizations.

From the previous figure, it can be noticed that the total shipping costs per FEU increases with the increasing the ship size, except for the 120 FEU ship which do not follow the trend, due to the relatively high purchase price compared to the ship 110 FEU I and 110 FEU II. The reason behind this high purchase price is that the 120 FEU ship is a special ship that can load different kind of dry bulk cargo with different loading methods (shipping company, 2014) meanwhile the rest of the ships are used traditional container ships. Additionally, For each ship, the lower the utilization is, the higher the total ship costs per FEU, since the total ship costs will be allocated to less number of containers.

7.2 Shipping cost analysis for SSS at Helsinki-Tallinn route

From Figure 14, it can be noticed that the shipping costs consists from three costs categories, each one of them contribute differently to the total shipping costs. Therefore, in order to analyze the shipping cost per FEU, it is necessary to analyze the contribution of these costs. The cost contributions are:

- Contribution 1: Cargo and port costs contribution

- Contribution 2: Fixed and fuel costs contribution
- Contribution 3: Salaries, overheads and maintenance costs contribution

Figure 16 demonstrates the results obtained in Figure 15, but with the difference that the shipping cost for each ship is divided into the three cost contributions. The results are illustrated in Figure 16 shows how the above mentioned contributions changes with the different utilization cases for the different ship sizes (see Appendix 4 for the cost contributions calculations for each ship).

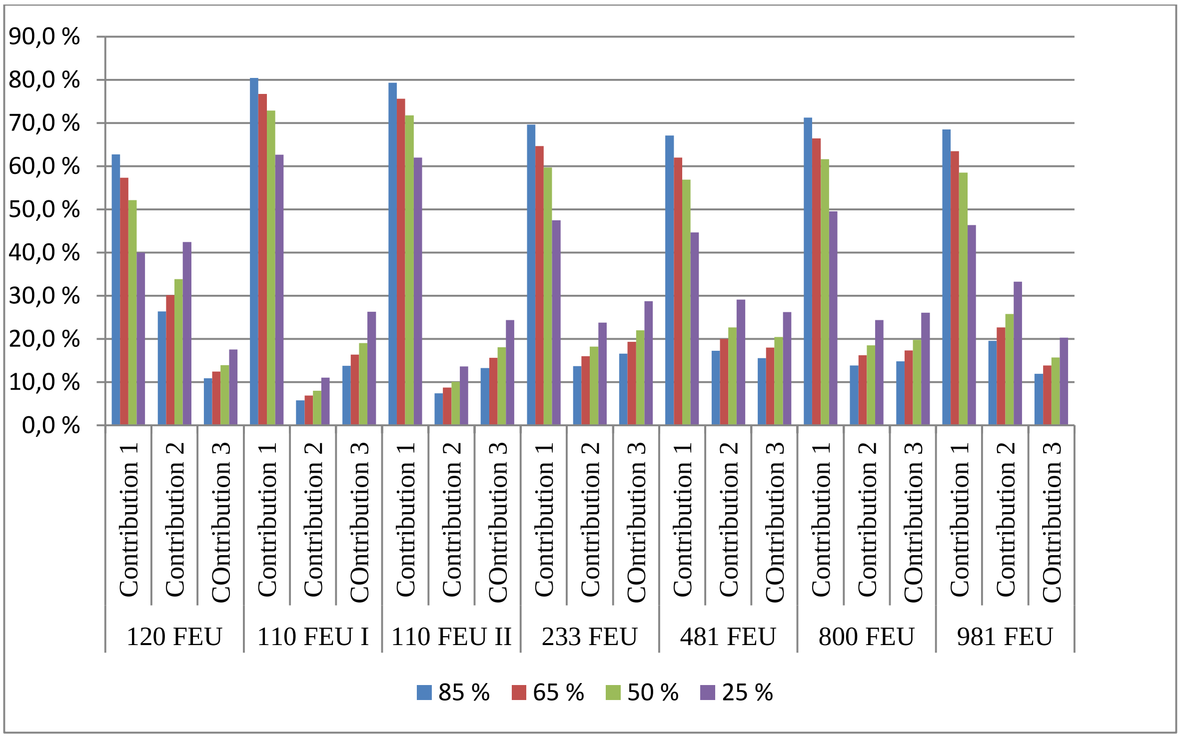

Figure 16 Costs contribution for different ship sizes with different utilizations.

From Figure 16, it can be noticed that the cargo and port costs contribute the most to the total shipping costs ranging from 62.8% in the case of the ship 120 FEU to 80.4% in the ship 110 FEU I for the 85% utilization case. The reason behind this is the 120 FEU is the most expensive ship among the others ships from Table 11, this relative high ship price will contribute more to the fixed costs, and consequently will increase the second contribution to be the highest among the other ships with 26.4% from the total shipping costs for the same utilization case. Meanwhile, contribution 2 is the lowest for the ship 110 FEU I due to the relative low ship price among other ships from the same table.

Regarding contribution 3, it was ranging from 10.9% in the 120 FEU ship to 16.6% in the case of the ship 233 FEU for the 85% utilization case. This could be explained as this cost contribution consists from salaries, overhead and maintenance costs, the bigger the ship capacity, the lower this contribution will be. Accordingly, the 120 FEU ship should have a higher contribution than the 233 FEU, but it is lower, due to the reason that the 120 FEU ship performs more trips a day than the ship 233 FEU, which will increase the amount of FEUs transported and consequently reduce the salaries, overhead and maintenance costs contribution.

Additionally, the cargo and port dues costs per FEU (contribution 1) is directly proportional to the utilization -more FEUs means more cargo charges- opposite to both; fixed and fuel costs per FEU (contribution 2) and salaries, overhead and maintenance costs per FEU (contribution 3) which inversely proportional to the utilization.

As a summary from this section, there are other factors influencing on shipping costs per FEU rather than ship size, which are: ship purchase price, utilization and number of performed trips per day. In the following subsections these factors will be discussed.

7.3. Factors affecting on SSS costs

7.3.1. Ship purchase price and utilization

Based on the data provided in Table 11, the purchase price for the ship 120 FEUs is 25 million Euros, meanwhile it is only 2.965 million Euros for the 110 FEUs. Despite the fact that both ships are approximately the same capacity and built year, but still there is a big difference in purchase price. The difference in price is due to the fact that, the 120 FEUs ship is a special ship with extra capabilities that enable it to act as multifunctional ship (see subchapter 7.6.). Figure 17, compares between costs contribution factors for both ships for different capacity utilizations scenarios.

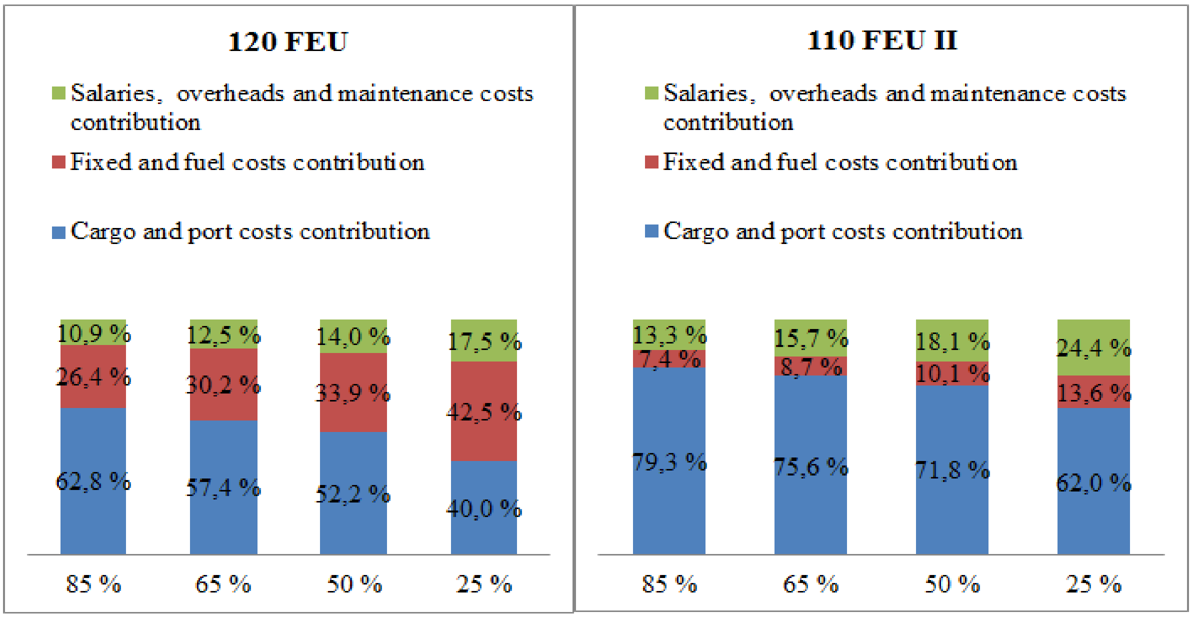

Figure 17 Comparison between costs contribution factors for 120 FEUs and the 110FEUs ship.

Figure 17 show how purchase price effects on the costs contribution, when calculating the shipping costs per FEU, and we can notice that when ship purchase price increase or relatively high the fixed and fuel costs contribution will increase (mainly fixed costs increases, with relatively increase in fuel consumption due to the extra weight from the same sized container ships), and this will decrease the cargo and port costs contribution, and the more the utilization decreases, the more the fixed costs and fuel costs contribution will increase, which means a big share of the shipping costs will be contributed from the ship purchasing price.

Additionally, from Figure 15 it can be noticed that the shipping cost per FEU inversely proportional to the utilization i.e. the shipping cost per FEU increases with the decrease in the utilization. Since, the total cost per FEU will be allocated to less number of units in the case of low utilization, which agrees with the economy of scale principle. Therefore, in order to take advantage of the economy of scale, the highest possible utilization should be always tried to reach, which can't be always guaranteed in such short sea leg as Helsinki-Tallinn route, since the wheeled cargo is dominating. According to Hilmola (2014), 96.2 % of the cargo transported between Finland and Estonia are on wheels.

7.3.2. Number of performed trips per day

The results presented in Figure 15 are based on certain number of visits per day/year for each ship in Table 11. The number of visits was calculated based on two factors: first, the time needed to cross the distance between Helsinki and Tallinn (which depends on the ship speed), and secondly the loading and unloading time needed at ports. The time needed to cross the distance between Helsinki and Tallinn, is almost constant for all ships, since the sailing speed is approximately similar for most of the cargo ships, since they tend to take advantage of low steaming as discussed in the subsection 4.6.1. Meanwhile, loading and unloading time at ports depends heavily on the loading/unloading method.

Currently, both harbours Vuosaari and Muuga uses the LOLO [4] operations for loading/unloading the containerships by the gantry cranes. The gantry crane can perform roughly an average of 30 moves per hour (30 FEUs per hour). However, some terminal operations companies can promise a maximum capacity up to 50 moves per hour, in case of available sufficient amount of containers to cover a full shift of 8 hours, which can't be always guaranteed in short sea routes like Helsinki-Tallinn route (cargo flow solutions experts 3, 2014).

Table 13, represents the number of performed trips per day for ships using gantry crane with a loading /unloading capacity of an average of 30 moves per hour, and

Table 13 Number of performed trips per day

SHIP Capacity (in FEUs)	120	110	233	481	800	981
Time needed to cross the distance between Helsinki and Tallinn (in days)	0.19	0.19	0.19	0.19	0.19	0.19
Loading and unloading time with gantry crane (in days)	0.33	0.31	0.65	1.34	2.22	2.73
Number of trips per day	1.92	2.03	1.20	0.66	0.41	0.34

[4] LOLO (Lift On-Lift Off) is an operation for loading and unloading the cargo over the top of the ship using cranes.

From Table 13, it can be noticed that the number of trips per day inversely proportional to the ship capacity, which is mainly because of the increasing loading/unloading time for bigger ships. Although, the ship 800 and 981 FEUs are large enough to be loaded/unloaded with two gantry cranes in the same time, but as mentioned earlier, it depends on the availability of containers volumes. Additionally, the number of trips calculations assumes that the port operates 24 hours a day, which is theoretically possible (Vuosaari, 2014), but practically it will be more expensive, since the salaries of the port workers will increase, due to the extra payment for the night shift (cargo flow solution expert 3, 2014).

As a summary, there are other factors effecting on shipping costs rather than the ship size, like ship purchase price, utilization, and number of trips per day. Utilization and number of trips per day depends mainly on the availability of enough transported units, and the bigger the ship is, the more challenging to guarantee a high utilization and more trips. Moreover, low utilization and less number of trips increases the shipping costs per FEU transported, and as a result it will effect on the competitiveness of the container transportation at Helsinki-Tallinn route.

7.4. Ropax shipping cost per unitized cargo at Helsinki-Tallinn route

Calculating Ropax shipping cost per unitized cargo, can be done by following the model provided in Figure 14 except the time at port, it will not be taken into consideration, since the Ropax ferries have a fixed trip schedule per day, so both passengers and cargo would be on time. Regarding cargo, its mainly wheeled cargo, so it will be driven into the ferry by its own power, and the ferry lashing crew will take the responsibility of lashing each truck in the inside lanes. Table 14 illustrate the key features of the chosen Ropax ferry example; m/s Star which is one of Tallink Silja company´s fleet.

Table 14 Ropax ferry key features

ship	M/s Star
Built year	2007
Procurement costs € (MGO modification costs added)	131400000
Semi-trailer Length "truck" (in metres)	17.3
Trucks capacity	120
Average load of semi-trailer (in tonne)	13.85
Cars capacity	450
Car length (in metres)	5
Passengers capacity	1900
Lane capacity (in metres)	2000
Gross tonnage of sea vessel (in tonne)	36249
Net tonnage of sea vessel (in tonne)	13316
Amount of trips per day	6

(Source: Tallink Silja, 2014)

As it can be seen in Table 14, m/s Star lane capacity is either 120 trucks or 450 passenger cars, but in daily trips a mixture of both cars and truck are being loaded to.

The result of applying the cost calculation model on the Ropax ferry case, is illustrated in Table 15 (see Appendix 5 for the full calculation of the Ropax cost per visit calculations). Port dues are calculated as for any other container ship, with the following differences: Water dues is paid only for the first 30 times in port of Helsinki and the first 60 times in port of Tallinn per year. Additionally, port of Helsinki give discount on sea vessels payment for ships having fixed schedule for at least three months in the year, meanwhile, port of Tallinn gives discount on payments for the increasing Tonnage (Port of Helsinki, 2014a; port of Tallinn, 2014b). Additionally, port cost per visit, is allocated to truck only, since the port dues depend on the volumes and type of cargo loaded on trucks.

Table 15 Ropax ferry shipping costs per visit

Average amount of trucks per visit (2014)	33.22	Costs share from the total costs per visit
Passengers fees in both ports per one visit	3 263.01	5.4%
Ports costs per visit (in €)	20670.08	34.5%
Fixed and fuel costs per visit (in €)	18340.84	30.6%
Salaries costs per visit (in €)	11393.75	19%
Overhead costs per visit (in €)	5696.88	9.5%
Maintenance costs per visit (in €)	530.37	0.9%
Total cost per visit (in €)	59 894.93	

As it can be noticed from the cost calculations presented in Table 15, it doesn't take into consideration truck capacity utilization cases, due to the fact that Ropax ferries carries passengers, cars and trucks, so the total costs per visit should be allocated to the three of them with a certain percentage determined by the company itself. According to Tallink Silja´s cargo sales manager, in 2012 the biggest share of the revenue came from restaurant and on board sales with 59%, following by the tickets sales with 28%, and in the third place cargo with 11% and the final share to others with 1% (cited in Hämälainen 2014).

Additionally, in Table 15 the average amount of trucks per visit is calculated based on the monthly published data by the company exchange press releases (Tallink Grupp, 2014). From these statistics, the average truck capacity per visit was calculated by finding the total sum of trucks transported in the year 2014, then dividing the average per month over 30 (amount of days of the month), and finally dividing the result by 14 (total number of departures per day by Tallink Silja fleet between Helsinki and Tallinn). However, the allocation of other costs like salaries, overheads, fuel consumption and maintenance costs cannot be allocated only to trucks, because there are still the passengers and passengers' cars transported in the same ferry. Based on Tallink Silja monthly reports, in 2014 the average volumes transported between Finland and Estonia in a month was 13950.92 trucks, 66506.83 passenger's cars and 376501.08 passengers. So, in order to calculate the costs per truck, the following assumption was made: 40% of the total costs are allocated to trucks and passenger cars transported, and 60% to the passengers. Moreover, the 40% allocated to trucks and passenger cars is also divided as 40% for trucks and 60% for passengers' cars.

Moreover, a cost of 1 passenger is added to the cost per each truck (since the truck will be driven by its power) and the costs of two passengers with each passenger car. The results are shown in Table 16 (see the full calculations in Appendix 6):

Table 16 Ropax cost allocations

Item	Amount per visit	Cost per unit calculated (Euros)	Company selling price (Euros)
Truck (with 1 pass.)	33.22	349.9*	446
Car (with 2 pass.)	158.35	164.8	90
Passenger	554.19	40.6	30

** Additional 4.5 Euros will be added to each truck for loading/unloading from the ship in Port of Tallinn*

In Table 16, company selling prices for cars and passengers are based on the published prices from Tallink Silja´s website (prices vary depending on seasonality), meanwhile the selling price for truck transportation is based on the study of Hilmola (2012). Additionally, it can be noticed from the cost calculations that the selling prices for passenger tickets and transporting passengers' cars are lower than the calculated ones, meanwhile the selling price for trucks is higher than the cost calculations. Additionally, the general cargo payment in port of Helsinki was allocated only to trucks since it is charged based on the weight of the cargo and type (Port of Helsinki, 2014a), meanwhile the general cargo payment in port of Tallinn was allocated to trucks, cars, and passengers since the port of Tallinn charges the general cargo payment passed on the gross tonnage of the whole ship, but an additional of 4.5 Euros will be added to each truck for loading/unloading from the ship (Port of Tallinn, 2014e).

According to the calculations presented in Table 16 the cost per transported truck by a Ropax ship is 354.4 Euros, but for high volumes transport such as forest industries discount can be given by excluding the fixed, overhead, and maintenance costs from the total costs, and the charged cost per truck could be dropped to 266.87 Euros (see Appendix 6).

From the previous calculations, it can be noticed that the Ropax shipping cost calculations depends on the allocation ratio used, and using different allocation ratio than the used above, might give different results for the calculations. However, the flexibility of allocating the costs in Ropax ships on the transported trucks, cars, or passengers could be considered as advantage compared to containerships, where all the costs will be allocated on the transported containers. Additionally, as mentioned earlier the biggest share of revenue for the Ropax ships came from restaurant and on board sales.

7.5. CO_2 emissions due to SSS at Helsinki-Tallinn route

In this subchapter, the CO_2 emissions from the container ships listed in Table 11 and the Ropax ship used in subchapter 7.4 is calculated. CO_2 emissions were calculated as following: Firstly, the amount of fuel consumed during the trip between Helsinki and Tallinn was calculated, then converted to CO_2 emissions using the Department for Environment Food and Rural Affairs (Defra) conversion guide. Whereas, one litre of diesel oil is equivalent to 2.6569 kg of CO_2 (Defra, 2012). Secondly, adding the emissions produced from hinterland operations. For container ships it includes the emission from gate to container yard, from container yard to shore, and from shore to ship, meanwhile for Ropax ship hinterland emissions includes only the emissions from gate to ship. Thirdly, the total amount of emissions will be divided on the amount of unitised cargo transported in each utilization case.

Meanwhile, for Ropax ship CO_2 emission calculations, the previous steps were applied too, in addition to one extra step, which is finding the semi-trailers emissions share from the total ship emissions. According to Defra (2013), CO_2 emissions are allocated to passengers based on the weight of passengers, luggage, and cars relative to the total weight of cargo including cargo vehicles/containers, and from Defra the ratio is equated to just under 12% of the total emissions of the ferry operations. Meanwhile, LIPASTO (2009) allocates 84% of total ship emissions to cargo and 16% to passengers for a Ropax ship with a capacity of 300 semi-trailers and a gross tonnage of 40,000. Meanwhile, for a ferry of 60 semi-trailers and a gross tonnage of 43,000 the ratio is 80% for passengers and 20% for cargo. Therefore, due to the different methods for determining the emissions allocation ratio, in this research the ratio used is as the one used for the Ropax in the LIPASTO calculations.

Figure 18 compares between the emitted amounts of CO_2 in grams for different ship sizes with different utilization cases to transport one FEU (or semi-trailer in case of Ropax ship) via Helsinki-Tallinn route.

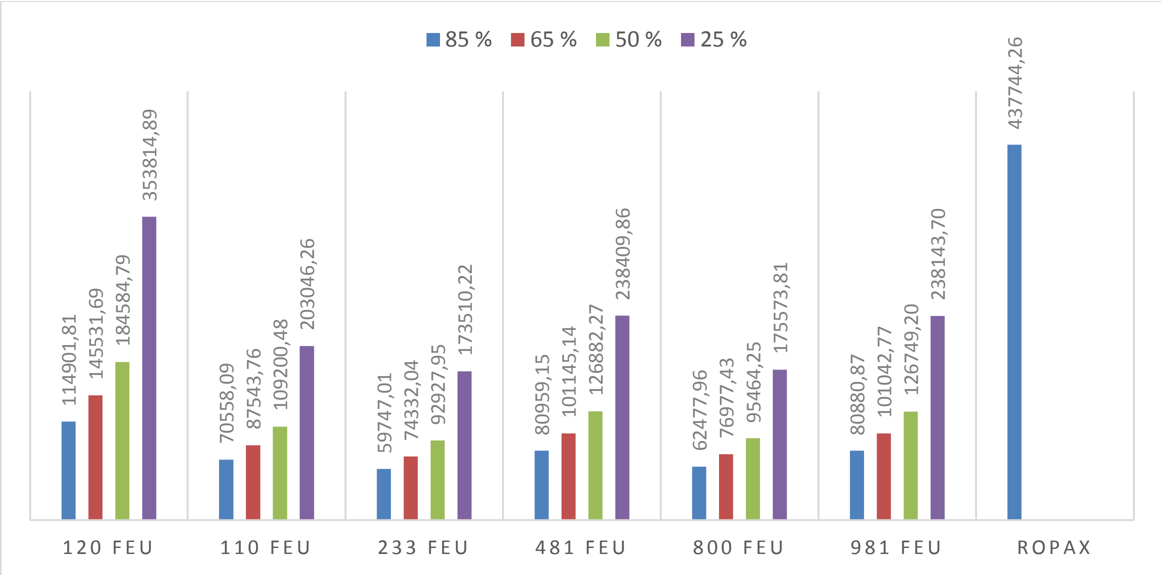

Figure 18 CO_2 emissions in g per unit transported by different ships at Helsinki-Tallinn route.

From Figure 18, it can be noticed that in case of container ships the better the utilization is, the less the emission per unit transported will be. As the total amount of CO_2 emissions will be divided on more units, and this will reduce the share of emission per unit. Meanwhile, in the Ropax case, the emissions where taken for one utilization case (85%), because the allocation ratio used is applied on one utilization case, and other utilization cases needs different allocation ratios (which might yield to variation in the emissions calculations), since the ratio calculation should take into account the utilization of the passengers as well.

As discussed in previous section, Ropax shipping serve both passengers and cargo, and it is favoured by the logistics companies mainly because of their fixed multiple trips in the day, which can help the industrial communities in both cities Helsinki and Tallinn, especially for whom are adapting the Just-In-Time (JIT)[5] principle (Industrial companies, 2014).

[5] JIT is principle that focus on reducing the warehousing and use the right amount of raw materials or semi-finished parts on the right time for assembly or any other phase in the supply chain (industrial companies, 2014)

However, the relative high amount of CO_2 emissions produced can be considered as a big disadvantage for such ships from environmental friendliness perspective. Moreover, the current amount of CO_2 emitted by the Ropax is calculated based on a speed of 18 knots, but with higher speed the amount of CO_2 increases too. According to LIPASTO calculations, increasing the speed by 33% would increase the emissions by 81% higher.

7.6. Ro-Ro traffic at Helsinki-Tallinn route

This subchapter examine the possibilities of Ro-Ro traffic at Helsinki-Tallinn route, specifically between Vuosaari and Muuga harbours, by investigating the possibilities of a CONRO ship, which is used as a case study.

The 120 FEUs ship described in Table 11 represent the Conro ship case study, due to its characteristics as multifunctional ship, which has the ability to handle unitized cargo and a variety of other dry cargo as well. The Conro ship has a length of 105.4 and a breadth of 18.8 metres with a working deck area of 1610 m^2. The significant feature of this ship is its ability to adjust the deck height above the water level to fit with different quays in different ports, due to its strong bumps that can control the deck height (Shipping Company interview, 2014). The ship capacity is relatively small (120 FEUs), but still can fit for Helsinki-Tallinn route volumes for both containers and wheel cargo.

As mentioned earlier Ropax ships are dominate carriers for wheeled cargo at Helsinki-Tallinn route (operating on other routes than Vuosaari-Muuga route) and its biggest advantage is the frequent visits per day as described in the subchapter 6.1, which makes the Ropax ship favoured by the industrial sector for transporting goods between Finland and Estonia as it can reduce their Lead Time[6]. According to the conducted interviews with the industrial companies in Estonia (2014), the trucks that collect the transported items in the end of the working day, are to be shipped in same evening so they reach the recipient in Finland in the second day, and vice versa.

[6] The amount of time that elapses between the start of a process and when it is completed.

Therefore, it can be concluded that in order to compete with Ropax ferries, Conro ship must make at least two trips a day in order to fulfil the demand of the route. This can be achieved by decreasing the time needed to make one trip, which consists from the time needed to cross the distance between Helsinki and Tallinn, and the time needed to load/unload the ship. The first part of the time is almost constant, since most of the ships prefer the low steaming. Meanwhile, the second part of the time can be reduced by using a faster method for loading and unloading the ships. The following subsections, discuss different alternatives for faster loading/unloading solutions.

7.6.1. Loading/unloading the CONRO ship by reach stackers[7]

The idea of using reach stacker in loading and unloading the Conro ship, is the flexibility of reach stacker to be driven to the edge of the quay, in order to load/unload the ship. Reach stacker can perform up to 20 moves per hour (cargo flow solutions expert 2 interview, 2014), which makes the gantry crane a faster option, unless two or more reach stackers are used to load/unload the ship. According to Table 12 the number of trips performed by the 120 FEUs (the Conro ship) was 1.92 trips per day using the gantry crane for loading/unloading. Meanwhile, by using two reach stackers the number of trips performed will be 0.251 trips per day, which means a 23.5% less than the time needed using a gantry crane. Additionally, the time would be even more less in case of mixed unitized cargo (i.e. containers and wheeled cargo), since not all the cargo will be in need for loading/unloading.

Though, theoretically it is possible to use two or more reach stackers for loading/unloading a ship, but still it depends on the ship length, that there would be enough space for the reach stackers to operate in the same time, which requires high driving skills as well (Cargo flow solutions expert 2 interview, 2014).

Ports´ observations

During ports´ visit (Vuosaari and Muuga), the possibility of loading a CONRO ship by a reach stacker was investigated, and it was noticed that it is possible to use it in Vuosaari, but not in Muuga. It is hard to be use it in Muuga, due to quays´ structure; the edge of the

[7] Rubber-tyred vehicles operates in terminals for handling containers, usually powered by diesel engines and equipped with a driver cabin.

quay from sea side is like the shape of inverted “L” letter (see Figure 19), which means that the reach stacker cannot be driven to the edge of the quay to load a ship. In some Muuga´s quays, the nearest point a reach stacker can approach is 4 metres from the edge, which will decrease the utilization of the ship (since the reach stacker will not be able to reach the far side of the ship).

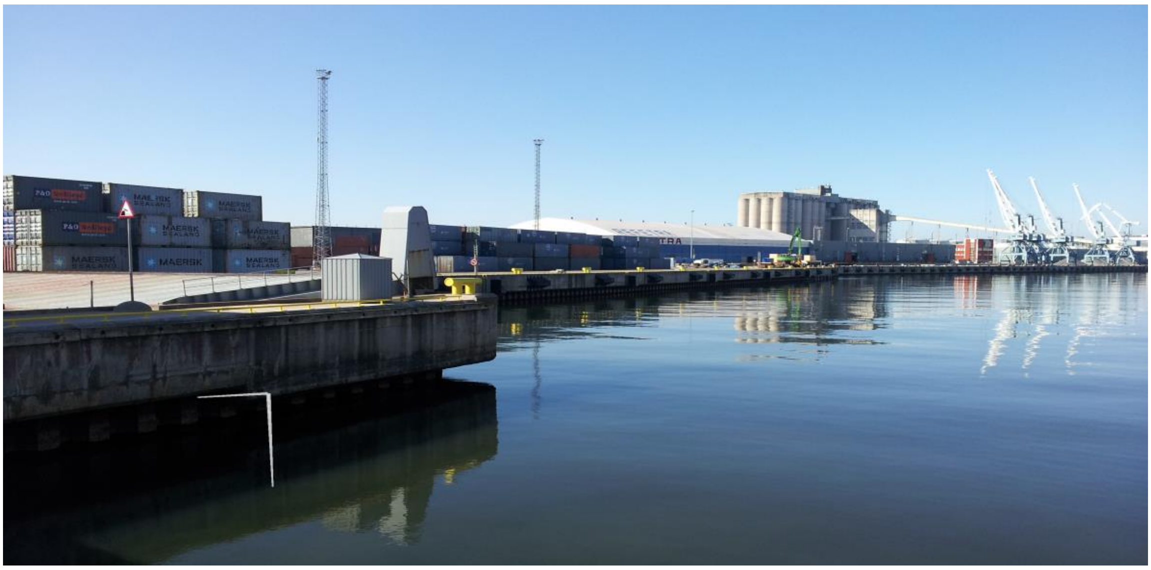

Figure 19 One of Muuga´s quay edge (quay 14).

Figure 19 represents quay 14 in Muuga´s port, which contain a ramp for Ro-Ro traffic, but currently there are no gantry cranes. Therefore, with the current conditions of quay 14, it is not possible to use it to load/unload a CONRO ship. But there is a possibility to use -an existing- movable crane, which can be relocated to quay 14. According to Muuga´s port operational director (2014) the existing movable crane has an efficiency of 20 moves per hour. Additionally, in quay 15 (exact opposite side to quay 14 as in Figure 20), there is a possibility of loading/unloading a CONRO ship, since there are two gantry cranes can be used. Though, there is no adjustable RORO ramp (as in quay 14), but it is possible to build one (Muuga´s port operational director interview, 2014).

Figure 20 Quay 14 and 15 in Muuga port

The challenge in using Quay 15 for loading/unloading a CONRO ship with multiple trips a day, is in scheduling. Especially, if there is a bigger ship already in the process of loading/unloading, the CONRO ship have to wait, unless a long term planned schedule have been made that can guarantee the instant loading for the Conro ship (Muuga´s port operational director interview, 2014).

7.6.2. Loading/unloading by innovative method

The ability of adjusting the height of the CONRO ship to fit with the quay height, inspired one of the cargo flow expert companies to innovate a method for fast loading/unloading, by introducing the Mega Blocks. Mega blocks consist of group of panels that can be dragged on the ship by some big tug trucks. The idea of the panels summarize as following: dividing the total load of containers into six panels, so each panel can take for example 20 FEUs (in case of full utilization), so the total of six panels will carry the 120 FEUs, then these panels driven or pushed onto the ship´s deck, within an hour (Cargo flow solutions expert 1 interview, 2014). Consequently, the loading/unloading time will be decreases dramatically, and the CONRO ship can make 4.36 trips per day using the Mega Blocks. Table 16 summarizes the results from the previous discussed methods for loading/unloading a CONRO ship, and the cost per FEU for each utilization case. The cost per FEU illustrated in table 17 is calculated based on the cost model discussed in Figure

14. Additionally, in the case of the Mega Blocks case, a 4,000,000 Euros were added on the ship price to cover the panels' costs.

Table 17 Number of trips per day for a CONRO ship by different loading methods

	Gantry crane	**Reach Stacker**	**Innovative Method (MB)**
Time needed to cross the route Helsinki-Tallinn (in days)	0.188	0.188	0.188
Loading/unloading time (in days)	0.521	0.190	0.042
Number of trips per day	1.920	2.510	4.364
Cost per FEU (85%)	461.78€	425.37€	390.53€
Cost per FEU (65%)	528.97€	481.36€	435.80€
Cost per FEU (50%)	614.64€	552.74€	493.52€
Cost per FEU (25%)	985.85€	862.07€	743.61€

One possible complication for the Mega Blocks, is the ramp maximum load limitations, in case of using the ramp to reach the ship´s deck. According to the port of Helsinki (2014c), the ramp can hold up to 30 tonne per axle, and if each panel loaded by 20 containers, this means a roughly more than 300 tonnes per panel, and this requires the panel to be at least with 10 axel in order to be driven over the ramp.

Additionally, Mega blocks idea might requires five groups of panels, two for each port and one as a spare. The two groups in each port include one to be shipped and the other to be prepared for the next trip, in order to reduce the needed time for loading. Moreover, these panels could be dragged (by external power), or by their own power, but the manufacturing of self-movable panels or dragged panels depends on the budget for building them (Cargo flow expert 1 interview, 2014).

7.7. CONRO shipping possibilities at Helsinki-Tallinn route

The previous subsections discussed the different loading/unloading methods and their effect on the number of trips per day a CONRO ship can do. This subchapter discuss the cost per unit transported by the CONRO ship. According to the CONRO ship characteristics, two scenarios were assumed regarding the volumes the ship can load, and the scenarios are: Scenario 1 assumes a load of 68 FEU and 10 semi-trailers; whereas the semi-trailers are located in the middle of the ship in two lanes (five semi-trailers in each lane), and the containers are alongside the semi-trailers from both sides. Accordingly, the cost per unit in this scenario 1 can be seen in Table 18.

Table 18 CONRO costs per unit according to scenario 1

Port dues	Loading/ unloading costs for containers	Total Costs	Container´s occupied area share	Semi-trailer occupied area share	Cost per FEU	Cost per semi-trailer
19 260.85	11 580.40	39 157.10	57 %	43 %	326.31	1 696.81
Allocating loading/unloading costs only to containers		27 576.70			400.11	1 194.99
Cost per mixed units (78 units)					502.01	

In Table 18, the relative huge difference between the cost per FEU and the cost per semi-trailer (326.31 to 1696.81 respectively), could be explained by the area occupied by the semi-trailers, 43% from the total loading area of the ship is occupied only by 10 semi-trailers, since there will no stacking over the semi-trailers (see Figure 21). Additionally, the loading/unloading costs were shared on both FEUs and semi-trailers, despite the fact that the loading/unloading is only for the containers, since the semi-trailers will be driven by their own power. Accordingly, when allocating the loading/unloading costs only to containers, the price will be 400.11 Euros per FEU and 1194.99 Euros per semi-trailer.

Meanwhile, scenario 2 assumes that a ramp can be built over the semi-trailers loading area, and over this ramp extra containers can be loaded (see Figure 21). The unit volume suggestions in scenario 2 are 88 FEU and 10 semi-trailers; whereas the semi-trailers are in the same configuration as in scenario 1, but over the built ramp an extra 20 FEUs will be added. Consequently, the costs per unit according to scenario 2 are shown in Table 19 below.

Table 19 CONRO costs per unit according to scenario 2

Port dues	Loading/unloading costs for containers	Total Costs	Container´s occupied area share	Semi-trailer occupied area share	Cost per FEU (88)	Cost per semi-trailer (10)
23 876.21	14 986.40	44 234.00	73 %	27 %	368.62	1 179.57
Allocating loading/unloading costs only to containers		29 247.60			414.03	779.94
Cost per mixed units (98 units)					451.37	

As shown in Table 19 the cost per FEU is 368.62 Euros and 1179.57 Euros per semi-trailer, and when allocating the loading/unloading costs only to containers, the costs became 414.03 Euros per FEU and 779.94 Euros per semi-trailer. Apparently, there is still a relative huge difference between the two costs per unit according to scenario 2, but comparing to scenario 1, the cost difference per semi-trailer is 517.24 Euros per unit and 415.05 Euro per unit when allocating the loading/unloading costs only to containers. Moreover, when calculating the cost per unit transported (container and semi-trailer) the cost would be 451.37 Euros, which is lower than the cost per FEU for the same ship when it was calculated to transport only containers at the same utilization (see Figure 15).

When comparing the costs per semi-trailer between the two scenarios, the difference in prices can be explained by the efficient usage of the working load area of the ship in scenario 2. The occupied area by semi-trailers dropped from 43% in scenario 1 to 27% in scenario 2, and this difference was used to load more containers over the semi-trailers´ area as it can be seen in Figure 21 below. Meanwhile, the in scenario 1 the area over the semi-trailers was not used, so it was a lost utilization from the ship.

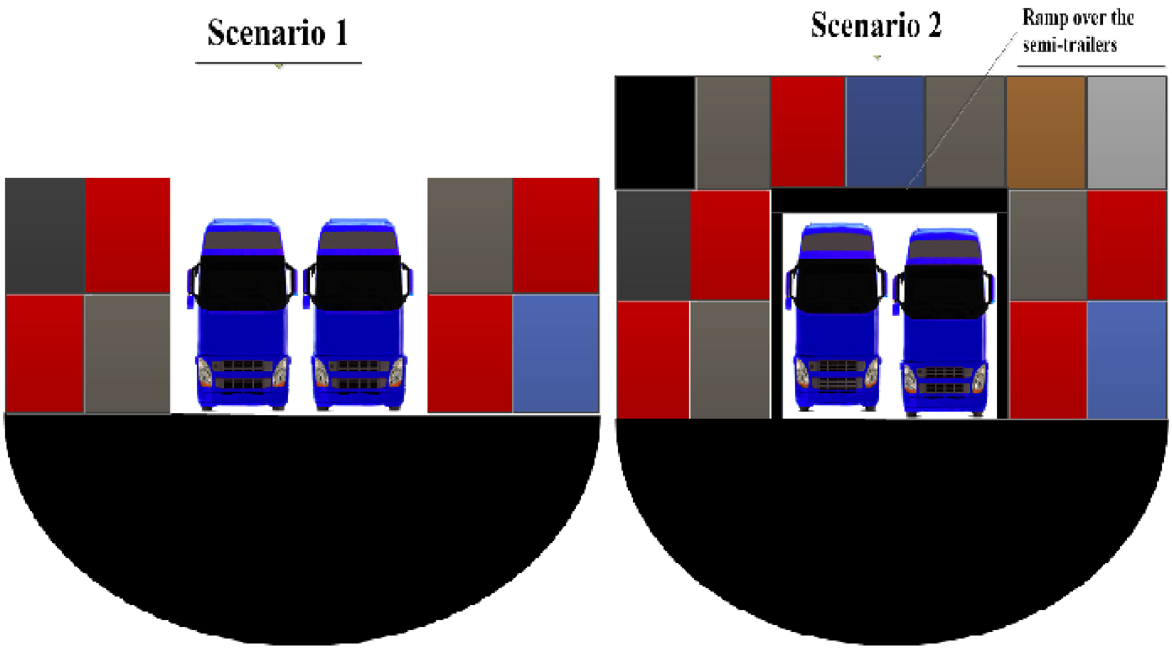

Figure 21 Back view for the CONRO ship in two different scenarios

Comparing the costs per unit in CONRO ships and Ropax ships, still the Ropax ship provide better offers to logistics companies, due to Ropax shipping companies´ strategy and the flexibility of allocating the costs to the different units transported and to the passengers as well. Moreover, the daily multi-trips fixed schedule for the Ropax ships tempts the logistics companies to make long-term contracts with Ropax shipping companies. Though, the many trips a day seems like advantage for Ropax shipping, but it is a disadvantage environmentally in respect to the amount of emissions, as described in Figure 18. Therefore, CONRO ships need some flexibility in pricing in order to compete with Ropax. Table 20 represents the costs per mixed unit transported with three costing options: Firstly, lower purchase price for the CONRO ship (i.e. 20 million Euros, instead of the current purchase price of 25 million), secondly 20 % discount on loading/unloading costs, and thirdly operating with zero profit.

Table 20 Costing options for CONRO ships

COSTING OPTIONS	SCENERIO 1	SCENERIO 2
Lower Purchase price	479.97	433.82
20 % Discount on loading/unloading	472.32	420.78
zero profit	456.38	410.33

As it can be noticed from Table 20, applying the new suggested costing options, influence the cost per mixed units in scenario 2 in a way that it became cheaper than the Ropax shipping cost per semi-trailer (see Table 15). Furthermore, other options could be applied rather than the mentioned one in Table 20, but it depends on the shipping company and the market conditions.

8. FINDINGS

This research discusses the development of the short sea shipping in Helsinki-Tallinn route, by presenting four research questions:

RQ 1: What are the main factors affecting on short sea shipping costs?

There are other factors influencing on the shipping costs per unit transported in SSS rather than ship size (the economy of scale), which are: ship purchasing price, utilization and the number of performed trips per day.

RQ 2: How to improve the cost per unit transported in short sea shipping?

The purchasing price, utilization and number of trips per day, cannot be studied separately, to decide how much the effect on cost per unit transported, because they are embedded to the context of the sea leg that they are investigated in. For instance, acquisition price will be less effecting with the multiple trips per day. For instance, the used Ropax ship in subchapter (7.4) have relatively highest purchase price compared to the other ships discussed in this research (Table 11). Additionally, the fixed cost contribution per visit, is not the highest among the same ships. But when comparing the same factor between ships similar in size and number of trips per day (as in Figure 17) the purchase price is effecting significantly on the shipping cost per unit. Moreover, the results from Table 20, shows how reducing the purchase cost effect on the competitiveness in general, by reducing the cost per unit transported.

Meanwhile, the utilization also plays an important role on the price per FEU, despite the fact that utilization depends on the available volumes for transportation in ports, though the higher the utilization, the lower the cost per unit for the same ship. But when comparing the utilization between different ship sizes, other factors interfere as well. For instance, when comparing the 25 % utilization case between the 481 FEUs, 800 FEUs and 981 FEUs ships, the cost per unit was the lowest in the 800 FEUs ship, due to the relative low purchase price.

Regarding the number of trips performed per day; as discussed earlier it is influencing heavily on the price per unit transported, it is inversely proportional to the cost per unit transported; the more trips per day, the lower the price per unit transported. The number of trips performed per day is affected by the time needed to cross the distance between the port of origin and the port of destination, in addition to the time at ports, which is influenced by loading/unloading method being used like gantry carne, reach stacker or any innovative method.

Loading/unloading ships by gantry crane, is widely used in many ports, but for ports serving SSS, the available volumes and the ship size limit, make the use of a gantry crane inefficient, especially when bigger ships (>1000 FEU) are being loaded, smaller ships have to wait. Meanwhile, loading/unloading by reach stacker represent an efficient way for relatively small ships that can be loaded from the sideway, but this method is not applicable in all ports, since the reach stacker need to approach the very end of the quay to be able to load the far side of the ship, and this is not possible in all ports, because in some ports the structure of quays cannot allow the reach stacker to drive over. Meanwhile, innovative loading/unloading method, as discussed in Table 16, it is an efficient method for loading/unloading a ship comparing to the time needed with respect to other methods discussed. Though, as in the reach stacker in some ports the side loading cannot be done due to the quays´ structure. Additionally, loading via the ramps is also a challenge, due to the axle load limits for some ports´ ramps.

Therefore, in order to improve the cost per unit transported, the previous factors should be taken into consideration which are: the competitive ship purchasing price, maximum possible utilization and maximum possible trips per day i.e. at least two trips per day, or one round trip (Helsinki-Tallinn-Helsinki or Tallinn-Helsinki-Tallinn).

RQ 3: What is the optimum ship type suitable for the development of Helsinki-Tallinn route?

Conro ship could be an optimum option for Helsinki-Tallinn route due to the ability of handling unitized cargo (containers and semi-trailers), and this could give many advantages like:

•The cost allocation; in the case of a CONRO ship the cost will be allocated to both containers and semi-trailers, which will reduce the cost per unit in general, because it will reduce the loading/unloading costs since not all the cargo will require to be load/unload, since the semi-trailers will be driven by their own power. Consequently, it will reduce the time at port as well. From Table 18, the price per unit (88 containers and 10 semi-trailers) is cheaper than the original price per unit for the same ship, when it was calculated only for containers with a same utilization as in Figure 15.

•The wheeled cargo share from the total volumes transported between Helsinki and Tallinn is more than for the containerized cargo (as described in the sub-section 7.2.2.), which will allow more trips per day, due to the fast loading/unloading and the availability of transported volumes.

RQ 4: What is the optimum ship size for the development of Helsinki-Tallinn route?

As described earlier in this research the ship size is measured by the amount of containers that can carry. Consequently, the optimum ship size should be able to cover the available volumes exists in Helsinki-Tallinn route and also the ship should be able to make at least one round trip a day. According to Table 12 a ship with around 110 – 120 FEUs can make a round trip a day, but as a suggested CONRO ship for this route, the CONRO ship should have a size of a net 120 FEUs in addition to a space of 34 semi-trailers (the average amount per visit transported by a Ropax ship as explained in subchapter 7.4). Additionally, the area occupied by a 34 semi-trailers is approximately equivalent to the area occupied by a 48 FEUs since the area of one semi-trailer is approximately equivalent to 1.4 the area of one FEU. So, taking into consideration the extra space that a semi-trailer will occupy on a ship, then the estimated suggested CONRO ship would be between 160 FEUs to 200 FEUs, in case the loading for containers and semi-trailers will be on the open deck of the ship (as described in Figure 21), or a lane capacity of not less than 589 meters, which represents the minimum lane space needed for 34 semi-trailers (the average amount of semi-trailers transported per visit in 2014 by a Ropax ship), as each semi-trailer needs a minimum lane length of 17.3 meters, in case of covered deck in the suggested CONRO ship.

9. DISCUSSION

This part of the research discusses the findings illustrated in the previous section, based on the literature review, and the data analysis.

In liner shipping, ship size plays an important role in shipping costs, and the optimal ship size can be defined as the containership size that minimizes the cost per TEU moved per trip on a given route (Talley 1990). Additionally, Cullinane & Khanna (2000) and Stopford (2004) refer in their studies regarding optimal ship size to economies of scale as the determinant for optimal ship size. Meanwhile, Jansson & Shneerson (1982) stated that the optimal ship size is obtained by trading-off economies of size in the hauling operations with diseconomies of size in port handling operations. In port handling costs per ton increase with ship size, while hauling costs per ton at sea, on the other hand, decline with size. Sys et al. (2008) studied the link between ship size and operations, and they concluded that optimal ship size and optimal operations cannot be studied separately. Both concepts develop hand in hand. Furthermore, the determination of the optimal ship size in relation to operations depends on the transport segment, terminal type, trade lane, and technology.

In this research, three factors were distinguished to be influencing on shipping costs in a SSS like Helsinki-Tallinn route. The factors are: First, ship acquisition/purchase price, which is directly proportional to the ship size and type/design (i.e. containership, Ropax, CONRO, etc.) Though, higher acquisition price leads to increase in the cost per unit transported, but from shipping companies´ point of view it raises the market entry barriers for new competitors, which will give a bargaining power to the shipping companies (Cullinane & Khanna 2000). The second factor is the utilization; in this research it was proved that the shipping costs is inversely proportional to the utilization; the lower utilization of a ship, the higher the cost per transported unit (see Figure 15), despite the fact that loading/unloading costs will be less (less units in the case of low utilizations). Furthermore, ports costs is directly proportional to the utilization; the higher the utilization is, the higher the port cost will be (more units will be charged at port), and generally the port costs in SSS is higher than the port cost for deep sea shipping. According to Pettersen & Marlow (2000), port costs makes from 40% to 60% of the total costs for a ship engaged in SSS trades, meanwhile from 10% to 15% in deep sea shipping. Figure 16 illustrate how the port cost contribution represents the highest share from the total shipping costs per unit transported. The third factor is the number of trips performed per day. Due to the short distance between Helsinki and Tallinn, trade volumes and customer demand (transportation lead time), it was noticed that performing two or more trips a day (if possible), will reduce the shipping costs per unit, especially for smaller ships.

In the literature there are many researches investigating the factors affecting on liner shipping costs. For instance, Gkonis & Psaraftis (2010) listed some studies regarding this issue and they also identified some variables affecting on liner shipping costs like; ship size, speed, port time, route distance and bunker costs. In deep sea shipping, route distance and bunker costs, plays an important role in the costs per unit transported, and time at sea is as important as the port time. Meanwhile, in SSS, due to the relative short route distances, the time at sea is not as important as the time at port, especially for feeder ship's size, which plan to make more than one trip a day, as discussed earlier in this research.

Research question two suggested how to improve the shipping costs per unit transported, and we find that the maximum possible ship capacity utilization and maximum trips performed per day can improve the shipping costs. Regarding maximum possible utilization, Styhre (2010) studied the ship capacity utilization and suggested the implementation of ship capacity utilization strategy. Styhre identified two extreme strategies: First; the cut peaks strategy, which aims to have high average capacity utilization by keeping the maximum capacity lower or increasing the market share. Second; the never say no strategy which allow higher unutilized capacity in order to have good flexibility, a possibility to grow and the ability to maintain a high service level for customers. Furthermore, Styhre (2010) suggested that before applying a vessel capacity utilization strategy, route characteristics and market conditions need to be analysed in order to identify an appropriate approach for the particular shipping service.

Meanwhile, the maximum number of performed trips per day can be achieved by reducing the total time the ship takes to complete one trip. According to Cullinane & Khanna (2000) the overall efficiency of a ship depends on the trip time, which consists of the time at port and the time at sea. The time at sea in SSS, don't play as important role as the time at port, due to the short distance travelled and the low steaming for the purpose of saving fuel and reducing emissions (as discussed in the subsection 4.6.1). Time at port can be reduced by reducing the loading/unloading time (as the main process for time consuming in port). The subsection 7.6.1 discussed some methods for fast loading/unloading, and it is illustrated that implementing fast methods for loading/unloading at port, will improve the shipping cost per unit transported and enables achieving more than one trip a day or one round trip. Multiple trips a day was described in the work of Lin & Tsai (2014) as daily frequency, and they concluded that daily frequency became a prevalent operational strategy in maritime liner shipping, and it enable carriers to provide service with better quality and enhance reliability, and reduce the idle of available resources as well.

Regarding research question three; the optimum ship type, we found that a ship that can handle the unitized cargo (containerized and wheeled cargo) would be a better option than container ship, due to the following reasons: firstly; the route characteristics, almost the entire European trade of Finland is being executed through SSS connections to Estonia, Sweden and Germany. But during Estonia's new independence era, the volumes via Estonian direction have increased noticeably, and are continuously growing (Hilmola, 2014). Secondly; the market condition, market entry barriers for small containerships (feeder ships) is relatively low due to the relative low investment size for such ships, but due to the cargo type available at the market (96.2% wheeled cargo), the introduction of ship that can handle both type of cargo is necessary. The suggestion of a CONRO ship to engage in the trade at Helsinki-Tallinn route, is to handle both types of unitised cargo, additionally the wheeled cargo, will contribute in reducing the time at port since not all the ship´s cargo will be in need for loading/unloading, since the trucks and semi-trailers (if they were with cabins) will be driven by their own power.

Additionally, the CONRO ship investment size is relatively high compared to the containership, and it will not be easy for the potential operator to find a ship that can meet both trailer and container segments without excessive cost and diminished flexibility (Brooks et al. 2006). Of course, the investment size will be depending on the ship size itself, which is suggested in research question four, and in the research the suggested optimal ship size is based on to the research findings regarding the market conditions in Helsinki-Tallinn route.

The optimal ship size can be determined by finding the shipping costs, since the optimal ship size is determined by minimising the cost per tonne at sea and in ports (Jansson & Shneerson, 1982). Additionally, the optimal ship size can be estimated by adapting a capacity utilization strategy that satisfies both the route characteristics and the market conditions, in addition to the loading/unloading method at port, which is one of the main factors in determining the possible amount of trips per day for the given available volumes at the ports in Helsinki-Tallinn route. Furthermore, recently (January 2015), Tallink Silja started their first RoRo shipping between Vuosaari Harbour and Tallinn´s old city harbour. Additionally, the chosen RoRo ship is with total lane capacity of 1000 meters (Tallink Silja, 2015), which fits to about 60 semi-trailers, which emphasize the route characteristics and market condition.

10. CONCLUSIONS

General conclusions

In liner shipping, ship size is one of the most important factors in determining the shipping costs, since it takes advantage from the economies of scale. Meanwhile, in short sea shipping, there are other factors affecting on shipping costs rather than the ship size. In the case of Helsinki–Tallinn route, factors like ship investment costs, utilization and number of trips performed per day were distinguished by their effect on shipping costs per unit transported. Additionally, the previous mentioned factors cannot be studied separately, for the purpose of deciding their contributions on the cost per unit transported, since these factors are interconnected and embedded on the context of the sea route conditions.

This research shows that Ro-Ro traffic at Helsinki-Tallinn route between Vuosaari and Muuga harbours is possible, due to the infrastructure suitability of both ports, and recently, a RoRo traffic already started operating between Vuosaari and old city harbour. Additionally, the research studies the possibility of CONRO shipping at Helsinki-Tallinn route, and found that the CONRO shipping could be an alternative development of the route. The optimal CONRO ship size can be decided based on the characteristics and market conditions of Helsinki-Tallinn route, and capacity utilization strategy. Investment size is an important factor for the shipping development, and investment cost contribution to the total shipping costs can be reduced by performing more trips a day, which will require a faster method for loading/unloading in order to reduce the time at port, which is directly proportional to the capacity utilization.

Limitations

This research has encountered the following limitations: Firstly, the geographical scope of the research, as it studies the transportation traffic only between port of Helsinki Vuosaari harbour and port of Tallinn Muuga harbour. Secondly, limited access to data like ship prices, fuel consumption and prices. Finally, limitations concerning the use of the statistical data of Finnish-Estonian trade and cargo flows and the interpretation of the results gained from the analysis, due to the difference in data collection and classification between different databases.

Suggestion for further research

Based on the research findings time at port effects heavily on short sea shipping and operating a CONRO ship at short sea routes require a prior long term scheduling, to guarantee the synchronisation of the loading process for the containers and semi-trailers, with the least possible time. So, the implementation of JIT principle would be a necessary future research in this domain.

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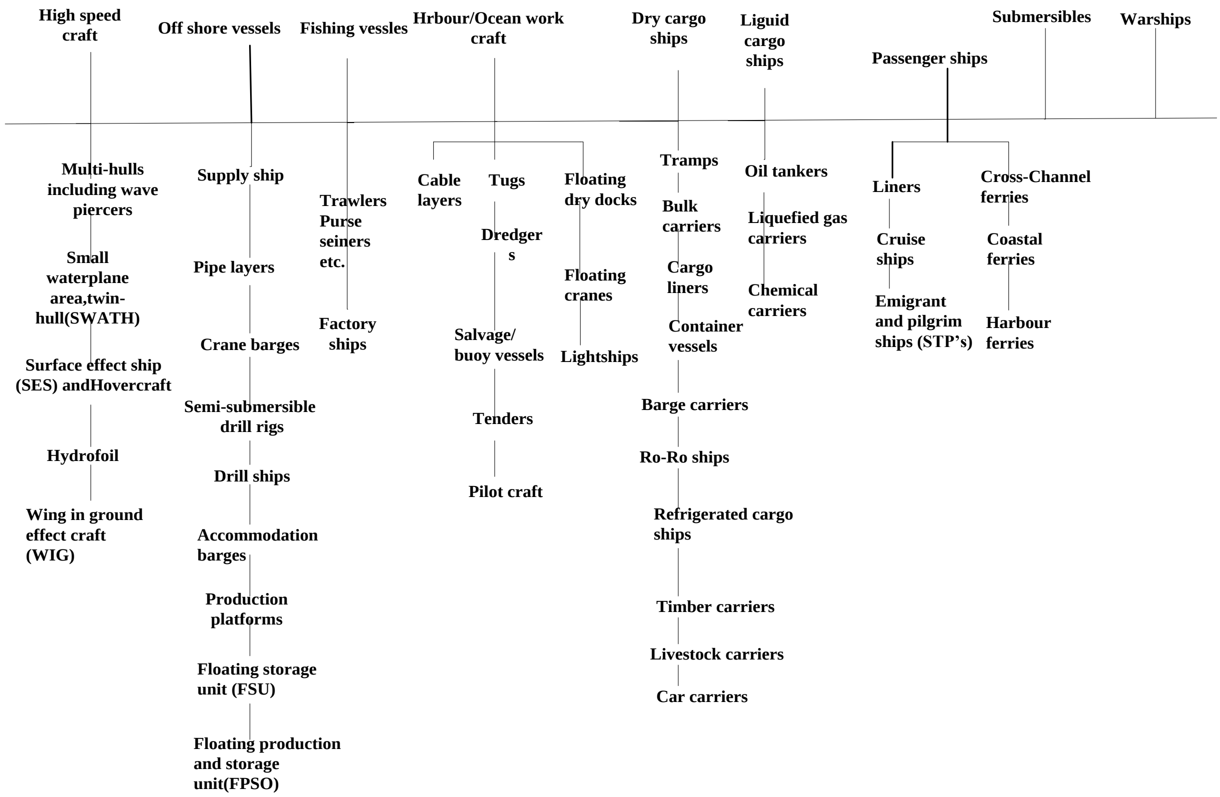
APPENDICES

Appendix 1: Ship types



(Source: Eyres 2001 p. 15)

Appendix 2: Summary of the conducted interviews with the cargo flow solutions experts and the interview questions

Cargo flow solutions experts	place	Date	Type of interview	Topic of the interview	Duration of the interview
Expert 1	Finland	20.8.14	One-to-one	Loading/unloading by innovative method	1.5 hours
Expert 2	Finland	19.9.14	One-to-one	Loading/unloading by Reach stacker	1 hour
Expert 3	Finland	16.10.14	One-to-one	Port operations	1 hour

Interview with Cargo flow solutions expert 1 regarding using innovative method for loading/unloading process over the ship´s deck, related to RQ 2.

A. The innovative loading/unloading method (MB) description:

1. Could you briefly describe the concept?
2. Is the concept being used anywhere or is it totally new and in development or piloting phase with possibility to apply for a patent?
3. Could this concept be used for very short term sea transportation (e.g. in Vuosaari-Muuga route) or longer ones?
4. How could the platform be transported to sea vessel from seaport and vice versa?
5. Costs regarding the concept
    a. How expensive would it be to produce the platform?
    b. What could be operating cost level e.g. on yearly basis?
    c. What could be maintenance cost level e.g. on yearly basis?
    d. What would be the price of the concept for the end-users?
    e. Are there additional investments required in the seaport area?
    f. Are there additional investments required for ships using it?
    g. What characteristics are needed in the targeted ships?
6. Time duration
    a. Duration of loading/unloading the platform in the seaport and on the sea vessel?
    b. How much time could be saved by using platform instead of traditional crane or reach stacker loading/unloading?
7. What are the main advantages and possibilities of the concept?

8. What are the main disadvantages and threads of the concept?
9. How much space is needed in seaport area?
10. How many platforms would be needed for successful and efficient operation between Vuosaari and Muuga?

B. Reach Stacker
    a. Do you know a contact person, who I could contact about questions regarding reach stackers?

Interview with Cargo flow solutions expert 2 regarding using the reach stacker in loading/unloading process over the ship´s deck, related to RQ 1 & 2.

1. Efficiency:
    b. How many containers per hour?
    c. Does speed vary depending on how containers are located or stacked?
    d. How does safety working distance (amount of free space for operation etc.) affect speed?
    e. Are there other reasons for varying efficiency?
2. Reachability:
    a. How high stacks are possible to create with Kalmar reach stackers?
    b. Could these limits be increased?
    c. Can loading/unloading done if surface is below reach stacker?
    d. What are the maximum weights of containers, when creating stacks?
3. Operating and maintenance costs
    a. What are the consumption rates for a reach stacker fuel, oil, etc.?
    b. What is the level of maintenance costs and how often?
4. Prices level of reach stackers? And possibility of renting / leasing?
5. Environment issues and electric reach stackers?
    a. What are the price, efficiency and maintenance?
6. Are there any problems if multiple reach stackers are used for one sea vessel at the same time?

7. Suitability with alternative concepts for short term sea transportation between Port of Helsinki (Vuosaari) and Port of Tallinn (Muuga)
    a. Small container vessels (surface on the same level or below)
    b. The innovative solution provided by cargo flow solution expert?
    c. How many reach stackers are needed, if 120 FEU are unloaded and loaded in one hour?
    d. What are the main advantages and disadvantages?
    e. What are the main threads and possibilities?

Interview with cargo flow solutions expert 3 regarding port operations in related to RQ 1 & 2.

1. Sea vessel calculation presentation and discussion
2. "Amount of trips per day" –calculation presentation and discussion
3. process chart presentation and discussion
4. What is the speed of crane operation (moves per hour)?
5. In what condition can two cranes be used?
    a. What is the minimum sea vessel size?
    b. What is the speed of double crane operation (moves per hour)?
6. Does ship loading/unloading process is happening 24 hours and seven days a week?
7. Are container ship schedules based on fixed schedule?
    a. If not, how are the schedules made?
    b. If they are based on fixes schedule, how are these schedules created? Are they based on certain utilization level of the sea vessel?
8. Do you know, what is price level of transporting semi-trailers and trucks with RoPax sea vessels between Helsinki and Tallinn?

Appendix 3: List of industrial sector´ interviews and the interview questions

Company	place	Date	type of the interview	Duration of the interview
Industrial company 1	Estonia	20.8.14	Email	-
Industrial company 2	Finland	27.8.14	Email	-
Industrial company 3	Estonia	18.9.14	One-to-one	1 hour
Industrial company 4	Estonia	1.10.14	Skype	45 min.

Industrial companies´ semi-structured interviews regarding their preferred ship type used, and the leading time for receiving the shipment, Related to is related to RQ 3.

1. Do you have a contracted third party logistics for transporting products from Estonia to Helsinki?

2. Who takes care of the transportation combination Truck-ship-truck from Estonia to Finland?

3. Do you have a scheduled transportation based on regular basis (daily, weekly) or it depends on the frequent of the orders coming from Finland?

4. How much transported volumes do you have (weekly or monthly) in semi-trailer units?

5. How much is the lead time for receiving the products in Finland (as they send from Estonia or vice versa)?

6. Does your transportation costs affected by bunker fuel fluctuation?

7. Would the Sulphur regulation in 2015(or other future regulations) affect your transportation prices or even to change your supply chain configuration?

Summary of the industrial sector answers to the interview questions:

- Continuous search for better price offering for transportation. This basically comes down to using more SME logistics companies instead of e.g. Schenker or DHL.
- Lead time: ranging from one working day to two working days. The transported products is collected in the end of the working day to be sent to the port where they will be shipped to reach in the second day to the final destination on the other side of the route

- Small shipments, but in continuous fashion (still JIT emphasis all over). This results in high transportation chain costs, which need to be minimized.

- Customers or markets are not willing or able to pay higher price from products. Logistics costs are at the disposal of manufacturers and cost-wise solutions are sought after.

Appendix 4a Cost per FEU calculations for the 120 FEUs ship

120 FEUs SHIP		85 %	65 %	50 %	25 %
Procurement costs (MGO modification added)	25 300 000,00				
Interest rate	6 %				
Number of payments (one payment a year)	20,00				
Weight of empty FEU (t)	3,80				
Average weight of load of FEU (t)	16,69				
Gross tonnage of sea vessel (t)	3 000,00				
Net tonnage of sea vessel (t)	1 008,00				
Amount of trips per day	2,00				
Amount of visits in Helsinki	252,00				
Amount of visits in Tallinn	252,00				
Amount of FEUs	120,00	102,00	78,00	60,00	30,00
Gross weight of freight (t)		1 702,38	1 301,82	1 001,40	500,70
Helsinki:					
Waterway dues	2,39	2 408,11	2 408,11	2 408,11	2 408,11
New waterway dues starting in 2015	1,098	1 106,78	1 106,78	1 106,78	1 106,78
Pilotage payment (once a year)	630,00	630,00	630,00	630,00	630,00
General cargo payment in sea port	2,70	4 596,43	3 514,91	2 703,78	1 351,89
Sea vessel payment in sea port	0,365	367,92	367,92	367,92	367,92
Waste payment in sea port	0,12	124,99	124,99	124,99	124,99
Mooring and unmooring	75,40	150,80	150,80	150,80	150,80
Handling of units in terminal area (Steveco)					
Gate fee, units arriving / departing to / from terminal:					
Containers (per container)	105,20	10 730,40	8 205,60	6 312,00	3 156,00
Units requiring wire-lift (per unit)	105,20	10 730,40	8 205,60	6 312,00	3 156,00
Arex fee, import and export containers (per container)	5,40	550,80	421,20	324,00	162,00
Tallinn:					
Waterway dues	0,30	900,00	900,00	900,00	900,00
Lighthouse dues	245,00	122,50	122,50	122,50	122,50
Navigation dues	170,00	85,00	85,00	85,00	85,00
Pilotage payment	335,00	335,00	335,00	335,00	335,00
Tonnage payment at sea port	0,82	2 460,00	2 460,00	2 460,00	2 460,00
Waste payment in sea port	0,02	51,00	51,00	51,00	51,00
Mooring payment in sea port	171,00	342,00	342,00	342,00	342,00
container handling	65,63	6 693,75	5 118,75	3 937,50	1 968,75
Yearly costs:					
Helsinki:					
New waterway dues starting in 2015		11 067,84	11 067,84	11 067,84	11 067,84
Waterway dues		24 081,12	24 081,12	24 081,12	24 081,12
Pilotage payment		630,00	630,00	630,00	630,00
General cargo payment in sea port		1 158 299,35	885 758,33	681 352,56	340 676,28
Sea vessel payment in sea port		92 715,84	92 715,84	92 715,84	92 715,84
Waste payment in sea port		31 497,98	31 497,98	31 497,98	31 497,98
Mooring and unmooring		38 001,60	38 001,60	38 001,60	38 001,60
Gate fee, containers		2 704 060,80	2 067 811,20	1 590 624,00	795 312,00
Arex fee		138 801,60	106 142,40	81 648,00	40 824,00

Continued on next page

In total (Helsinki)		4 188 088,30	3 246 638,47	2 540 551,10	1 363 738,82
Per visit (Helsinki)		16 619,40	12 883,49	10 081,55	5 411,66
Per FEU (Helsinki)		162,94	165,17	168,03	180,39
In total (Helsinki) new waterway dues starting in 2015		4 175 075,02	3 233 625,19	2 527 537,82	1 350 725,54
Per visit (Helsinki) new waterway dues starting in 2015		16 567,76	12 831,85	10 029,91	5 360,02
Per FEU (Helsinki) new waterway dues starting in 2015		162,43	164,51	167,17	178,67
Tallinn:					
Waterway dues		9 000,00	9 000,00	9 000,00	9 000,00
Lighthouse dues		30 870,00	30 870,00	30 870,00	30 870,00
Navigation dues		21 420,00	21 420,00	21 420,00	21 420,00
Pilotage payment		335,00	335,00	335,00	335,00
Tonnage payment at sea port		619 920,00	619 920,00	619 920,00	619 920,00
Waste payment in sea port		12 852,00	12 852,00	12 852,00	12 852,00
Mooring payment in sea port		86 184,00	86 184,00	86 184,00	86 184,00
container handling		1 686 825,00	1 289 925,00	992 250,00	496 125,00
In total (Tallinn)		2 467 406,00	2 070 506,00	1 772 831,00	1 276 706,00
Per visit (Tallinn)		9 791,29	8 216,29	7 035,04	5 066,29
Per FEU (Tallinn)		95,99	105,34	117,25	168,88
In total		6 655 494,30	5 317 144,47	4 313 382,10	2 640 444,82
Per visit		26 410,69	21 099,78	17 116,60	10 477,96
Per FEU		258,93	270,51	285,28	349,27
Fix costs and fuel costs (per FEU)		110,32	144,27	187,55	375,10
Salary costs (per FEU)		27,50	35,97	46,76	93,51
Overhead costs (per FEU)	50 %	13,75	17,98	23,38	46,76
Maintenance costs (per FEU)	10 %	4,29	5,61	7,29	14,59
Total (per FEU)		414,80	474,34	550,26	879,23
Profit	10 %	**456,28**	**521,78**	**605,28**	**967,15**
cargo and port costs contribution		62,42 %	57,03 %	51,84 %	39,72 %
Fixed and fuel costs contribution		26,60 %	30,41 %	34,08 %	42,66 %
salaries, overheads and maitenance costs contribution		10,98 %	12,56 %	14,07 %	17,61 %

Appendix 4b Cost per FEU calculations for the 120 FEUs II ship

110 FEUs II		85 %	65 %	50 %	25 %
Procurement costs (MGO modification added)	1 453 500,00				
Interest rate	6 %				
Number of payments (one payment a year)	18,00				
Weight of empty FEU (t)	3,80				
Average weight of load of FEU (t)	16,69				
Gross tonnage of sea vessel (t)	2 978,00				
Net tonnage of sea vessel (t)	1 314,00				
Amount of trips per day	2,00				
Amount of visitations in Finland	252,00				
Amount of visitations in Estonia	252,00				
Amount of FEUs	110,00	93,50	71,50	55,00	27,50
Gross weight of freight (t)		1 560,52	1 193,34	917,95	458,98
Finland:					
Waterway dues	2,39	3 139,15	3 139,15	3 139,15	3 139,15
New waterway dues starting in 2015	1,098	1 442,77	1 442,77	1 442,77	1 442,77
Pilotage payment	630,00	630,00	630,00	630,00	630,00
General cargo payment in sea port	2,70	4 213,39	3 222,00	2 478,47	1 239,23
Sea vessel payment in sea port	0,37	479,61	479,61	479,61	479,61
Waste payment in sea port	0,12	162,94	162,94	162,94	162,94
Mooring and unmooring	75,40	150,80	150,80	150,80	150,80
Handling of units in terminal area (Steveco)					
Gate fee, units arriving / departing to / from terminal:					
Containers (per container)	105,20	9 836,20	7 521,80	5 786,00	2 893,00
Units requiring wire-lift (per unit)	105,20	9 836,20	7 521,80	5 786,00	2 893,00
Arex fee, import and export containers (per container)	5,40	504,90	386,10	297,00	148,50
Estonia:					
Waterway dues	0,30	893,40	893,40	893,40	893,40
Lighthouse dues	245,00	122,50	122,50	122,50	122,50
Navigation dues	170,00	85,00	85,00	85,00	85,00
Pilotage payment	335,00	335,00	335,00	335,00	335,00
Tonnage payment at sea port	0,82	2 441,96	2 441,96	2 441,96	2 441,96
Waste payment in sea port	0,02	50,63	50,63	50,63	50,63
Mooring payment in sea port	171,00	342,00	342,00	342,00	342,00
container handling	65,63	6 135,94	4 692,19	3 609,38	1 804,69
Yearly costs:					
Finland:					
New waterway dues starting in 2015		14 427,72	14 427,72	14 427,72	14 427,72
Waterway dues		31 391,46	31 391,46	31 391,46	31 391,46
Pilotage payment		630,00	630,00	630,00	630,00
General cargo payment in sea port		1 061 774,41	811 945,13	624 573,18	312 286,59
Sea vessel payment in sea port		120 861,72	120 861,72	120 861,72	120 861,72
Waste payment in sea port		41 059,87	41 059,87	41 059,87	41 059,87
Mooring and unmooring		38 001,60	38 001,60	38 001,60	38 001,60
Gate fee, containers		2 478 722,40	1 895 493,60	1 458 072,00	729 036,00
Arex fee		127 234,80	97 297,20	74 844,00	37 422,00

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In total (Helsinki)		3 899 676,26	3 036 680,59	2 389 433,83	1 310 689,24
Per visit (Helsinki)		15 474,91	12 050,32	9 481,88	5 201,15
Per FEU (Helsinki)		165,51	168,54	172,40	189,13
In total (Helsinki) new waterway dues starting in 2015		3 882 712,52	3 019 716,85	2 372 470,09	1 293 725,50
Per visit (Helsinki) new waterway dues starting in 2015		15 407,59	11 983,00	9 414,56	5 133,83
Per FEU (Helsinki) new waterway dues starting in 2015		164,79	167,59	171,17	186,68
Tallinn:					
Waterway dues		8 934,00	8 934,00	8 934,00	8 934,00
Lighthouse dues		30 870,00	30 870,00	30 870,00	30 870,00
Navigation dues		21 420,00	21 420,00	21 420,00	21 420,00
Pilotage payment		335,00	335,00	335,00	335,00
Tonnage payment at sea port		615 373,92	615 373,92	615 373,92	615 373,92
Waste payment in sea port		12 757,75	12 757,75	12 757,75	12 757,75
Mooring payment in sea port		86 184,00	86 184,00	86 184,00	86 184,00
container handling		1 546 256,25	1 182 431,25	909 562,50	454 781,25
In total (Tallinn)		2 322 130,92	1 958 305,92	1 685 437,17	1 230 655,92
Per visit (Tallinn)		9 214,81	7 771,06	6 688,24	4 883,56
Per FEU (Tallinn)		98,55	108,69	121,60	177,58
In total		6 221 807,18	4 994 986,51	4 074 871,00	2 541 345,16
Per visit		24 689,71	19 821,38	16 170,12	10 084,70
Per FEU		264,061	277,22	294,00	366,72
Fix costs and fuel costs (per FEU)		19,066	24,93	32,41	64,83
Salary costs (per FEU)		30,005	39,24	51,01	102,02
Overhead costs (per FEU)	50 %	15,002	19,62	25,50	51,01
Maintenance costs (per FEU)	10 %	0,285	0,37	0,48	0,97
Total (per FEU)		328,42	361,38	403,41	585,53
Profit	10 %	**361,26**	**397,52**	**443,75**	**644,09**
cargo and port costs contribution		80,40 %	76,71 %	72,88 %	62,63 %
Fixed and fuel costs contribution		5,81 %	6,90 %	8,03 %	11,07 %
salaries, overheads and maitenance costs contribution		13,79 %	16,39 %	19,09 %	26,30 %

Appendix 4c Cost per FEU calculations for the 120 FEUs I ship

120 FEU I		85 %	65 %	50 %	25 %
Procurement costs (MGO modification added)	3 265 159,38				
Interest rate	6 %				
Number of payments (one payment a year)	20,00				
Weight of empty FEU (t)	3,80				
Average weight of load of FEU (t)	16,69				
Gross tonnage of sea vessel (t)	3 739,00				
Net tonnage of sea vessel (t)	1 491,00				
Amount of trips per day	2,00				
Amount of visitations in Finland	252,00				
Amount of visitations in Estonia	252,00				
Amount of FEUs	110,00	93,50	71,50	55,00	27,50
Gross weight of freight (t)		1 560,52	1 193,34	917,95	458,98
Finland:					
Waterway dues	2,39	3 562,00	3 562,00	3 562,00	3 562,00
New waterway dues starting in 2015	1,098	1 637,12	1 637,12	1 637,12	1 637,12
Pilotage payment	630,00	630,00	630,00	630,00	630,00
General cargo payment in sea port	2,70	4 213,39	3 222,00	2 478,47	1 239,23
Sea vessel payment in sea port	0,37	544,22	544,22	544,22	544,22
Waste payment in sea port	0,12	184,88	184,88	184,88	184,88
Mooring and unmooring	75,40	150,80	150,80	150,80	150,80
Handling of units in terminal area (Steveco)					
Gate fee, units arriving / departing to / from terminal:					
Containers (per container)	105,20	9 836,20	7 521,80	5 786,00	2 893,00
Units requiring wire-lift (per unit)	105,20	9 836,20	7 521,80	5 786,00	2 893,00
Arex fee, import and export containers (per container)	5,40	504,90	386,10	297,00	148,50
Estonia:					
Waterway dues	0,30	1 121,70	1 121,70	1 121,70	1 121,70
Lighthouse dues	245,00	122,50	122,50	122,50	122,50
Navigation dues	170,00	85,00	85,00	85,00	85,00
Pilotage payment	335,00	335,00	335,00	335,00	335,00
Tonnage payment at sea port	0,82	3 065,98	3 065,98	3 065,98	3 065,98
Waste payment in sea port	0,02	63,56	63,56	63,56	63,56
Mooring payment in sea port	171,00	342,00	342,00	342,00	342,00
container handling	65,63	6 135,94	4 692,19	3 609,38	1 804,69
Yearly costs:					
Finland:					
New waterway dues starting in 2015		16 371,18	16 371,18	16 371,18	16 371,18
Waterway dues		35 619,99	35 619,99	35 619,99	35 619,99
Pilotage payment		630,00	630,00	630,00	630,00
General cargo payment in sea port		1 061 774,41	811 945,13	624 573,18	312 286,59
Sea vessel payment in sea port		137 142,18	137 142,18	137 142,18	137 142,18
Waste payment in sea port		46 590,77	46 590,77	46 590,77	46 590,77
Mooring and unmooring		38 001,60	38 001,60	38 001,60	38 001,60
Gate fee, containers		2 478 722,40	1 895 493,60	1 458 072,00	729 036,00
Arex fee		127 234,80	97 297,20	74 844,00	37 422,00

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In total (Helsinki)		3 925 716,14	3 062 720,47	2 415 473,72	1 336 729,13
Per visit (Helsinki)		15 578,24	12 153,65	9 585,21	5 304,48
Per FEU (Helsinki)		166,61	169,98	174,28	192,89
In total (Helsinki) new waterway dues starting in 2015		3 906 467,33	3 043 471,66	2 396 224,91	1 317 480,32
Per visit (Helsinki) new waterway dues starting in 2015		15 501,85	12 077,27	9 508,83	5 228,10
Per FEU (Helsinki) new waterway dues starting in 2015		165,80	168,91	172,89	190,11
Tallinn:					
Waterway dues		11 217,00	11 217,00	11 217,00	11 217,00
Lighthouse dues		30 870,00	30 870,00	30 870,00	30 870,00
Navigation dues		21 420,00	21 420,00	21 420,00	21 420,00
Pilotage payment		335,00	335,00	335,00	335,00
Tonnage payment at sea port		772 626,96	772 626,96	772 626,96	772 626,96
Waste payment in sea port		16 017,88	16 017,88	16 017,88	16 017,88
Mooring payment in sea port		86 184,00	86 184,00	86 184,00	86 184,00
container handling		1 546 256,25	1 182 431,25	909 562,50	454 781,25
In total (Tallinn)		2 484 927,09	2 121 102,09	1 848 233,34	1 393 452,09
Per visit (Tallinn)		9 860,82	8 417,07	7 334,26	5 529,57
Per FEU (Tallinn)		105,46	117,72	133,35	201,08
In total		6 410 643,23	5 183 822,56	4 263 707,05	2 730 181,21
Per visit		25 439,06	20 570,72	16 919,47	10 834,05
Per FEU		272,076	287,70	307,63	393,97
Fix costs and fuel costs (per FEU)		25,451	33,28	43,27	86,53
Salary costs (per FEU)		30,005	39,24	51,01	102,02
Overhead costs (per FEU)	50 %	15,002	19,62	25,50	51,01
Maintenance costs (per FEU)	10 %	0,604	0,79	1,03	2,05
Total (per FEU)		343,14	380,63	428,43	635,58
Profit	10 %	**377,45**	**418,69**	**471,28**	**699,13**
cargo and port costs contribution		79,29 %	75,59 %	71,80 %	61,99 %
Fixed and fuel costs contribution		7,42 %	8,74 %	10,10 %	13,61 %
salaries, overheads and maitenance costs contribution		13,29 %	15,67 %	18,10 %	24,40 %

Appendix 4d Cost per FEU calculations for the 233 FEUs ship

233 FEUs		85 %	65 %	50 %	25 %
Procurement costs (MGO modification added)	5 489 028,90				
Interest rate	6 %				
Number of payments (one payment a year)	7,00				
Weight of empty FEU (t)	3,80				
Average weight of load of FEU (t)	16,69				
Gross tonnage of sea vessel (t)	5 239,00				
Net tonnage of sea vessel (t)	2 625,00				
Amount of trips per day	1,00				
Amount of visits in Finland	126,00				
Amount of visits in Tallinn	126,00				
Amount of FEUs	233,00	198,05	151,45	116,50	58,25
Gross weight of freight (t)		3 305,45	2 527,70	1 944,39	972,19
Helsinki:					
Waterway dues	2,39	6 271,13	6 271,13	6 271,13	6 271,13
New waterway dues starting in 2015	1,098	2 882,25	2 882,25	2 882,25	2 882,25
Pilotage payment	683,00	683,00	683,00	683,00	683,00
General cargo payment in sea port	2,70	8 924,73	6 824,79	5 249,84	2 624,92
Sea vessel payment in sea port	0,37	958,13	958,13	958,13	958,13
Waste payment in sea port	0,12	325,50	325,50	325,50	325,50
Mooring and unmooring	75,40	150,80	150,80	150,80	150,80
Handling of units in terminal area (Steveco)					
Gate fee, units arriving / departing to / from terminal:					
Containers (per container)	105,20	20 834,86	15 932,54	12 255,80	6 127,90
Units requiring wire-lift (per unit)	105,20	20 834,86	15 932,54	12 255,80	6 127,90
Arex fee, import and export containers (per container)	5,40	1 069,47	817,83	629,10	314,55
Tallinn:					
Waterway dues	0,30	1 571,70	1 571,70	1 571,70	1 571,70
Lighthouse dues	410,00	205,00	205,00	205,00	205,00
Navigation dues	380,00	190,00	190,00	190,00	190,00
Pilotage payment	478,00	478,00	478,00	478,00	478,00
Tonnage payment at sea port	0,82	4 295,98	4 295,98	4 295,98	4 295,98
Waste payment in sea port	0,02	89,06	89,06	89,06	89,06
Mooring payment in sea port	171,00	342,00	342,00	342,00	342,00
container handling	65,63	12 997,03	9 938,91	7 645,31	3 822,66
Yearly costs:					
Helsinki:					
New waterway dues starting in 2015		28 822,50	28 822,50	28 822,50	28 822,50
Waterway dues		62 711,25	62 711,25	62 711,25	62 711,25
Pilotage payment		683,00	683,00	683,00	683,00
General cargo payment in sea port		1 124 515,62	859 923,71	661 479,78	330 739,89
Sea vessel payment in sea port		120 723,75	120 723,75	120 723,75	120 723,75
Waste payment in sea port		41 013,00	41 013,00	41 013,00	41 013,00
Mooring and unmooring		19 000,80	19 000,80	19 000,80	19 000,80
Gate fee, containers		2 625 192,36	2 007 500,04	1 544 230,80	772 115,40
Arex fee		134 753,22	103 046,58	79 266,60	39 633,30

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In total (Helsinki)		4 128 593,00	3 214 602,13	2 529 108,98	1 386 620,39
Per visit (Helsinki)		32 766,61	25 512,72	20 072,29	11 004,92
Per FEU (Helsinki)		165,45	168,46	172,29	188,93
In total (Helsinki) new waterway dues starting in 2015		4 094 704,25	3 180 713,38	2 495 220,23	1 352 731,64
Per visit (Helsinki) new waterway dues starting in 2015		32 497,65	25 243,76	19 803,34	10 735,97
Per FEU (Helsinki) new waterway dues starting in 2015		164,09	166,68	169,99	184,31
Tallinn:					
Waterway dues		15 717,00	15 717,00	15 717,00	15 717,00
Lighthouse dues		25 830,00	25 830,00	25 830,00	25 830,00
Navigation dues		23 940,00	23 940,00	23 940,00	23 940,00
Pilotage payment		478,00	478,00	478,00	478,00
Tonnage payment at sea port		541 293,48	541 293,48	541 293,48	541 293,48
Waste payment in sea port		11 221,94	11 221,94	11 221,94	11 221,94
Mooring payment in sea port		43 092,00	43 092,00	43 092,00	43 092,00
container handling		1 637 625,94	1 252 302,19	963 309,38	481 654,69
In total (Tallinn)		2 299 198,36	1 913 874,61	1 624 881,79	1 143 227,11
Per visit (Tallinn)		18 247,61	15 189,48	12 895,89	9 073,23
Per FEU (Tallinn)		92,14	100,29	110,69	155,76
In total		6 427 791,36	5 128 476,74	4 153 990,77	2 529 847,49
Per visit		51 014,22	40 702,20	32 968,18	20 078,15
Per FEU		257,58	268,75	282,99	344,69
Fix costs and fuel costs (per FEU)		50,88	66,54	86,50	173,00
Salary costs (per FEU)		39,61	51,80	67,34	134,68
Overhead costs (per FEU)	50 %	19,81	25,90	33,67	67,34
Maintenance costs (per FEU)	10 %	1,97	2,58	3,35	6,70
Total (per FEU)		369,85	415,57	473,85	726,41
Profit	10 %	**406,84**	**457,12**	**521,23**	**799,05**
cargo and port costs contribution		69,64 %	64,67 %	59,72 %	47,45 %
Fixed and fuel costs contribution		13,76 %	16,01 %	18,25 %	23,82 %
salaries, overheads and maitenance costs contribution		16,60 %	19,32 %	22,02 %	28,73 %

Appendix 4e Cost per FEU for the 481 FEUs ship

481 FEUs SHIP		85 %	65 %	50 %	25 %
Procurement costs (MGO modification added)	14 977 538,92				
Interest rate	6 %				
Number of payments (one payment a year)	20,00				
Weight of empty FEU (t)	3,80				
Average weight of load of FEU (t)	16,69				
Gross tonnage of sea vessel (t)	10 288,00				
Net tonnage of sea vessel (t)	5 464,00				
Amount of trips per day	0,50				
Amount of visits in Helsinki	63,00				
Amount of visits in Tallinn	63,00				
Amount of FEUs	481,00	408,85	312,65	240,50	120,25
Gross weight of freight (t)		6 823,71	5 218,13	4 013,95	2 006,97
Helsinki:					
Waterway dues	2,39	13 053,50	13 053,50	13 053,50	13 053,50
New waterway dues starting in 2015	1,098	5 999,47	5 999,47	5 999,47	5 999,47
Pilotage payment	683,00	683,00	683,00	683,00	683,00
General cargo payment in sea port	2,70	18 424,01	14 088,95	10 837,65	5 418,83
Sea vessel payment in sea port	0,37	1 994,36	1 994,36	1 994,36	1 994,36
Waste payment in sea port	0,12	677,54	677,54	677,54	677,54
Mooring and unmooring	208,35	416,70	416,70	416,70	416,70
Handling of units in terminal area (Steveco)					
Gate fee, units arriving / departing to / from terminal:					
Containers (per container)	105,20	43 011,02	32 890,78	25 300,60	12 650,30
Units requiring wire-lift (per unit)	105,20	43 011,02	32 890,78	25 300,60	12 650,30
Arex fee, import and export containers (per container)	5,40	2 207,79	1 688,31	1 298,70	649,35
Tallinn:					
Waterway dues	0,30	3 086,40	3 086,40	3 086,40	3 086,40
Lighthouse dues	570,00	285,00	285,00	285,00	285,00
Navigation dues	540,00	270,00	270,00	270,00	270,00
Pilotage payment	581,00	581,00	581,00	581,00	581,00
Tonnage payment at sea port	0,82	8 436,16	8 436,16	8 436,16	8 436,16
Waste payment in sea port	0,02	174,90	174,90	174,90	174,90
Mooring payment in sea port	171,00	342,00	342,00	342,00	342,00
container handling	65,63	26 830,78	20 517,66	15 782,81	7 891,41
Yearly costs:					
Helsinki:					
New waterway dues starting in 2015		59 994,72	59 994,72	59 994,72	59 994,72
Waterway dues		130 534,96	130 534,96	130 534,96	130 534,96
Pilotage payment		683,00	683,00	683,00	683,00
General cargo payment in sea port		1 160 712,48	887 603,66	682 772,04	341 386,02
Sea vessel payment in sea port		125 644,68	125 644,68	125 644,68	125 644,68
Waste payment in sea port		42 684,77	42 684,77	42 684,77	42 684,77
Mooring and unmooring		26 252,10	26 252,10	26 252,10	26 252,10
Gate fee, containers		2 709 694,26	2 072 119,14	1 593 937,80	796 968,90
Arex fee		139 090,77	106 363,53	81 818,10	40 909,05

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In total (Helsinki)		4 335 297,01	3 391 885,84	2 684 327,45	1 505 063,48
Per visit (Helsinki)		68 814,24	53 839,46	42 608,37	23 889,90
Per FEU (Helsinki)		168,31	172,20	177,17	198,67
In total (Helsinki) new waterway dues starting in 2015		4 264 756,77	3 321 345,60	2 613 787,21	1 434 523,24
Per visit (Helsinki) new waterway dues starting in 2015		67 694,55	52 719,77	41 488,69	22 770,21
Per FEU (Helsinki) new waterway dues starting in 2015		165,57	168,62	172,51	189,36
Tallinn:					
Waterway dues		30 864,00	30 864,00	30 864,00	30 864,00
Lighthouse dues		17 955,00	17 955,00	17 955,00	17 955,00
Navigation dues		17 010,00	17 010,00	17 010,00	17 010,00
Pilotage payment		581,00	581,00	581,00	581,00
Tonnage payment at sea port		531 478,08	531 478,08	531 478,08	531 478,08
Waste payment in sea port		11 018,45	11 018,45	11 018,45	11 018,45
Mooring payment in sea port		21 546,00	21 546,00	21 546,00	21 546,00
container handling		1 690 339,22	1 292 612,34	994 317,19	497 158,59
In total (Tallinn)		2 320 791,75	1 923 064,87	1 624 769,72	1 127 611,12
Per visit (Tallinn)		36 837,96	30 524,84	25 790,00	17 898,59
Per FEU (Tallinn)		90,10	97,63	107,23	148,84
In total		6 656 088,76	5 314 950,71	4 309 097,17	2 632 674,60
Per visit		105 652,20	84 364,30	68 398,37	41 788,49
Per FEU		258,41	269,84	284,40	347,51
Fix costs and fuel costs (per FEU)		66,58	87,07	113,19	226,39
Salary costs (per FEU)		38,38	50,19	65,24	130,48
Overhead costs (per FEU)	50 %	19,19	25,09	32,62	65,24
Maintenance costs (per FEU)	10 %	2,53	3,31	4,31	8,62
Total (per FEU)		385,10	435,50	499,76	778,24
Profit	10 %	**423,61**	**479,05**	**549,74**	**856,06**
cargo and port costs contribution		67,10 %	61,96 %	56,91 %	44,65 %
Fixed and fuel costs contribution		17,29 %	19,99 %	22,65 %	29,09 %
salaries, overheads and maitenance costs contribution		15,61 %	18,05 %	20,44 %	26,26 %

Appendix 4f Cost per FEU for the 800 FEUs ship

800 FEUs ship		85 %	65 %	50 %	25 %
Procurement costs (MGO modification added)	6 230 318,75				
Interest rate	6 %				
Number of payments (one payment a year)	7,00				
Weight of empty FEU (t)	3,80				
Average weight of load of FEU (t)	16,69				
Gross tonnage of sea vessel (t)	16 145,00				
Net tonnage of sea vessel (t)	8 222,00				
Amount of trips per day	0,333				
Amount of visits in Helsinki	41,96				
Amount of visits in Tallinn	41,96				
Amount of FEUs	800,00	680,00	520,00	400,00	200,00
Gross weight of freight (t)		11 349,20	8 678,80	6 676,00	3 338,00
Helsinki:					
Waterway dues	2,39	19 642,36	19 642,36	19 642,36	19 642,36
New waterway dues starting in 2015	1,098	9 027,76	9 027,76	9 027,76	9 027,76
Pilotage payment	736,00	736,00	736,00	736,00	736,00
General cargo payment in sea port	2,70	30 642,84	23 432,76	18 025,20	9 012,60
Sea vessel payment in sea port	0,37	3 001,03	3 001,03	3 001,03	3 001,03
Waste payment in sea port	0,12	1 019,53	1 019,53	1 019,53	1 019,53
Mooring and unmooring	357,75	715,50	715,50	715,50	715,50
Handling of units in terminal area (Steveco)					
Gate fee, units arriving / departing to / from terminal:					
Containers (per container)	105,20	71 536,00	54 704,00	42 080,00	21 040,00
Units requiring wire-lift (per unit)	105,20	71 536,00	54 704,00	42 080,00	21 040,00
Arex fee, import and export containers (per container)	5,40	3 672,00	2 808,00	2 160,00	1 080,00
Tallinn:					
Waterway dues	0,30	4 843,50	4 843,50	4 843,50	4 843,50
Lighthouse dues	1 060,00	530,00	530,00	530,00	530,00
Navigation dues	990,00	495,00	495,00	495,00	495,00
Pilotage payment	865,00	865,00	865,00	865,00	865,00
Tonnage payment at sea port	0,82	13 238,90	13 238,90	13 238,90	13 238,90
Waste payment in sea port	0,02	274,47	274,47	274,47	274,47
Mooring payment in sea port	171,00	342,00	342,00	342,00	342,00
container handling	65,63	44 625,00	34 125,00	26 250,00	13 125,00
Yearly costs:					
Helsinki:					
New waterway dues starting in 2015		90 277,56	90 277,56	90 277,56	90 277,56
Waterway dues		196 423,58	196 423,58	196 423,58	196 423,58
Pilotage payment		736,00	736,00	736,00	736,00
General cargo payment in sea port		1 285 712,28	983 191,74	756 301,34	378 150,67
Sea vessel payment in sea port		125 917,22	125 917,22	125 917,22	125 917,22
Waste payment in sea port		42 777,36	42 777,36	42 777,36	42 777,36
Mooring and unmooring		30 020,95	30 020,95	30 020,95	30 020,95
Gate fee, containers		3 001 507,49	2 295 270,43	1 765 592,64	882 796,32
Arex fee		154 069,78	117 818,06	90 629,28	45 314,64

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In total (Helsinki)		4 837 164,65	3 792 155,34	3 008 398,36	1 702 136,73
Per visit (Helsinki)		115 285,87	90 379,79	71 700,23	40 567,63
Per FEU (Helsinki)		169,54	173,81	179,25	202,84
In total (Helsinki) new waterway dues starting in 2015		4 731 018,63	3 686 009,32	2 902 252,34	1 595 990,71
Per visit (Helsinki) new waterway dues starting in 2015		112 756,06	87 849,98	69 170,42	38 037,82
Per FEU (Helsinki) new waterway dues starting in 2015		165,82	168,94	172,93	190,19
Tallinn:					
Waterway dues		48 435,00	48 435,00	48 435,00	48 435,00
Lighthouse dues		22 237,74	22 237,74	22 237,74	22 237,74
Navigation dues		20 769,21	20 769,21	20 769,21	20 769,21
Pilotage payment		865,00	865,00	865,00	865,00
Tonnage payment at sea port		555 477,77	555 477,77	555 477,77	555 477,77
Waste payment in sea port		11 516,00	11 516,00	11 516,00	11 516,00
Mooring payment in sea port		14 349,64	14 349,64	14 349,64	14 349,64
container handling		1 872 375,75	1 431 816,75	1 101 397,50	550 698,75
In total (Tallinn)		2 546 026,10	2 105 467,10	1 775 047,85	1 224 349,10
Per visit (Tallinn)		60 680,35	50 180,35	42 305,35	29 180,35
Per FEU (Tallinn)		89,24	96,50	105,76	145,90
In total		7 383 190,75	5 897 622,45	4 783 446,22	2 926 485,84
Per visit		175 966,22	140 560,14	114 005,58	69 747,98
Per FEU		258,77	270,31	285,01	348,74
Fix costs and fuel costs (per FEU)		50,43	65,94	85,73	171,45
Salary costs (per FEU)		34,65	45,31	58,90	117,80
Overhead costs (per FEU)	50 %	17,32	22,65	29,45	58,90
Maintenance costs (per FEU)	10 %	1,96	2,56	3,32	6,65
Total (per FEU)		363,13	406,77	462,41	703,53
Profit	10 %	**399,44**	**447,44**	**508,65**	**773,89**
cargo and port costs contribution		71,26 %	66,45 %	61,64 %	49,57 %
Fixed and fuel costs contribution		13,89 %	16,21 %	18,54 %	24,37 %
salaries, overheads and maitenance costs contribution		14,85 %	17,34 %	19,82 %	26,06 %

Appendix 4g Cost per FEU for the 981 FEUs ship

981 FEUs ship		85 %	65 %	50 %	25 %
Procurement costs (MGO modification added)	11 419 347,66				
Interest rate	6 %				
Number of payments (one payment a year)	7,00				
Weight of empty FEU (t)	3,80				
Average weight of load of FEU (t)	16,69				
Gross tonnage of sea vessel (t)	21 842,00				
Net tonnage of sea vessel (t)	9 251,00				
Amount of trips per day	0,333				
Amount of visits in Helsinki	41,96				
Amount of visits in Tallinn	41,96				
Amount of FEUs	981,00	833,85	637,65	490,50	245,25
Gross weight of freight (t)		13 916,96	10 642,38	8 186,45	4 093,22
Helsinki:					
Waterway dues	2,39	22 100,64	22 100,64	22 100,64	22 100,64
New waterway dues starting in 2015	1,098	10 157,60	10 157,60	10 157,60	10 157,60
Pilotage payment	736,00	736,00	736,00	736,00	736,00
General cargo payment in sea port	2,70	37 575,78	28 734,42	22 103,40	11 051,70
Sea vessel payment in sea port	0,37	3 376,62	3 376,62	3 376,62	3 376,62
Waste payment in sea port	0,12	1 147,12	1 147,12	1 147,12	1 147,12
Mooring and unmooring	357,75	715,50	715,50	715,50	715,50
Handling of units in terminal area (Steveco)					
Gate fee, units arriving / departing to / from terminal:					
Containers (per container)	105,20	87 721,02	67 080,78	51 600,60	25 800,30
Units requiring wire-lift (per unit)	105,20	87 721,02	67 080,78	51 600,60	25 800,30
Arex fee, import and export containers (per container)	5,40	4 502,79	3 443,31	2 648,70	1 324,35
Tallinn:					
Waterway dues	0,30	6 552,60	6 552,60	6 552,60	6 552,60
Lighthouse dues	1 225,00	612,50	612,50	612,50	612,50
Navigation dues	1 115,00	557,50	557,50	557,50	557,50
Pilotage payment	989,00	989,00	989,00	989,00	989,00
Tonnage payment at sea port	0,82	17 910,44	17 910,44	17 910,44	17 910,44
Waste payment in sea port	0,02	371,31	371,31	371,31	371,31
Mooring payment in sea port	171,00	342,00	342,00	342,00	342,00
container handling	65,63	54 721,41	41 845,78	32 189,06	16 094,53
Yearly costs:					
Helsinki:					
New waterway dues starting in 2015		101 575,98	101 575,98	101 575,98	101 575,98
Waterway dues		221 006,39	221 006,39	221 006,39	221 006,39
Pilotage payment		736,00	736,00	736,00	736,00
General cargo payment in sea port		1 576 604,68	1 205 638,88	927 414,52	463 707,26
Sea vessel payment in sea port		141 676,01	141 676,01	141 676,01	141 676,01
Waste payment in sea port		48 131,03	48 131,03	48 131,03	48 131,03
Mooring and unmooring		30 020,95	30 020,95	30 020,95	30 020,95
Gate fee, containers		3 680 598,56	2 814 575,37	2 165 057,97	1 082 528,99
Arex fee		188 928,06	144 474,40	111 134,15	55 567,08

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In total (Helsinki)		5 887 701,68	4 606 259,02	3 645 177,03	2 043 373,70
Per visit (Helsinki)		140 323,70	109 782,62	86 876,81	48 700,46
Per FEU (Helsinki)		168,28	172,17	177,12	198,57
In total (Helsinki) new waterway dues starting in 2015		5 768 271,27	4 486 828,61	3 525 746,62	1 923 943,29
Per visit (Helsinki) new waterway dues starting in 2015		137 477,27	106 936,19	84 030,38	45 854,03
Per FEU (Helsinki) new waterway dues starting in 2015		164,87	167,70	171,32	186,97
Tallinn:					
Waterway dues		65 526,00	65 526,00	65 526,00	65 526,00
Lighthouse dues		25 699,28	25 699,28	25 699,28	25 699,28
Navigation dues		23 391,59	23 391,59	23 391,59	23 391,59
Pilotage payment		989,00	989,00	989,00	989,00
Tonnage payment at sea port		751 486,24	751 486,24	751 486,24	751 486,24
Waste payment in sea port		15 579,59	15 579,59	15 579,59	15 579,59
Mooring payment in sea port		14 349,64	14 349,64	14 349,64	14 349,64
container handling		2 296 000,76	1 755 765,29	1 350 588,68	675 294,34
In total (Tallinn)		3 193 022,09	2 652 786,62	2 247 610,01	1 572 315,67
Per visit (Tallinn)		76 100,44	63 224,81	53 568,09	37 473,56
Per FEU (Tallinn)		91,26	99,15	109,21	152,80
In total		9 080 723,78	7 259 045,64	5 892 787,04	3 615 689,38
Per visit		216 424,13	173 007,43	140 444,90	86 174,02
Per FEU		259,55	271,32	286,33	351,37
Fix costs and fuel costs (per FEU)		74,19	97,02	126,13	252,26
Salary costs (per FEU)		28,25	36,95	48,03	96,06
Overhead costs (per FEU)	50 %	14,13	18,47	24,02	48,03
Maintenance costs (per FEU)	10 %	2,92	3,82	4,97	9,94
Total (per FEU)		379,05	427,59	489,48	757,66
Profit	10 %	**416,95**	**470,35**	**538,42**	**833,43**
cargo and port costs contribution		68,47 %	63,45 %	58,50 %	46,38 %
Fixed and fuel costs contribution		19,57 %	22,69 %	25,77 %	33,29 %
salaries, overheads and maitenance costs contribution		11,95 %	13,86 %	15,73 %	20,33 %

Appendix 5 Ropax cost per visit calculations

Ms Star					
Procurement costs (MGO modification added)	131400000			yearly payment(loan+interest costs)	11 456 050,79 €
Interest rate	6 %			montly payment (loan+interest costs)	954 670,90 €
Number of payments (one payment a year)	20			Daily paymeny (loan+interest costs)	31 822,36 €
Semi-trailer Lenght "truck" (in metres)	17,3			per visit paymeny (loan+interest costs)	5 303,73 €
Trucks	120	33,22		Fuel cost per visit	13037,11549
Average load of semi-trailer	13,85			Fixed and fule costs per visit	18 340,84 €
Cars capacity	450	158,35			
Car lenght (in metres)	5				
Passengers capacity	1900	896,43	Average voulme of passengers per visit		
Lane capacity (in metres)	2000				
Gross tonnage of sea vessel (t)	36249				
Net tonnage of sea vessel (t)	13316				
Amount of trips per day	6				
Amount of visits in Helsinki	1095				
Amount of visits in Tallinn	1095				
Gross weight of freight of trucks load (t)		460,097			
Helsinki:					
Passengers charge	1,89	1694,25			
Waterway dues (30 times a year)	1,045	13915,22			
Pilotage payment (once a year)	1042	1042			
General cargo payment in sea port	3,14	1444,70			
Sea vessel payment in sea port	0,219	2916,20			
Waste payment in sea port	0,124	1651,184			
Mooring and unmooring	357,75	715,5			
Tallinn:					
Passenger charge	1,75	1568,75			
Waterway dues (max. 60 times a year)	0,12	4349,88			
Lighthouse dues *	2045	1022,5			
Navigation dues *	1500	750			
Pilotage payment	1360	1360			
Tonnage payment at sea port	0,241	8736,009			
Waste payment in sea port (per day for passenger ship)	0,016	579,984			
Mooring payment in sea port	114	228			
Vehicle cargo charge	4,5	4,5 Euros per unit including (buses, trucks, trailers, reel trailes, caravans, etc).			
Yearly costs:					
Helsinki:					
Waterway dues		417456,6			
Pilotage payment		1042			
General cargo payment in sea port		1581951,515			
Sea vessel payment in sea port		3193243,38			
Waste payment in sea port		1808046,48			
Mooring and unmooring		9527598			
Passengers fees		1694,25486			
In total (Helsinki)		16529337,98			
Per visit (Helsinki)		15095,28582			
Per truk (Helsinki)		454,4035467			
Tallinn:					
Waterway dues		260992,8			
Lighthouse dues		1119637,5			
Navigation dues		821250			
Pilotage payment		1360			
Tonnage payment at sea port		3439803,544			
Waste payment in sea port		211694,16			
Mooring payment in sea port		249660			
In total (Tallinn)		6104398,004			
Per visit (Tallinn)		5574,792697			
Per truck (Tallinn)		167,8143497			
In total		22633735,98			
ports costs Per visit		20670,08	34,5 %		
Fxed and fuel costs per visit		18 340,84 €	30,6 %		
Salaries costs per visit		11 393,75 €	19,0 %		
overhead costs per visit	50 %	5 696,87 €	9,5 %		
Maintenance costs per visit	10 %	530,37 €	0,9 %		
Passengers fees in both ports per visit		3 263,01 €	5,4 %		
Total cost per vist without passengers fees		**56 631,92 €**			
Total cost per vist with passenger fees		59 894,93 €	100,0 %		

Appendix 6 Ropax costs allocation

Costs without passengers fees	56631,92
General cargo payment in Helsinki	1444,70
Costs without cargo payment and passengers fees	55187,21
Passengers fees	3 263,01 €

			Total	Passengers fees
To trucks		40 %	8830,0	
To cars		60 %	13244,9	
	Monthly			
Trucking passengers (1 per truck)	13950,92	3,7 %	1226,9	120,91 €
Car passengers (2 per car)	133014	35,3 %	11698,2	1 152,79 €
Passengers	229537	61,0 %	20187,2	1 989,32 €
Total	376501,08			
			66506,83	

	Total		
Total costs, truck	11622,5		
Total costs, cars	26095,9		
Total costs, passenger	22176,5		
	Monthly	Daily (30 days)	Per leave (14 departures)
Amount of trucks (with 1 pass.)	13950,92	465,03	33,22
Amount of cars (with 2 pass.)	66507	2216,89	158,35
Amount of passengers	229537	7651,22	546,52
			896,43

Item	Cost (Euros)	Price now (Euros)
Per truck (with 1 pass.)	349,9	579,8
Per car (with 2 pass.)	164,8	91
Per passenger	40,6	33
	354,4	

4.5 Euors will be added to each truck for loading or unloading it from the ship in port of Tallinn. So, the total cost per truck would be: 354.4€

costs contribution per visit	share	Truck	Car	Passenger
ports costs	34,5 %	122,31	56,87	14,00
Fxed and fuel costs	30,6 %	108,52	50,46	12,43
Salaries costs	19,0 %	67,42	31,35	7,72
overhead costs	9,5 %	33,71	15,67	3,86
Maintenance costs	0,9 %	3,14	1,46	0,36
Passengers fees in both ports	5,4 %	19,31	8,98	2,21
Total	100 %	354,40	164,80	40,58

For fores industries (high volumes)	share	cost per truck
ports costs	34,5 %	122,31
fuel costs	21,8 %	77,14
salaries	19 %	67,42
total		266,87