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ROUTING ANALYSIS VIA BALTICA, 2015 IMPACTS OF SULPHUR RESTRICTIONS ON TRANSPORT SERVICE PRODUCTION

Case: DSV Road Oy

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Transport Service production
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ABSTRACT

This Master's Thesis analyses the impacts of the International Maritime Organisation's amended rules on emissions from maritime shipping referred to as the MARPOL Annex VI. As an effort to incorporate the MARPOL agreements into EU law, an EU Directive (2005/33/EC) is in place. Although the harmonizing of the two entities is not complete, the concept of the Sulphur Emissions Control Area (SECA) has been agreed upon, consisting of the Baltic and the North Sea as well as the English Channel. As and from January 2015 stricter fuel standards of 0,1 % sulphur contents in ships bunker fuel becomes applicable on the SECA area indicating that cleaner, more expensive fuels are used in ships. Rising fuel costs are incorporated in their entirety in sea freight costs suggesting that sea transportation will become more expensive in 2015.

An empirical study is carried out for the case company, DSV Road Oy, with an objective to identify the impact of the sulphur restriction in the context of transport service production between Finland and mainland Europe. The aim of the research is to compare the use of the direct sea lanes between Helsinki, Gdynia and Travemünde to that of routing via the Baltic States, including a hypothetical assumed infrastructure of the Rail Baltica Corridors. Ultimately, the objective is to make recommendations to routings and identify a break-point for the impact of the sulphur restriction required to initiate the exploitation of Baltica through a Transport System Analysis framework.

A simple method of calculating the present price difference of the fuel grades, HFO (380) and MGO, is used to predict the futures cost increase of 37 % in sea freight. With the sea freight representing one component of the total production costs, the impact of the sulphur emissions restriction indicated an increase of 7-20% as a market average for the 13 European countries analysed. In the context of the depot-to-depot linehaul services, the impact of the sulphur restriction is identified to correlate a) the specific route taken b) the length of the sea segment in relation to the location analysed. The research suggests that the cost increases will initiate shifts in routings to favour the offerings of the Baltica particularly for Eastern and Southern European locations without jeopardizing the performance criteria analysed. The findings show that the Rail Baltica Corridors provide relief for the excess environmental burden, as well as the added journey time caused from routing via Baltica, nevertheless not due to assist in 2015 as estimated to be ready at earliest in 2022.

Further study is suggested to include the analyzing of routing via Gdynia and Sweden as an effort to combat the upcoming cost increases and favour the short sea segments in order to reduce cost volatility of transport services.

Key words: Bunker adjustement factor, emissions control, emissions restriction, performance criteria, routing, sulphur emissions control area, transport service production

Lahden ammattikorkeakoulu
Liiketalouden laitos

RAVANTTI, HEDE:

Reititysanalyysi Baltian kauttakulkuun, 2015 rikkirajoituksen vaikutus kuljetuspalvelutuotannossa
Case: DSV Road Oy

Ylempi amk-tutkinto, opinnäytetyö, 145 sivua, 40 liitesivustoa

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TIIVISTELMÄ

Tämä opinnäytetyö keskittyy analysoimaan kansainvälisen merenkulkujärjestön MARPOL-yleissopimuksen uudistetun ilmansuojeluliitteen (Annex VI) alusliikenteen rikkidioksidipäästörajoituksen vaikutusta kuljetuspalvelutuotannossa. MARPOL sopimuksen ja EU lain yhdenmukaistamisen tukipilariksi on asetettu EU rikkidirektiivi (2005/33/EC). Vaikkakin näiden kahden tahon harmonisointi on keskeneräinen, on päästy yhteisymmärrykseen rikkipäästöjen kontrollialueesta (SECA) joka sisältää Itämeren, Pohjanmeren ja Englannin kanaalin. Tammikuussa 2015 rikkipäästöjen kontrollialueen rajoitus tiukkenee 0.1% rikkirajaan joka edellyttää puhtaamman, kalliimman, polttoaineen käytön alueen merenkulussa. Koska nousevat polttoainekustannukset sisällytetään kokonaisuudessaan merirahteihin on oletettavissa että merirahdin hinta nousee huomattavasti 2015.

Tutkielma suoritetaan DSV Road Oy:lle, tavoitteena määritellä rikkidirektiivin vaikutus Suomen ja Manner-Euroopan välisessä kuljetuspalvelutuotannossa. Tutkielma keskittyy vertailemaan suorien lauttayhteyksien, Helsingin ja Gdynian sekä Travemünden välillä, reititykseen Baltian kautta, mukaan lukien hypoteettisen kannanoton Rail Baltica infrastruktuurin läsnäolosta. Perimmäinen tavoite on antaa tulevaisuuden reitityssuosituksia ja löytää rikkirajoituksen pysäytyspiste joka ohjaa Baltian hyödyntämiseen käyttäen kuljetusjärjestelmäanalyysin viitekehystä.

Yksinkertaista menetelmää käyttäen, laskemalla tämän hetkisen hintaerotuksen HFO (380) ja MGO polttoainelaatujen välillä, tutkielma ennustaa merirahdin kustannusnousuksi 37%. Huomioiden merirahdin edustavan yhtä kustannusrakennekomponenttia, rikkirajoituksen keskiarvovaikutus 13 analysoidun markkinan osalta indikoi 7-20% kustannuskorotusta. Kappaletavaran runkorahtituotannossa rikkirajoituksen vaikutus määräytyy pääosin a) valitusta reitityksestä ja b) merirahdin pituudesta maantieteellisessä kokonaisuudessa. Tutkielma osoittaa että Baltiaa suosivat reititykset painottuvat pääosin Itä- ja Etelä-Euroopan kohteisiin vaarantamatta analysoituja palvelumittareita. Tutkielma osoittaa että Baltian kauttakulusta koituva ylimääräinen ympäristö- ja aikataulurasite olisivat mittavasti vähennettävissä Rail Balticaa hyödyntäen. Tämä tukiverkosto ei kuitenkaan tuo helpotusta 2015 koska infrastruktuurin arvioitu valmistuminen on aikaisintaan 2022.

Jotta tulevaa kustannuskorotusta voidaan minimoida optimaalisesti ja kuljetuspalvelutuotannon hintaherkkyyttä tasata hyödyntämällä lyhyempiä merisegmenttejä, jatkoanalyysi reititystehokkuuteen Gdynian ja Ruotsin kauttakulkuun nähdään tarpeelliseksi.

Avainsanat: polttoainelisä, päästöjen hallinta, päästörajoitus, palvelumittarit, reititys, rikkipäästöjen kontrollialue, kuljetuspalvelutuotanto

FOREWORD

This Master's Thesis is a continuation study for the case company, DSV Road Oy, on routing allocation and solutions for freight transportation service production between Finland and other European locations. The initial study was my Batchelor's Thesis in 2008, *Routing Analysis Using Intermodal Transport Chains (Reititysanalyysi intermodaali-kuljetusketjuille)*, where the focus was on DSV Road Oy's depot to depot services between Finland and Great Britain. This Master's Thesis on the other hand looks at the depot to depot services between Finland and mainland European locations.

From Finland's point of view, in geographical terms, what in these studies is central is the motivation for both research, today and five years ago; the increasing cost of sea freight. From a competitive positioning view point, Finnish export industries' ability to remain competitive with European rivals poses increased pressure on transport service production, in its efforts to minimise the impacts of the cost increase at sea. This pressure leaves no alternatives but to seek solutions other than that of the use of the direct sea services between Finland and other European ports.

Although the approach to routing analysis is similar in both studies the emphasis of the contents varies greatly. The focus of the batchelor thesis is more on the role of transportation in the entire logistics process, carrier expectations and performance measurement, components of transport service production and intermodal transport chains. Whilst the Master's Thesis looks more at the role of policy making and European investment schemes in transport service production, the impact of the decided sulphur restriction in ship's bunker fuel and the potential relief of the Rail Baltica network. Although the Batchelor's Thesis scratched the surface of the topic of green logistics, the Master's Thesis places more emphasis on the subject, as it is after all the driving force beyond the increased cost structures, an effort to improve the environment we live in. On the other hand, as proven to work in the Batchelor's Thesis, the same Transport Systems Analysis tool is used in the Master's Thesis.

The routings of the traffic flows between Finland and Great Britain have evolved substantially in the past few years. Whilst in the past the majority of the units were transported via the direct sea services between the Finnish and the UK ports, whilst it remained competitive. The current flows on the other hand are much distributed among various alternatives. The transport service production for the UK market has become competitive with alternative routing solutions via Denmark, Germany and Sweden, and the use of the direct vessels remains mainly due to other operational constrains. The use of the shorter sea segments also accommodate increased flexibility with more frequent sailing schedules and minimise the impacts of the increased ship's bunker fuel in the total production costs.

With the current developments foreseen for 2015 similar shifts are likely to take place for the routings between Finland and other Mainland European locations. There comes a point where the use of the direct sailings no longer offer a cost efficient solution and alternatives become attractive dispite of compromises in other performance criteria, mainly green logistics and in particular the emphasising of emmissions control towards improved air quality. These issues highlight the role of policy making and the prioritising of national and international investments, for say in the field of developing infrastructure.

As the current Benelux, Ireland and UK Traffic Manager for DSV Road Oy, the study is supported with my experience in transportation systems and transport service production as well as gained expertise in the market area under analysis. This position has also accommodated access to information and contacts relevant to conducting the empirical analysis of the Master's Thesis.

CONTENTS

ABBREVIATIONS

B-AC	Baltic-Adriatic Corridor
BAF	Bunker Adjustement Factor
CO_2e	Carbon Dioxide Emissions
ECA	Emissions Control Area
EMSA	European Maritime Safety Agency
ESN	Short Sea Network
GRP	Groupage
HFO	Heavy Fuel Oil
IFEU	Institute for Energy and Environmental Research
IMO	International Maritime Organization
LNG	Liquified Natural Gas
MGO	Marine Gas Oil
M&G	Map and Guide Navigation Tool
NTM	Network for Transport and Environment
RBGC	Rail Baltica Growth Corridor
SECA	Sulphur Emissions Control Area
SPC	Short Sea Promotion Centre
SSS	Short Sea Shipping
TEN-T	Trans-European Transport Network
TSA	Transportation System Analysis

1 INTRODUCTION

The focus of this master's thesis is on the Finnish transport industry and in particular International road transport service production between Finland and mainland Europe. The emphasis is on the carriage of goods rather than passengers. The idea is to demonstrate an analysis based on gathered information from interviews as well as from relevant, current literature in order to establish a futures vision for transport service production after the implications of the emissions restrictions once applicable in January 2015.

1.1 Background

The new International Maritime Organisation (IMO) regulation will have an impact on the transport service production between Finland and mainland Europe as the demands on the use of cleaner fuels in the Sulphur Emissions Control Area (SECA) will reflect in increased sea freight costs. These costs will burden many of Finland’s export industries and subsequently question the competitive positioning of Finland on the European market. This on the other hand will emphasise the importance of keeping transportation costs at bay and pressure transportation service providers to search for the most cost efficient alternative production methods to service the European markets.

Transport service providers will likely favour connections that allow for short sea segments in order to minimise the impacts of the sulphur restrictions. Depending on the geographic location of both the loading and unloading places in Finland and mainland Europe, the most efficient usable route will be determined. Modal shift is likely to take place and the transit via the Baltic and Sweden is going to increase. The breakpoints and relative geographic positions will be investigated, evaluated and recommended in the master’s thesis case study.

In the near futures building up to 2015 and thereafter more emphasis will be allocated on infrastructure between Finland and mainland Europe, as well as further studies on the impacts of the agreed IMO regulation. It is however evident that a gradual modal shift will take place and the futures road freight service production will distribute amongst various routings rather than focus on the usage of direct sea crossings between Finland and mainland Europe. This modal shift will also have an impact on the CO_2 emissions, congestion on European road networks, and demands on short sea segments as well as overall haulage capacity on these markets.

The aim of the Master’s Thesis is to provide an overview of the situation and provide recommendations in alternative production methods in order to minimise the impacts of the regulations without jeopardizing the service standards.

1.2 Research questions, objectives and scope

The issue at hand has been briefly introduced. In order to assume the impacts of the 2015 sulphur restrictions on service production possible alternatives are identified. The initial step to finding a potential alternative is simply by drawing geographically optimal lines on between the desired locations. In this case as shown in the map of Europe in figure 1 below, there are two possible futures.

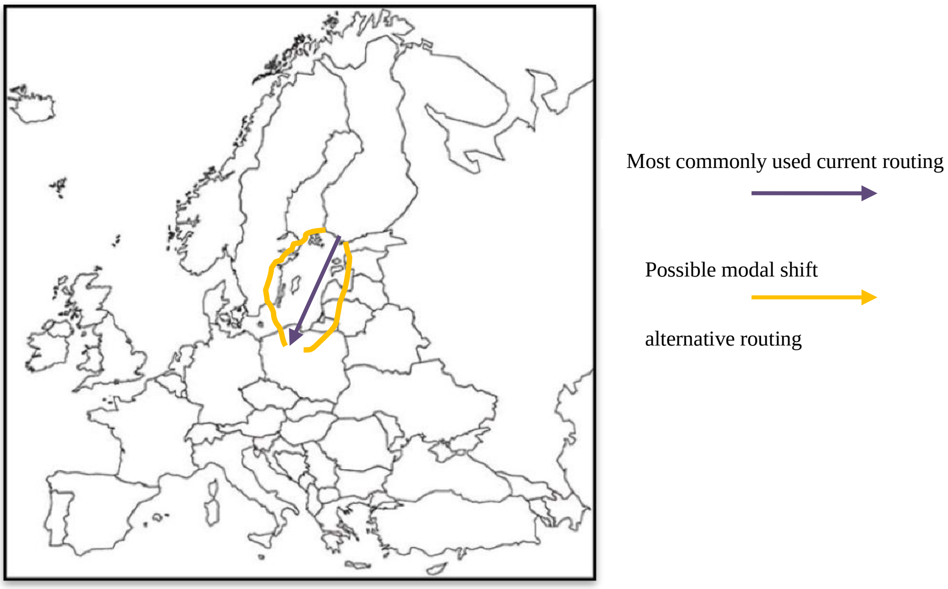


Figure 1. Possible futures (map of Europe[2])

As explained above, it is possible to identify likely alternatives by drawing the most desired lines, routes, on the map. In order, however to reach a desired future state, the transport system must be analyzed. Based on current literature, discussion and an existing understanding of the infrastructure as well as the current situation, the probable futures are selected. The illustrated alternatives from figure 1 on the previous page are discussed in brief in the following paragraphs.

The most common routing currently used to bridge Finland and mainland Europe are the direct sailings from Finland into Germany vise versa. As explained, the rises in sea freight costs are a likely lead to modal shift and a search for routings that accommodate shorter sea segments, reflecting a smaller impact of the suplur restrictions in ships bunker fuel. These alternatives include going via the Baltic countries or Sweden as shown in Figure 1. The modal shift is however strongly tied to geographic location, where the loading and unloading places between Finland and mainland Europe lie. It is the geographic positioning that will determine which one of the possibilities is most efficient and likely to be used.

The current infrastructure allows for the modal shift to take place. The sea and road networks are in place to cater for the change. Whilst focusing on Sweden, a railway connection for inland transportation from port A to port B in Sweden is a beneficial contributor to favouring the "Western" routing. On the other hand, using Sweden as a country of transit requires two sea crossings, placing pressure on the connection patterns en route.

Via the Baltic States, the "Eastern" routing, requires one sea crossing only, but on the other hand suffers from the lack of development for the Rail Baltica corridors. The Rail Baltica network is merely underway and has been work-in-progress for twenty years now. Naturally, for Shippers near the eastern border, the eastern route is most likely to offer better cost efficiency. Nevertheless, from a broader Finnish perspective, routing via Baltica and in particular the development of the Trans European Transport Network (TEN-T) corridors is a real world alternative that requires an indepth investigation. It is therefore, that the study in question focuses on the possibilities offered by the Baltic States only.

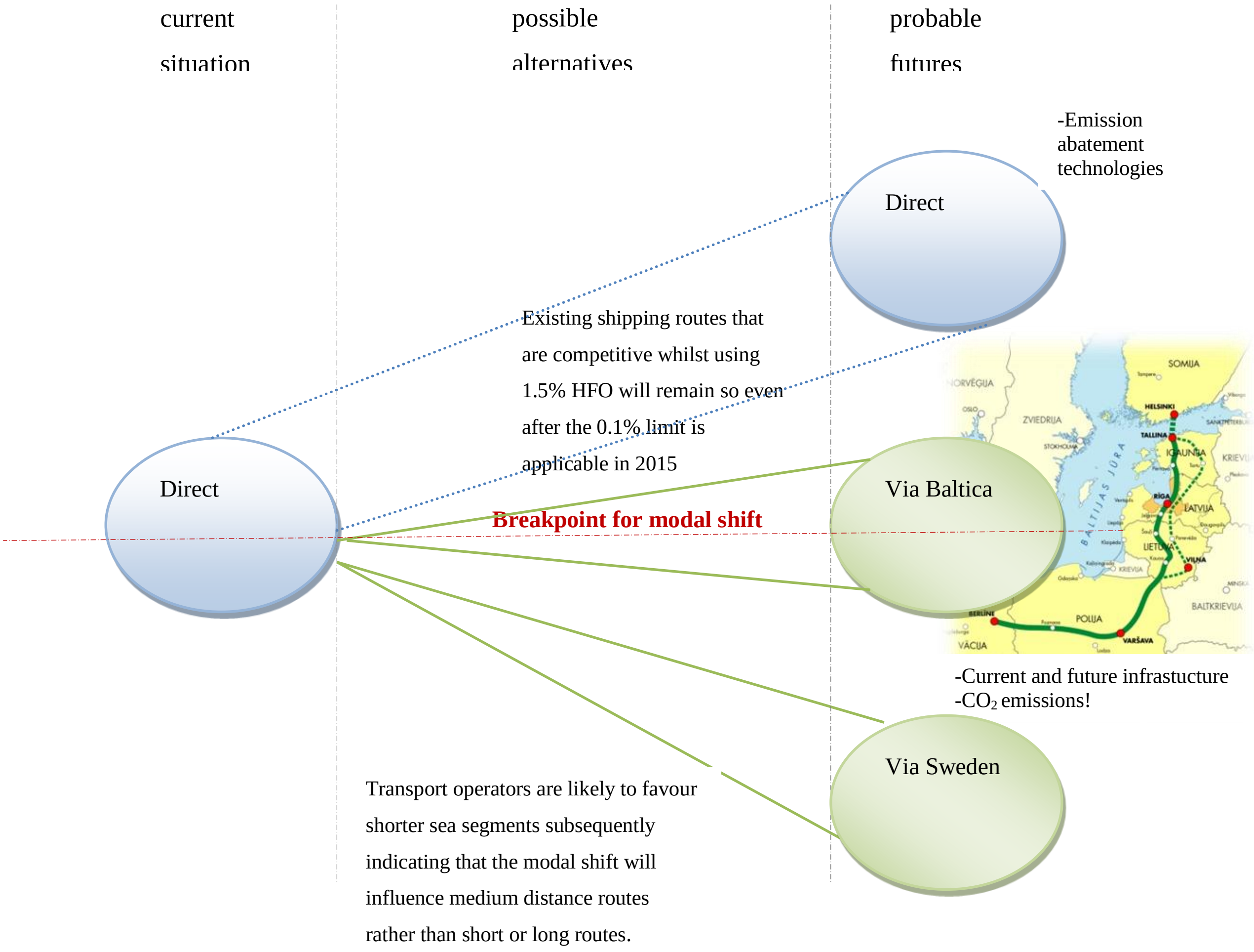
The objectives of the research are outlined as follows:

- To identify the meaning and the impact of the sulphur restriction in the context of transport service production between Finland and mainland Europe

- To outline the alternative routing solution via Baltica and make comparison, through performance criteria, to the existing service production methods for major European locations, including the assumed infrastructure of Rail Baltica Corridors

- To make recommendations to routings and identify a break-point for the impact of the cost increase reflected by the sulphur restrictions

Although the upcoming cost increase is a central element of the research, cost is however only one of the performance criterions used to determine the probability of the use of routing via Baltica. Another important aspect of the study is the environment the impact of each routing on the environment. A secondary study is also conducted to compare some of the available emissions calculation tools in an effort to establish comparability of the tools in general.



-Emission abatement technologies

Existing shipping routes that are competitive whilst using 1.5% HFO will remain so even after the 0.1% limit is applicable in 2015

-Current and future infrastucture
-CO_2 emissions!

Transport operators are likely to favour shorter sea segments subsequently indicating that the modal shift will influence medium distance routes rather than short or long routes.

Figure 2. Probable futures 2015

At this point, it is vital to highlight the **limitations** of the study. With a research question as broad as in this Master's Thesis, it is of essence to harmonise, simplify and assume certain aspects in order to create an environment of fair comparison. It is also necessary to assume the current ratios amongst factors remain stable in the futures vision with the methods used for this particular analysis. These factors are outlined in table 1 below.

Table 1. Limitations outlined

creating an **environment of comparison** for multiple markets, assuming **current ratios remain at the same level in 2015**	**depot-to-depot road freight** service production for **main European depots** from a **Finnish perspective**	**linehaul for groupage** services, although findings beneficial to **PTL and FTL production**	The cargoes in question
	assuming import is a reversed mirror image of export	focus on **export flow and cost distribution**	ship operator's capability to pass on increased fuel price
	Assumed availability of capacity; vessel space and haulage	Assuming that plans go accordingly; impact of **unforeseen conditions** affecting transport service production are eliminated	The ship used and the specific route taken
	Focus on **Gdynia and Travemünde through port flows**	Comparison is made between routing Gdynia vs Baltica and Travemünde vs Baltica	The specific route taken and the lenght of the sea segment
	Assuming optimal connections	**the waiting time for connective schedules are not included** in the total journey time calculations for use of rail	The specific route taken
	The 2015 view is based on the calculated cost increase for ship's bunker fuel comparing the **present price difference of the fuel grades**	method does not consider **factor contributors influencing the futures price of fuels** eg. consumption, availability	the ship used and the lenght of the sea segment
	The presence of the **motorway network is assumed as adequate** presence of **infrastructure**	any **potential increased demands** on current infrastructures are not evaluated	the specific route taken
	Presence of **Rail Baltica** corridor is **based on the latest indicators**	Rail Baltica is work-in-progress and **potential alternatives are not considered**	the specific route taken

Shown later in the paper, under section 2.1, are findings made by the European Maritime Safety Agency (EMSA) indicating that the impact of the sulphur restrictions will vary in accordance with five criteria; the specific route taken, the ship used, the cargoes in question, the lenght of the sea segment and the ship operator's capability to pass on the increased fuel prices. These criteria are linked to the limitations in the right column of table 1. After outlining what the study includes, it is time to move on to the knowledge base of the research.

1.3 Knowledge base of the research

One of the challenging aspects of this Master's Thesis was the gathering of the information. It has required a long process of staying connected with the news and establishing an understanding of the current viewpoints on the matter from a Finnish perspective on the sulphur directive. The challenge with the topic is that there are numerous takes on it and big questions that remain unanswered. The limited numbers of relative studies are tied to interest groups indicating uncertainty of what to expect in January 2015. Figure 3 nonetheless indicates the knowledge base of the research.

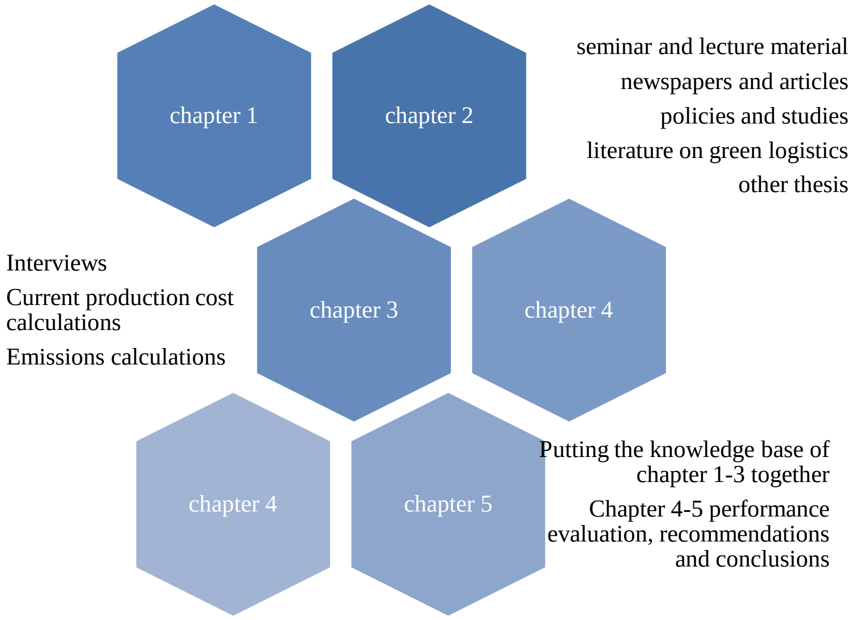


Figure 3. Knowledge base of the research

The list of references at the back of the Master's Thesis shows the variety of the studies used to understand the impacts of the upcoming changes as well as practical material such as intervies, seminar presentations and newspapers. The appendices on the other hand indicate the emphasis of numerical data, various calculations, required to make conclusions on the topic. Both qualitative and quantitative research methods have been required to make findings, evaluations and recommendations, bridging onto the next subheading on the research approach.

1.4 Research approach

The research approach is opened in this section of the thesis. Table 2 illustrates how qualitative and quantitative research methods are used to reach the goals of the Master's Thesis. The table also explains the objectives of each research method as well as the corresponding items referred to. For example qualitative research methods were used to uncover dominant trends through interviews and articles as shown below.

Table 2. Research approach

	Qualitative Research	**Quantitative Research**
Objective	• To gain an understanding of underlying reasons and motivations **Policies and studies, current literature on relevant topics** • To provide insights into the setting of a problem, generating ideas and hypotheses for later quantitative research **Seminar and lecture material, other thesis** • To uncover dominant trends in thought and opinion **Interviews, newspapers and articles** **Chapter 2+4**	• To generate and calculate data and generalize results from a sample to the population of interest **Current production cost and performance components** **Futures production cost and performance components** • To measure the incidence of various views and opinions in a chosen sample **Cost and performance calculations** • Sometimes followed by qualitative research which is used to explore some findings further **Comparison of current and futures cost and performance components** **Chapter 3+4**
Sample	Usually a small number of non-representative cases. Respondents	Usually a large number of cases representing the population of

	selected to fulfill a given quota **Availability of information (knowledge base of research)**	interest. Randomly selected respondents. **Main European depots (limitations)**
Data collection	Unstructured or semi-structured techniques e.g. individual depth interviews or group discussions **Interviews, literature**	Structured techniques such as online questionnaires, on-street or telephone interviews. **Emissions calculation tools, route calculation tool, freight and service contracts, bunkerworld: fuel prices**
Data analysis	Non-statistical. **PESTE analysis, Transport Systems Analysis (TSA)**	Statistical data is usually in the form of tabulations. Findings are conclusive and usually descriptive in nature. **Excel worksheets + databases, Tableau**
Outcome	Exploratory and investigative. Findings are not conclusive and cannot be used to make generalizations about the population of interest. Develop an initial understanding and sound base for further decision making. **Supporting pillar for chapter 4+5 recommendations and conclusions**	Used to recommend a final course of action **Recommendations and conclusions** **Chapter 4+5**

The used tools as mentioned in table 2 are discussed in more detail next.

Bunkerworld

Bunkerworld is an online platform aimed at top management in the marine and energy sectors. Bunkerworld has been published since 1997 and offers exclusive material on marine fuels, highly relevant to making succesful and sustainable business strategies (Bunkerworld, 2013). Educational institutions can obtain full access to suscriber information free of charge (King, C. 2013) which was done upon request by the Lahti University of Applied Sciences information and library services for the purpose of this Master's Thesis. Full access to the Bunkerworld website has been granted for all the computers in the Felmannia building in Lahti (Lahdenranta, M. 2013).

Bunkerworld is the leading publication on marine fuels with over 50 000 industry player visits per month. The publication focuses on areas such as fuel markets, alternative fuels, marine lubes, the environment, legislation and corporate markets. Figure 4 indicates some of the useful contents of the publications as explained by Bunkerworld (2013).

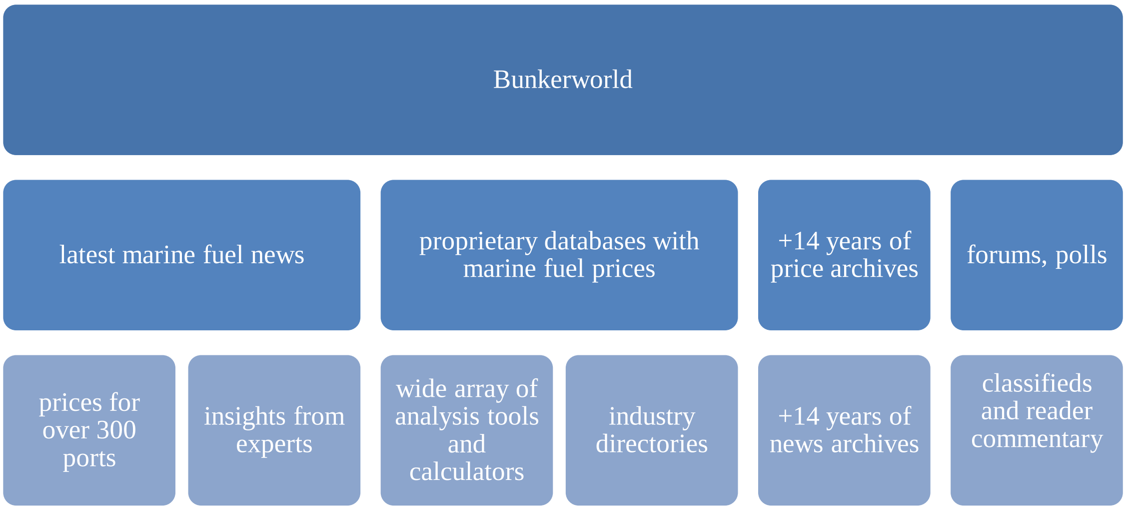


Figure 4. Contents of Bunkerworld

For the purpose of this Master's Thesis the Bunkerworld publication was mainly used to determine the present ratio for the price difference in the various fuel grades. This was used as the basis for the calculations on the futures price for the sea freight, see figure 35 on page 52.

With a lot of emphasis on the emissions in this research, a secondary analysis was made to benchmark some freely available emissions calculators as is introduced next.

Emissions calculation tools

A total of three tools were used to benchmark CO_2 emissions on mainland Europe, these were the PVT M&G Internet (M&G), Eco TransIT World, and the NTM Calc portals. The M&G will be introduced in more detail under route calculation tools as it was used to calculate the routings in this Master's Thesis as well as other performance criteria under analysis. The specs, value basis and factor contributors, of these three tools are compared in more detail in table 11 under section 3.1.2 CO_2 emissions benchmarking. Here a brief introduction to the bodies behind the emissions calculation tools.

Eco TransIT World is a project that commenced in 2000, initiated by five European railway companies; DB Schenker Rail, Schweizerische Bundesbahnen (SBB), Green Cargo AB, Trenitalia S.p.A, Société Nationale des Chemins de Fer Français (SNCF). Since then new partners have joined; Red Nacional de los Ferrocarriles Españoles (RENFE) and Société Nationale des Chemins de fer Belges (SNCB). All project partners provide information for the database and constantly update the tool according to national policies. The tool itself is developed by the Institute for Energy and Environmental Research (ifeu) from Heidelberg, the Öko-Institut from Berlin, the Rail Management Consultants GmbH (RMCon/ IVE mbH) from Hanover (Eco TransIT World, 2013a).

NTM Calc, developed by the Network for Transport and Environment in Stockholm, is a non-profit organisation initiated in 1993. The aim of the organisation has been to develop a common base value for calculating the emissions of various transport modes. Private persons, companies and institutions have the opportunity to join the organisation's efforts through a membership fee. The membership aims to offer access to the following (NTM, 2013).

- To increase transport-related environmental expertise and competence.
- To develop professional network and personal skills.
- To influence the prioritization and the future focus of transport-related environmental aspects.
- Through NTM’s database increase credibility whilst reporting transports’ environmental performance.

The various European routings were benchmarked for emissions as shown in appendix 8.

Freight Contracts

The basis for the production cost calculations are the case company's current freight agreements with the various service providers. The futures prices are only amended by the expected change in the sea freight costs, based on fuel prices at present. The market specific km-rates were based on interviews as is explained next.

Interviews

The expert interviews carried out were used as an effort to create a more in depth understanding of the topic surrounding the Master's Thesis as well as to support the literature base of the research. The professional interviews allowed for the establishment of market specific calculations and benchmarking of other performance measurement standards, such as schedules. The vessel operators accommodated in the validication of the literature base as well as opened a central view point to the Master's Thesis. The interviews are outlined in table 3 below.

Table 3. Interviews as a knowledge base

Type of interview	Method	Objective
Expert interviews		
1. ***Mr Björn Andler*** **Division Director, Western Europe and Domestic,** **DSV Road Oy**	In person, questionnaire, (appendix 1) 16.11.2012	To get an initial understanding of the situation at hand as well as the goals for the master's thesis from the case company.
2. ***Mr Håkan Fagerstrom*** **Director, Cargo Services (Tallink Silja Oy)**	By email, questionnaire, (appendix 2) 16.9.2013, 27.9.2013	To strengthen and support the understanding of the situation from a Finnish perspective. To gather first hand expert information directly from the market. To support the literature base of the master's thesis.
Professional interviews		
1. ***Mr Roi Kohi*** **Traffic Manager, East, DSV Road Oy**	In person, discussion 20.6.2013	To establish an understanding of the Eastern European traffics and production methods. To establish a basis for the calculations of the Eastern markets (appendix 15).
2. ***Ms Maija Naumanen*** **Traffic Manager, South, DSV Road Oy**	In person, discussion 3.7.2013	To establish an understanding of the Southern European traffics and production methods. To establish a basis for the calculations of the Southern markets (appendix 11).
3. ***Mr Mikko Kuosmanen*** **Traffic Manager, Germany and Austria, DSV Road Oy**	In person, discussion 3.7.2013	To establish an understanding of the German and Austrian traffics and production methods. To establish a basis for the calculations of the markets (appendix 10).

continued

Vessel Operator interviews		
1. ***Finnlines Plc*** **Mr. Juha Ahia, Manager Projects and Newbuildings** **2.** ***Transfennica Ltd*** **Mr. Kimmo Kari, Director Traffic Operations** **3.** ***Viking Line Abp*** **Mr. Kari Pihlajaniemi, Vice President Marine Operation**	By email, questionnaire, (appendix 3-4) 16.9.2013, 30.9.2013, 4.10.2013, 8.10.2013	To strengthen and support the understanding of the situation from a Finnish vessel operators' perspective. To gather first hand expert information directly from the market. To support the literature base of the master's thesis.

A political, economic, sociological, technological and environmental conclusion of the sulphur emissions restrictions is drawn together through a PESTE analysis as explained under the following subheading.

PESTE Analysis

Section 2.1., ammended rules on emissions from maritime shipping, was concluded with a PESTE-analysis visualisation (see figure 12 on page 20) as an effort to highlight the **p**olitical, **e**conomic, **s**ociological, **t**echnological and **e**nvironmental reasoning and pressures beyond the IMO amendment and the sulphur directive as an entity. A PESTE-analysis is a continuation of a PEST-analysis, where the environmental aspects are highlighted separate to those of the sociological. The aim of the analysis is to study the environment surrounding the subject, often used as a supporting or continuation tool for a SWOT-analysis. The next figure 5 shows a simple model for a PEST-analysis, a basis for the PESTE.

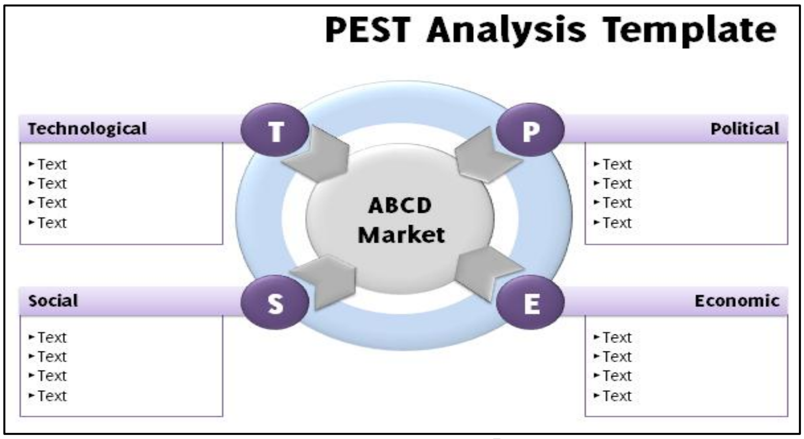


Figure 5. Example template for a PEST-analysis[5]

The aim for the PESTE visualization is to emphasise the various factor contributors in the policy-making process. As mentioned earlier, a route calculation tool was used as a basis for the performance measurement and caulculations of this Master's Thesis, PTV Map&Guide is introduced next.

Route Calculation Tool

The case company has a licence agreement with PTV Planung Transport Verkehr AG (PTV) who operates the service PTV Map&Guide internet, referred to as M&G, for route planning, emissions calculations, traffic information and vehicle management. For over 20 years, PTV Map&Guide has established itself as professional transport route planner in the industry with over 55,000 customers at present (MapandGuide, 2013).

The tool is used to support the mainland European disponents' tasks for daily transport planning. For the case of this Master's Thesis, the tool was used to calculate each routing alternative and the route specific performance measures used. These were collected into Excel-sheets and are referred to as worksheets and databases and presented in the appendices of this research. Table 4 below shows the route specific performance measurements supplied by M&G, the example is a result from the M&G calculation as shown in appendix 5.

Table 4. M&G Route specific performance measurement example

Route calculation result			
Visibility	**Route length**	**Toll route**	**Empty run**
Route 1	630.83 km	447.70 km	0.00 km
Date of departure	**Departure**	**Date of arrival**	**Arrival**
09/08/2013	12:43	09/08/2013	22:09
Journey time	**Driving time**	**Route costs**	**Route costs ∑**
9:26 h	8:41 h	0.00 EUR	0.00 EUR
Time costs	**Toll**	**Toll costs ∑**	**Fixed costs**
0.00 EUR	81.93 EUR	81.93 EUR	0.00 EUR
Special toll charges	**Total costs ∑**	**Freight cost surcharge**	**Tariff zone**
0.00 EUR	81.93 EUR	0.00 EUR	0.00 EUR
Price list	**Motorway**	**Remaining working hours until break time**	**Remaining shift time**
0.00 EUR	Yes	0:18 h	3:33 h
Remaining working hours until break	**Remaining driving break time**	**CO2e**	
0:18 h	0:45 h	557.77 kg	

Particular measurement criteria was chosen from the above sample and used as the basis for the analysis, these are explained in table 10 on page 43, key criterion used as a basis for analysis. All of the performance measures used fall under the categories demonstrated below in figure 6; time, infrastructure, cost, environment and cost volatility.

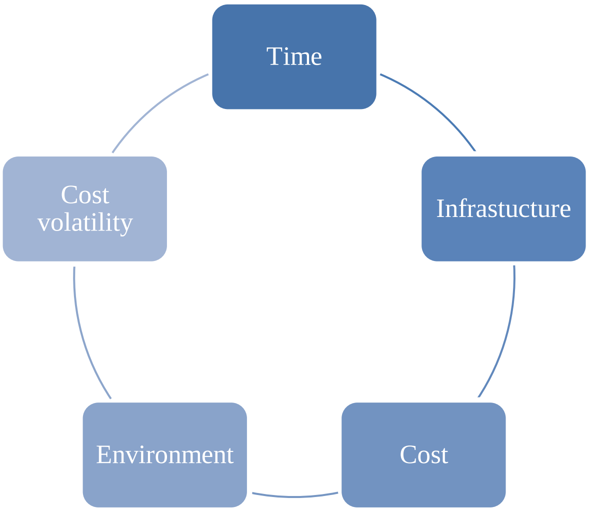


Figure 6. Performance measurement categories

The performance measurement categories are discussed in more detail under chapter 3 on the research methods and context. Next, the tool used to analyse the collected data is introduced, Tableau.

Tableau

For the purpose of this Master's Thesis, the Tableau software was used to analyse the data collected into the Excel files. Tableau aims to provide software that allows for everyone to see and understand data. Tableau is founded in 2003 by three Stanford personnel; a computer scientist, an Academy-Award winning professor and a business leader with a passion for data (Tableau, 2013).

It is possible to connect data to the Tableau software, in this Master's Thesis the Excel files shown in the appendices, and make fast analysis with numerous charts, figures, tables and other functional options. The Tableau software allows for excellence in visualisation which was a matter of importance in this Thesis due to the complex nature of the topic and the vast amount of measurement criteria at hand.

Transport System Analysis

The transport system analysis is the backbone of the entire Master's Thesis and subsequently introduced in more detail under chapter 3 on the research context and methods. Through a Transport System Analysis (TSA) possible future events are analyzed and assumptions challenged as shown in figure 7 below.

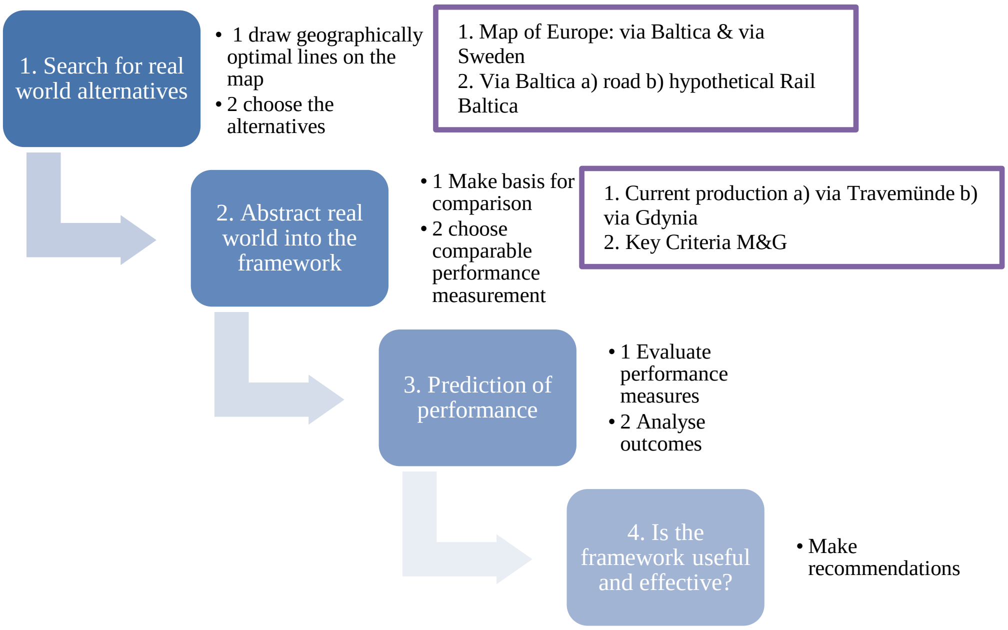


Figure 7. TSA Process

As shown in the figure above, the alternative chosen for analysis is the routing via the Baltic States and the basis for the comparison is established through the current production standards. The performance is then evaluated and recommendations made prior to making closure, bridging onto a more detailed look at the structure of the Master's Thesis.

1.5 Strucrure of the research report

This section of the introduction is an important one as is demonstrates the progress of the Master's Thesis and clarifies the sections of the research as well as the contents of each section as shown in figures 8 and 9 on the following page.

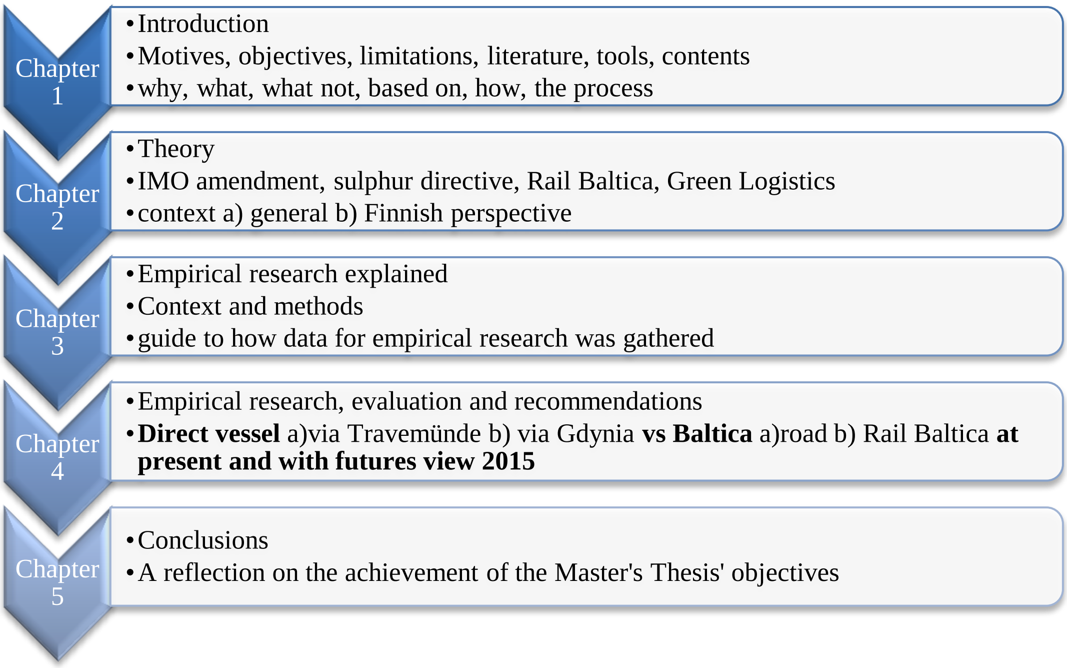
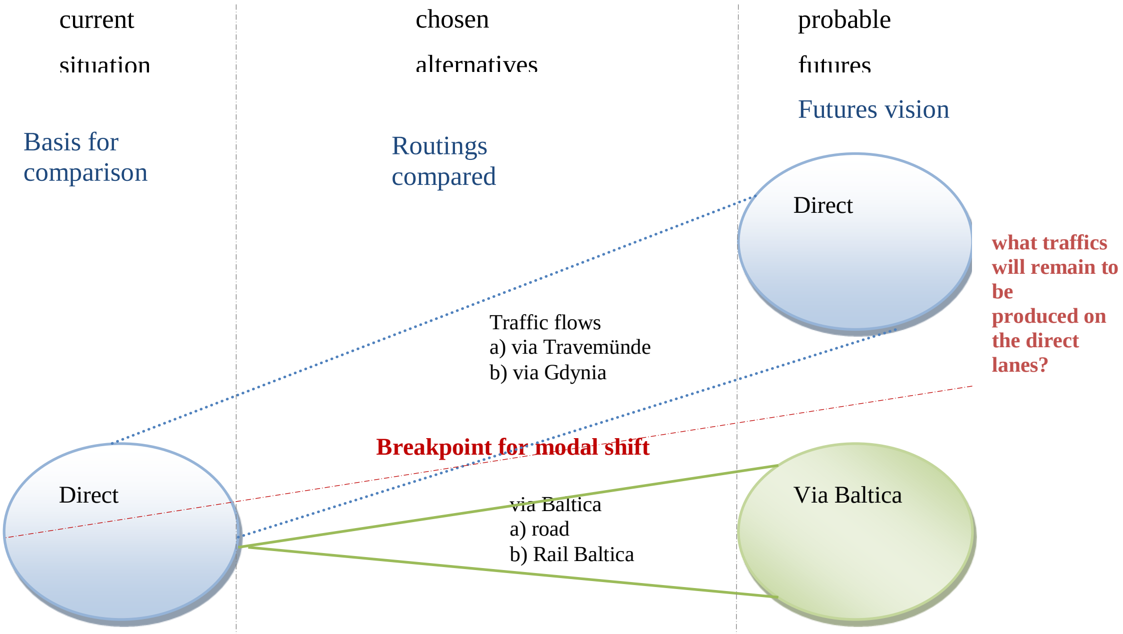


Figure 8 & 9. structure of the Thesis & contents of the empirical research

The aim of the introduction is to outline what is being done and why, as well as how. The second part focuses on the matter at hand from both a general point of view as well as a more Finnish perspective. The third section goes on to explain the context of the empirical research, as shown below in figure 9, in more detail and how the data was gathered for the evaluation and recommendations followed in the fourth chapter. The last part of the Thesis gives conclusions to the findings of the entity.



Depot to depot service production 2013 vs 2015

2 EMISSIONS CONTROL AND TRANSPORT SERVICE PRODUCTION

This chapter focuses on three key areas; the amended rules on emissions from maritime shipping, the Rail Baltica Corridors and the concept of Green Logistics in transportation service production.

2.1 Ammended rules on emissions from maritime shipping

In order to improve air quality in the EU, amended rules on emissions from maritime shipping were adopted by the International Maritime Organization (IMO) in 2008 referred to as the MARPOL Annex VI. IMO is the United Nations specialised agency with responsibility for the safety and security of shipping and the prevention of marine pollution by ships (IMO, 2013). As stated by a European Commission working paper (2011) the standards for international shipping have lagged behind land-based environmental standards, combined together with the growth of the international shipping sector, as well as a better established understanding of its contribution to inland air pollution, cause for action in regards maritime emissions was evident. Additional protection is placed on areas particularly sensitive or prone to pollution, referred to as Emission Control Areas (ECAs). As Northern Europe is particularly affected by acidification, caused by Sulphur emissions from shipping, SECA was defined. As demonstrated by figure 10, SECA includes three sea areas; the Baltic and the North Sea as well as the English Channel.

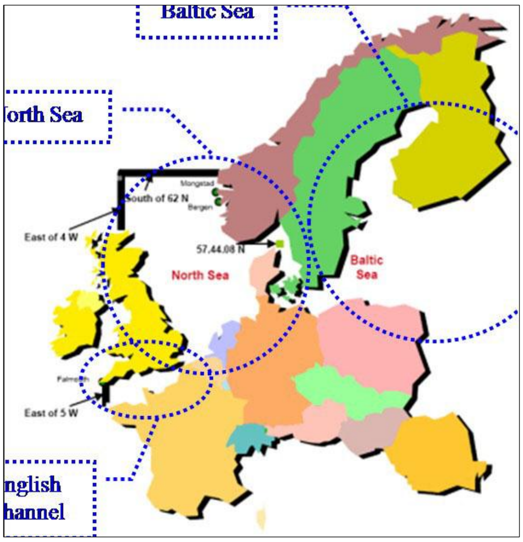


Figure 10. Sulphur Emmissions Control Area, SECA[1]

An EU Directive is in place, as a tool, to incorporate the IMO MARPOL agreements into EU law. The "harmonising" of the two entities in not complete, however the concept of the SECA is reflected as a significant revision in the EU Directive (2005/33/EC). This revision went beyond the IMO rules, as a further effort to improve air quality and protect the human health, and as stated by the European Commission (2011) the most important requirements highlighted as; a) the obligation for ships at berth or anchorage in EU ports to use fuels containing max 0,1 % sulphur, b) the obligation for passenger ships on regular service to EU ports to use fuels containing max 1,5% sulphur, c) the introduction of a possibility to test and use the emission abatement technologies.

These stricter fuel standards, 0,1 % sulphur contents in ships bunker fuel, effective as and from January 2015, on the other hand indicate higher fuel costs, contributing to increased sea transportation costs. As explained by the Ministry of Transport and Communications Finland (2009) the use of cleaner fuels will increase the fuel costs considerably as it is more expensive to produce than heavy fuels. Table 5, below, indicates the effects of the estimated price rise in fuel on the freight charges as a percentage increase on current levels (Ministry of Transport and Communications Finland, 2009).

Table 5. Price rise on freight charges

Freight type	**Sulphur content in ships bunker fuel**		
	1%	0.5%	0.1% 1.1.2015
Container	4-13%	8-18%	44-51%
Lorry	**3-10%**	**6-14%**	**35-41%**
Private car	3-10%	6-14%	35-41%
Freight tonne (bulk)	4-11%	7-15%	39-44%

The Geographical location of Finland poses a challenge as it is furthest sea journey away from mainland and other parts of Europe, indicating a higher cost increase in transportation costs to Finnish exporters in relation to other European competitors. As illustrated by Gröhn (2010) this may increase the possibility of a modal backshift, see figure 11 below.

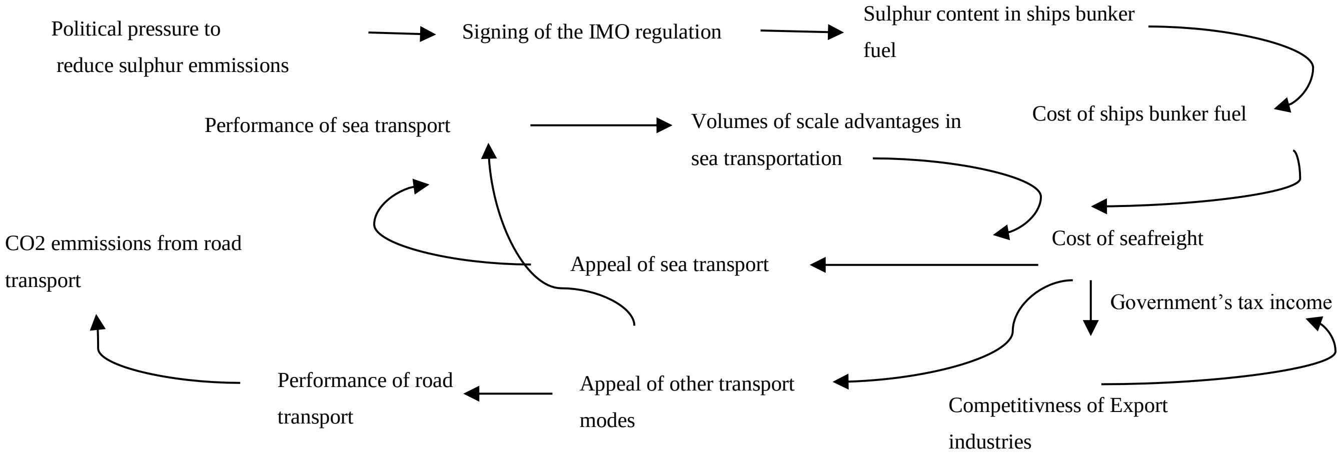


Figure 11. impacts of the new IMO regulations

The European Maritime Safety Agency (EMSA) conducted an assessment on studies carried out by stakeholders and concludes with similar findings to that expressed above. A risk of modal backshift may take place due to effects of the increased fuel costs on sea shipping patterns in SECAs. Modal back shift refers to a transfer from sea to road transportation, which runs counter to EU policy. The Commission however does not consider it a serious enough worry to revise the IMO's regulation, as published by Interferry's CEO Roueche (2012). Transport operators are likely to favour shorter sea segments subsequently indicating that the modal backshift will influence medium distance routes rather than short or long routes. The assessment study also however concludes that existing shipping routes that are competitive whilst using 1,5% heavy fuel oil (HFO) will remain so even after the 0,1% limit is applicable in 2015. To summarize the findings of the EMSA assessment; the impact of the new IMO rules will vary in accordance with the following criteria (European Commission, 2011):

1. The specific route taken
2. The ship used
3. The cargoes (commodity) in question
4. The length of the sea segment
5. Whether a ship operator can pass on increased fuel prices to the customers

Figure 12 summarizes the IMO regulation, as explained in the above paragraphs, in form of a PESTE analysis.

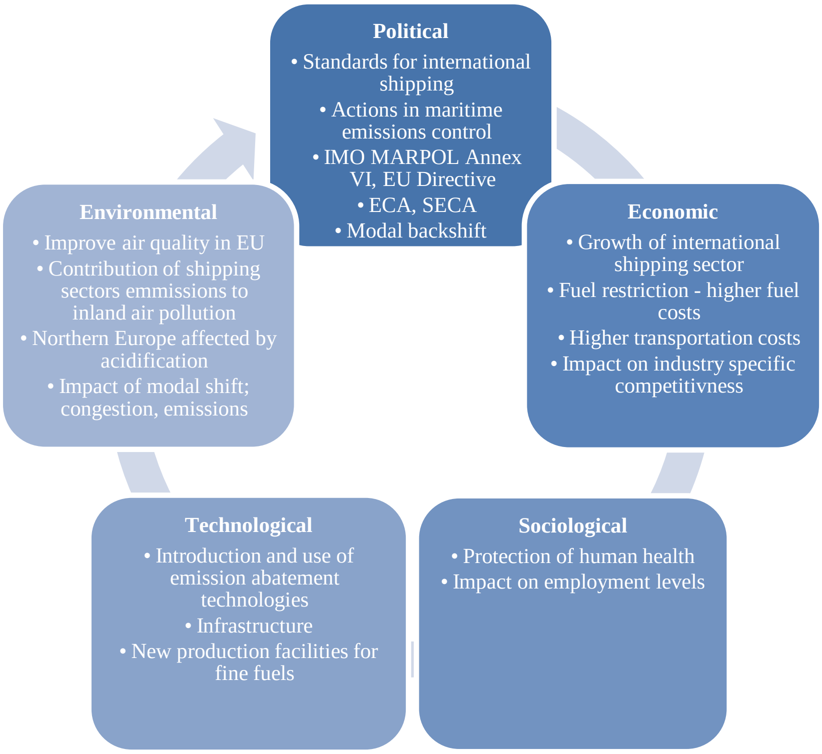


Figure 12. PESTE-analysis, IMO regulation

From a road transport service production point of view, it has been established that in order to minimize the impacts of the IMO's regulation on costs without jeopardizing service standards, alternative service production methods need to be investigated. A breakpoint for modal shift must be determined in order to establish preferred routings to and from mainland Europe for scheduled transportation services.

2.1.1 Sulphur Directive and Finland

Initially, in the 1990s, Finland approached the IMO with an application to join the Sulphur Emissions Control Area unlike any European country. Years later, Finland becomes the only country to reject the regulations to reduce the sulpur emissions in control areas at a faster pace than elsewhere. This change of mind however appears too late as the proposal was passed in May 2012 (Helsingin Sanomat, 2012a). As part of the rejection movement, as reported in Kauppalehti

(2012a), the Finnish export workers' and employers' unions have come together to make demands on the Finnish Government to find methods to improve Finland's competitiveness. This message was brought forward again by Hänninen (2013) in his article about the heavy demands made by the Forest, Chemical and Technological industries towards the Finnish Government in reference of being able to claim back the extra costs created by the sulphur directive. In excess of that, the industries made further demands for the uplifting of channel fees applicable in maritime transports. Overall, the demands made, reflect the ammence pressure felt in the Finnish export industries today. The Finnish economy strongly relies on the added value brought on by the export; this will be no different in the future, and as argued by Laaksonen (2013) out of all markets, the Finnish export industry will get the hardest blow from the sulphur restrictions as it is a 100% dependent on the Baltic Sea area.

Pöysä (2012a) writes about the forest industry point of view in an effort to emphasise that sawn mills are not to be closed down as a side produce of the sulphur restrictions, as indicated by Jouslehto (2012) one fift of the forest industry's turnover account for its logistics costs. The sulphur directive on the other hand poses an increased threat to the ability to compete due to Finland's geographic position leading to extra costs of an estimated at 200 million euros per annum (Jouslehto, 2012). With this in mind, UPM has already indicated that the cost increase is near enough equivalent to one medium sized paper machine's annual production. In other words the production would shift to mainland Europe where it is more competitive (Maaseudun Tulevaisuus, 2012). Herrala (2012) demonstrates the extra costs for the Finnish industries, as estimated by Labour Market Organizations, as shown below in figure 13.

600 Mio €/annum cost increase from sulphur restrictions in Finland

- **200 Mio € Forest Industry**
- **200 Mio € other industries**
- **100 Mio € Chemical Industry**
- **100 Mio € Metal Industry**

Figure 13. 2015 Cost increase per Finnish industry

This Pöysä (2012) addresses in his article on the challenges to crack the cost burden of the sulphur directive. Some of the relief mechanism proposals as discussed by Pöysä (2012a) are shown in figure 14 below, with the majority of proposals destined to be handled in 2014 - 2015.

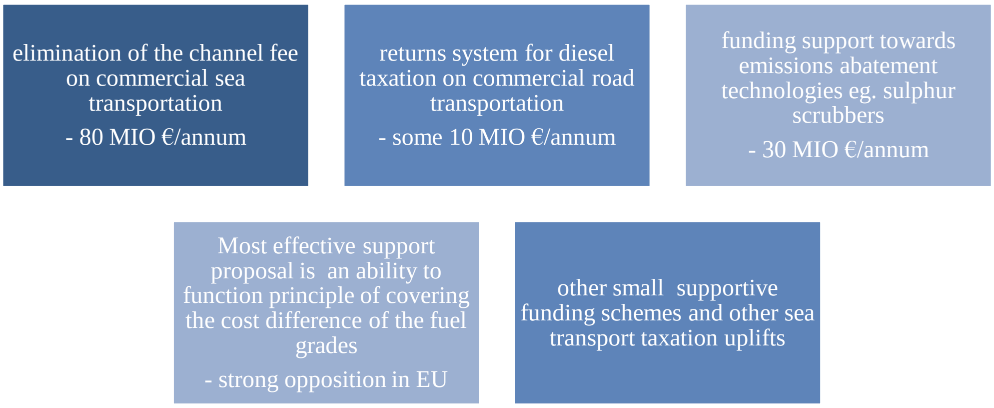


Figure 14. Finland's proposals to tackle the sulphur directive

Part of the struggle to tackle the cost increases from the sea freight have been placed on the road transportation. The pressures to reduce costs on the road segment of the journey has created fear amongst Finnish hauliers, causing concern that they will become the payers of the sulphur directive. A work group has proposed for the maximum weight restriction of a combination load to be increased by 16 tonnes, leading to a potential annual 200 million euro cost saving. The hauliers' investments have not however been included in the calculations or the current maximum average payload potentials (Yle, 2012).

With the demands to find alternative solutions, time is running out for solutions to be applicable by January 2015. Demari (2011) reported about Finland's hopes to prolong the sulphur restriction application to the year 2025 in an effort to level out the European competitiveness now due to hit only the markets relative to the SECA area. Sweden is still hopeful to obtain special industry or business sector related allowances as an effort to overcome the cost burden as explained by Lukkari (2012). According to Lukkari's article, it is the Finnish understanding that only IMO has the power to grant special allowances and that they are extrimely difficult to obtain. Sources state that Finnish vessel operators have applied for special provisions which have not been granted. It was stated that only vessels using sulphur scrubbers or liguefied natural gas (LNG) gas are eligible for the releases. Although discussions are ongoing, Sweden's optimism is not shared in Finland in light of special release provisions from the sulphur restrictions.

Although the signals on the Finnish market with relation to the sulphur directive are viewed as a threat to the Finnish economy, an article in Helsingin Sanomat (2012) argues that it ought to be viewed as an opportunity. It urges for the Finnish export industries to demand the use of biodoesel on commercial maritime traffic, not only as an effort to minimise the impacts of the sulphur directive but also as a means to develop a new industry sector in Finland, already piloting biodoesel refinery facilities. Whilst on this line of thought however, as expressed by Pohjanpalo (2013) although Wärtsilä in cooperation with Metso are one of the market leaders in producing sulphur scrubbers, they are manufactured in China and Norway rather than Finland. Alongside the biodiesel sector, another beneficiary is viewed to be the port of Hanko as discussed by Ojanperä (2012). This is seen to be the case as Hanko is the shortest sea journey away from mainland Europe, indicating the lowest fuel consumption and subsequently impact in sea freight costs.

LOGY (2013) writes about the thoughts of Professor Ojala, named the 2013 logistician, on the importance of addressing the upcoming changes rather than expecting any form of exemption from the sulphur restrictions. Future pressures on reducing traffic related health and environmental burdens are to continue despite any economical strain they may pose he estimates. The emphasis should therefore be on making investments that support minimising the societal burdens whilst maximising the business potential. Infact, as written by Helsingin Sanomat (2012a) the sulphur directive is considered to be the most considerable health related ammendment in years and that the European Commissions estimates for its added value through health care to be worth 2-25 times bigger than the cost burdens it proposes.

2.2 Rail Baltica Corridors

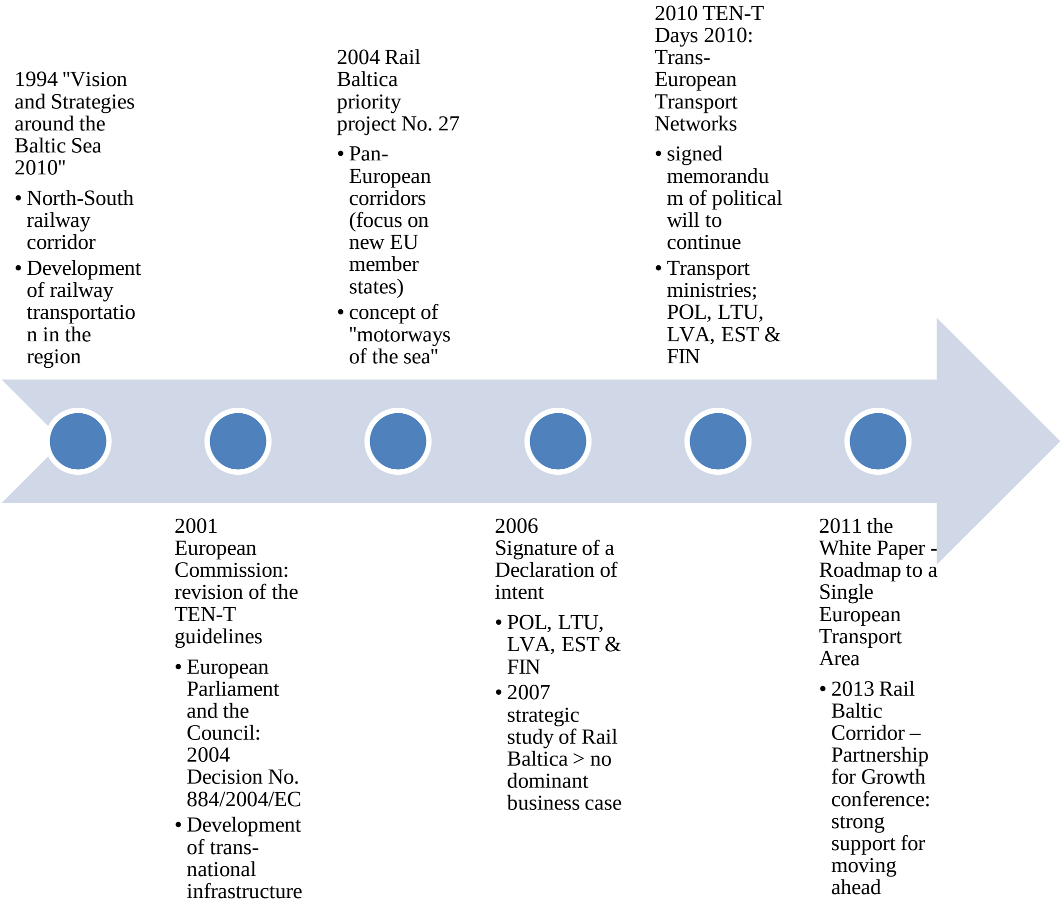
The Rail Baltica Corridors in the context of this Master's Thesis looks at linking Finland and mainland Europe with a railway network providing an alternative to the use of seaways. Figure 15 below indicates in green the geographical position of the corridor in respect to Finland.

Figure 15. The Rail Baltica Growth Corridor[4]

The framework around the Baltic rail system becomes central with the potential modal backshift ahead. In addition to the potential or probable backshift ahead, an Aecom Final Report on Rail Baltica (2011) highlight the positive prospects for rail transportation due to a) increasing world fuel prices, b) evolving competition in the Baltic States, c) growing container market and d) EU policies developed to support sustainable transports.

Rail Baltica is a project steered towards harmonizing the gauge rail networks in an effort to accommodate interoperability. The Baltic rail system is based on a 1520mm gauge rail network in comparison to that of 1435mm gauge network in Poland and Germany, making the rail network of the Baltic States inefficient from an international stand-point.

Initially the Rail Baltica development was highlighted in 1994, surrounded by a joint political effort to further enhance the Baltic Sea Region. Prior to the Estonian, Latvian and Lithuanian European Union membership, the development of the railway was not highlighted as a matter of great importance. In an effort to enhance the transportation systems between the EU and the new member states, the European Commission's Trans-European Transport Network, TEN-T, assigned a priority project number for the Rail Baltica in 2004. Figure 16 below shows the planning timeline of the Rail Baltica in more detail (Aecom, 2011 and RBGC, 2013).



1994 "Vision and Strategies around the Baltic Sea 2010"
- North-South railway corridor
- Development of railway transportation in the region

2001 European Commission: revision of the TEN-T guidelines
- European Parliament and the Council: 2004 Decision No. 884/2004/EC
- Development of trans-national infrastructure

2004 Rail Baltica priority project No. 27
- Pan-European corridors (focus on new EU member states)
- concept of "motorways of the sea"

2006 Signature of a Declaration of intent
- POL, LTU, LVA, EST & FIN
- 2007 strategic study of Rail Baltica > no dominant business case

2010 TEN-T Days 2010: Trans-European Transport Networks
- signed memorandum of political will to continue
- Transport ministries; POL, LTU, LVA, EST & FIN

2011 the White Paper - Roadmap to a Single European Transport Area
- 2013 Rail Baltic Corridor – Partnership for Growth conference: strong support for moving ahead

Figure 16. Rail Baltica timeline

As can be seen from the above, it has taken 20 years for the Rail Baltica Corridor to receive strong support for moving ahead from the initial vision and strategies session in 1994. Once we move onto take a look at the Finnish perspective on the Rail Baltica Corridors it is possible to establish some of the items that have lead to the development of the interest in going forward with the investment.

2.2.1 Rail Baltica and Finland

In light of the upcoming sulphur restrictions, the Rail Baltica network is viewed as a win for Finland's export as discussed by Herrala (2012) in his article. Experts indicate that particularly for Finland, the anticipated 30 - 40 % increase in sea freight can be partly tackled with the Rail Baltica investment. Cargo (2012a) also emphasises the importance of the development in the context of Finland and emphasises that if it is not delayed excessively, it has the potential to act as the foundation to the development of the Baltic Sea region. It would offer an alternative routing for the Finnish export to reach mainland Europe.

The Rail Baltica investment, estimated at 3,7 billion euros, has a potential to receive upto 85 % EU funding. With the current plans, the network does not have a likelyhood to be ready until 2021 (Herrala, 2012). Cargo (2012a) estimates the equivalent year to be 2022 at earliest. The city of Helsinki is strongly committed to the development of the Rail Baltica network and recent developments not only with the sulphur directive but also the ash cloud and the stevedores strike actions in the Finnish ports have enhanced the Finnish interest towards the project and rail transportation in general as shown in figure 17 below.

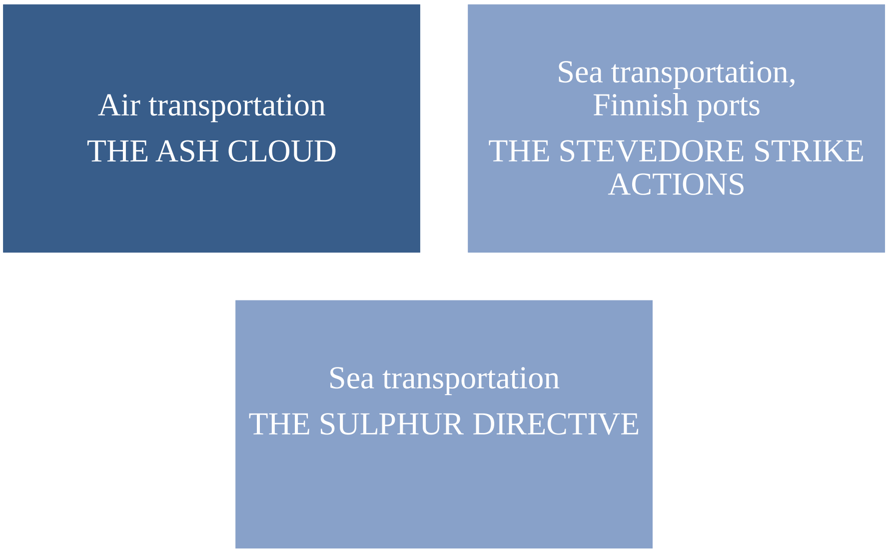


Figure 17. Rail Baltica, enhanced Finnish interest

From the Finnish Forrest industry's point of view the anticipated relief from the Rail Baltica Corridors is too slow with its current planned schedules. Although the common message from industry representatives is that it is too early to comment on the likelyhood for the use of train or other alternative routings after the sulphur directive becomes applicable in 2015, the possibility to exploit the Rail Baltica Corridors are being investigated as part of the strategies geared towards tackling the anticipated extra costs (Cargo, 2012a).

With regards the development of the Baltic regions ports, the 2012 Baltic Port Barometer revealed a positive outlook with the growing volumes not expected to decrease for the region in the future. The Estonian volumes grew by 5 % (ITJ, 2012b) and with the future prospects being optimistic, development is to follow. The potential of the Rail Baltica reflects as added congestion on the Baltic Sea, alternatives have been seeked to accommodate the railway linkeage. World's longest railway tunnels under the Baltic Sea have been under analysis; a feasibility study for a 100km railway tunnel from Trelleborg Sweden to Stralsund Germany has been presented (ITJ, 2013) as well as initiations for a 87km tunnel from Helsinki to Tallinn. The Finland to Estonia tunnel plans are not however on their way at present (Cargo, 2012a).

From the perspective of the case comapny, DSV Road Oy, the use of train is a promoted alternative in the production of transportation services, accommodating increased flexibility and an environmentally friendlier solutions (Moves, 2012). Environmentally sustainable solutions lead us to the following sub heading on green logistics.

2.3 Green Logistics

According to the European Environmental Agency, air pollution reduces human life with up to two years within the European Union (Helsingin Sanomat, 2012b & Hassi 2012). Transportation is one of the major contributors of harmful emissions and therefore policies aimed at reducing them is increasingly called for. In fact as dicussed by Lättilä et al (2013) decreasing harmful emissions, in particular CO_2, is one of the most important tasks for the society as an entity in the 21st century and onwards. Lehtimäki (2010) highlights the reduction targets by 2020 from emissions caused by transportation per country as shown in figure 18 on the following page, the targets are set depending on the 2005 GNP levels;

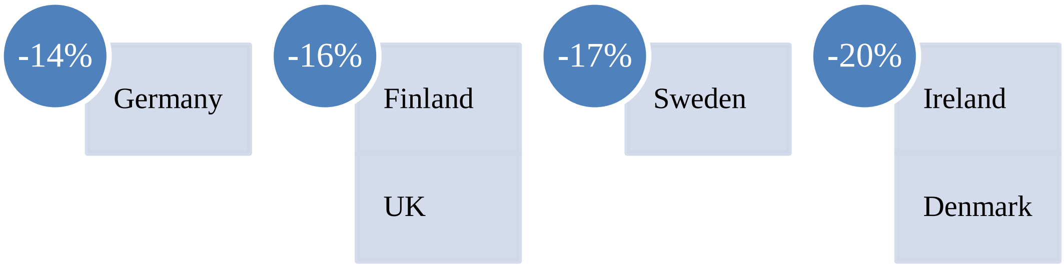


Figure 18. 2020 target for reducing transport related emissions

With the growing concern for the environment, costs are no longer associated in monetary terms only. Climate change, air pollution, noise, vibration and accidents are some of these external costs related to logistics. Green logistics aims for a more sustainable balance between environmental, economic and social objectives. This is demonstrated in figure 19 below (Green Logistics, 2008)(Höfer, 2009).

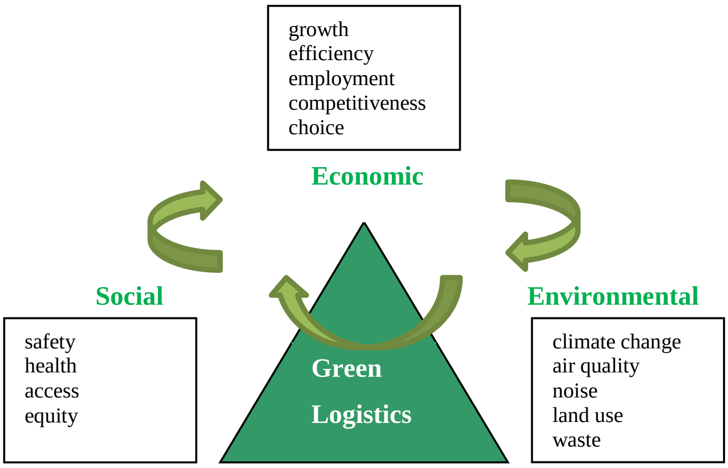


Figure 19. Sustainable logistics

With road transportation being a major contributor of CO_2 emissions, it is no surprise that public transportation is promoted in passenger transportation terms. It is no different when it comes to the movement of freight; lifting off the road and onto other means of transportation is emphasised. Bask and Laine (2000, 15) address the main benefit of using intermodal transportation in road transport, as the promotion of green logistics. Lättilä et al (2013) discuss the same topic stressing that whenever there is availability to move road traffic by sea and rail, an environmentally friendly approach is supported and CO_2 emissions reduced considerably. As shown in table 6, road transportation has the highest impact on the environment. Rail and sea both indicate a lower environmental burden. This poses an opportunity to promote green logistics when infrastructure is in place to support the transportation system in exploiting environmentally friendlier transport modes. Therefore joint-border projects geared towards the development of infrastructure become central elements of developing international trade.

As mentioned earlier, transportation is one of the largest consumers of energy and creates environmental expenses not only through air pollution but congestion, and noise pollution as well. Table 6 below, indicates some of the environmental impacts posed through transportation, as illustrated by Kalenoja and Kuukka-Ruotsalainen (2001, 19).

Table 6. Environmental impacts posed through transportation

Impact	Main cause of impact	Main contributor to cause	Coverage of impact
Global warming	CO_2	Road transportation	**Global**
Decrease in the ozone layer	CFC combinations, Haloalkane, NO_x	Air transportation	**Global**
Tropospheric ozone	NO_x, VOC, HC	Road transportation	**Regional**
Acid rain	NO_x	Road transportation	**Regional**
Hazardous chemicals	various	Road transportation, rail transportation	**Local**
Oil and fuel leakages	Fuels, oils	Sea transportation	**Local**
Land use	various	Roads, airports	**Local**
Noise	various	All modes of transportation	**Local**
Wastes	combinations	All modes of transportation	**Local**

On top of infrastructure, policies are developed to enhance greener logistics. These policies concentrate on the following items (Browne et al 1994, 282 – 290):

- Improvements in lorry design
- Making road transport comparatively more expensive
- Encouraged use of combined transport; intermodal networks

Figure 20 on the following page, transport parametres and policy measures (McKinnon, 2010), supports Browne et al (1994) findings in that the pricing of road transportation has the most impacts on freight parametres whilst vehicle routing and the CO_2 intensity have the most impacts on the government measures taken. These would support the development of infrastructure and equipment as an effort to tackle emissions and routings. One of the main strategies involves moving the transportation off the roads into other modes, by investing to improve the linkages between the modes. These efforts are in place to improve environmental performance and to remove traffic congestion (Kajander and Karvonen 2001, 16).

The White Paper 2011, 40 initiatives geared to developed and improve the quality and efficiency of transportation within the European Union, making it a competitive and resource efficient transport system. An integral part of the initiatives is to reduce emissions considerably and by 2050, the key goals will include (European Comission, 2013):

- ✓ at least 40% cut in shipping emissions
- ✓ a 50% shift of medium distance freight journeys from road to rail and waterborne transport
- ✓ all of which will partly contribute to a 60% cut in transport emissions by the middle of the century

As discussed by McKinnon et al (2010), on one hand there is a constant pursue to facilitate the growth of freight movement whilst on the other hand there is an increasing effort to reduce the impacts of transportation on the environment. Figure 20 below is a direct take from McKinnon (2010; 346) on the relationship between key freight transport parametres and government transport policy measures.

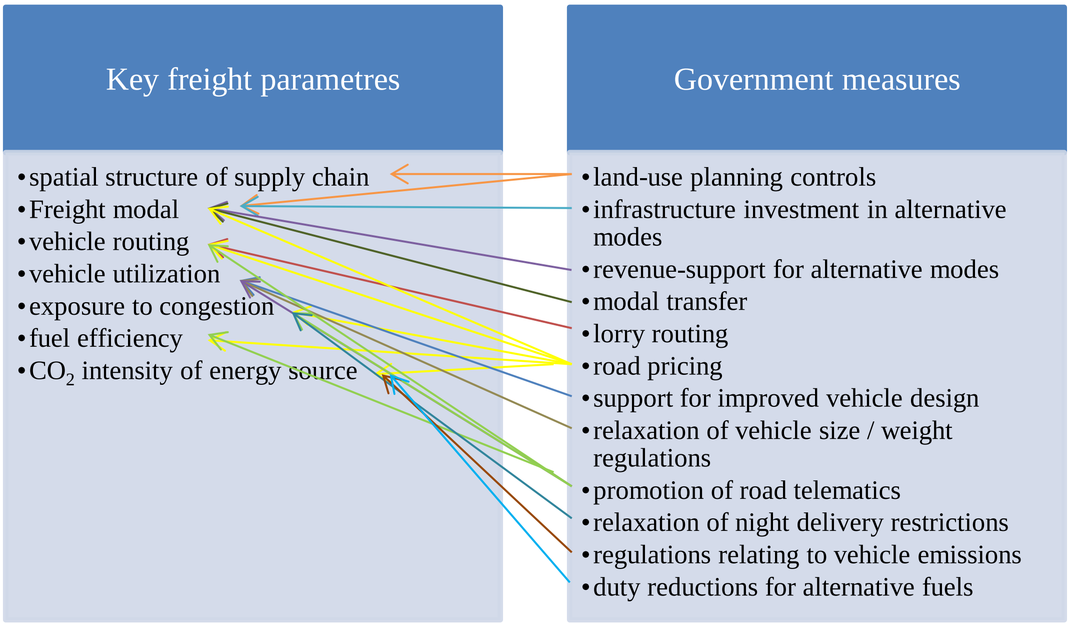


Figure 20. transport parametres and policy measures

As can be seen above, the pricing of road transportation has the most impacts on freight parametres whilst vehicle routing and the CO_2 intensity have the most impacts from the government measures.

As emphasised by Blanchard (2010; 203-214) companies across the board ought to be able to understand and measure the sustainability of their products. The same matter is brought to life by Höfer (2009; 46) whereby he discusses how companies should internalise the environmental and social costs that they have been able to disregard in the past. Blanchard (2010; 205) refers to it through carbon footprint, the amount of greenhouse gas emissions (CO_2) produced or used through product and service creation. All in all, the amount of emissions created through the transportation of an item is part of its carbon footprint. As discussed by Nykänen (2011; 31-41), in the Finnish context, the reporting of the carbon footprint and other environmental measures is still limited. It is brought to light that only large companies, with a turnover of 100 million euros or more, had continuous efforts of reporting and analysing environmental performance measures, and those companies were mainly food, forest - and chemical industry based. Szymankiewicz (1993) conducted a survey on including environmental awareness in business activities and concluded to find that companies with larger turnovers felt the pressure more severely than smaller companies. Although the survey was done 20 years ago, it could indicate why bigger companies are much ahead today. Nykänen (2011) based his analysis on a questionnaire carried out in 2010 where 2273 Finnish logistics related companies were approached regarding environmental measurement. Ahokainen (2011; 14) addresses similar findings on a more general scale indicating that there are numerous companies who offer no concrete concern for emissions reporting or environmental measurement. Ahokainen (2011) implemented a case study for a company's carbon footprint for a product from Italy to Finland through studies on transport-related emissions.

Although the wave of green opportunities has been central for quite some time now, the practices are slower to follow. Blanchard (2010; 204-205) discusses the 'price' of carbon, where the cost of the components may change even significantly indicating that carbon contributors may cause for products in their current form to become much more expensive to produce and transport. Isaksson and Huge-Brodin (2013) study how these environmental challenges can be turned into business offerings and integrated into the services, particularly in the case of logistics service providers whose core business is an environmental impact in itself. The 6 potentials discussed by Isaksson & Huge-Brodin (2013; 218-221) are shown in figure 21 below.

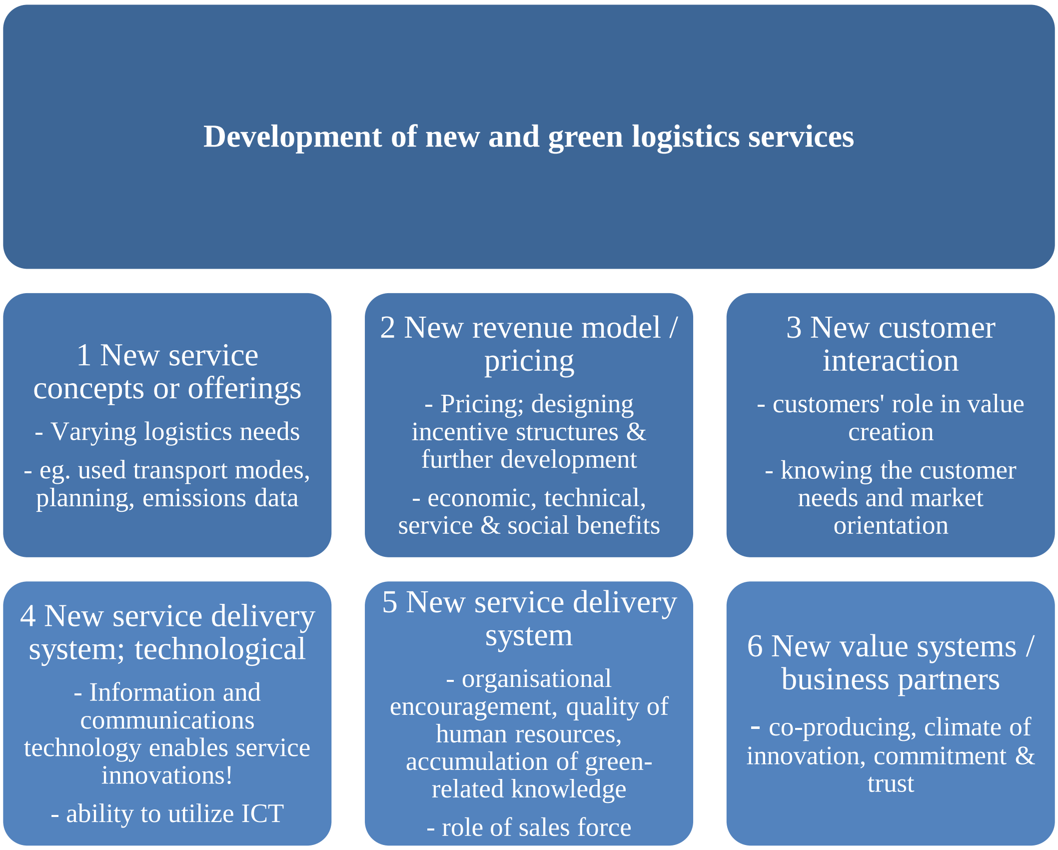


Figure 21. Opportunities from environmental challenges

Managing the sustainable development from a company's point of view becomes an element of differentiation as Höfer (2009; 46) explains. Van Hoek (1999) complies with the same line of thought, expressing that the focus of greening should be implemented as a competitive initiative. It represents a more proactive approach of greening, instead of reactive compliance with regulation. This thinking was already introduced in 1993 by Byrne and Deeb in their article on "Logistics must meet the Green challenge". Other driving forces behind green opportunities as highlighted by Phyper & MacLean (2010; 12) are;

- ✓ Increased amount and complexity of government legislation related to environmental issues, including market-based incentives
- ✓ Customer demands for green and safe products and services
- ✓ Significant demand for renewable energy and clean water
- ✓ Greening of the boardroom

Chang and Chen (2013) share Phyper & MacLean's (2010) findings on the signifigance of the greening of the boardroom, with their research indicating that a green organizational identity positively affects green innovation performance. These findings support Isaksson & Huge-Brodin's (2013) recommendations on new and green logistics services and particularly item number 5 introduced in figure 21.

Modal backshift

In the light of a potential modal backshift due to increased sea freight costs, an increased environmental burden is posed. Abdelkader and Eglese (2010) in their study on Combinatorial optimization and Green Logistics found that environmental benefits from routing analysis are generally not emphasised if measured. They found that the reduction in total distance, in itself providing environmental benefits due to the reduction in fuel consumed and the consequent pollutants, was generally not measured or emphasized. Their paper brings to light some of the problems that arise when the objectives considered are not simply economic, but involve wider environmental and social considerations too. Eng-Larsson & Kohn (2012) write about the barriers of modal shift as expressed in figure 22 on the following page.

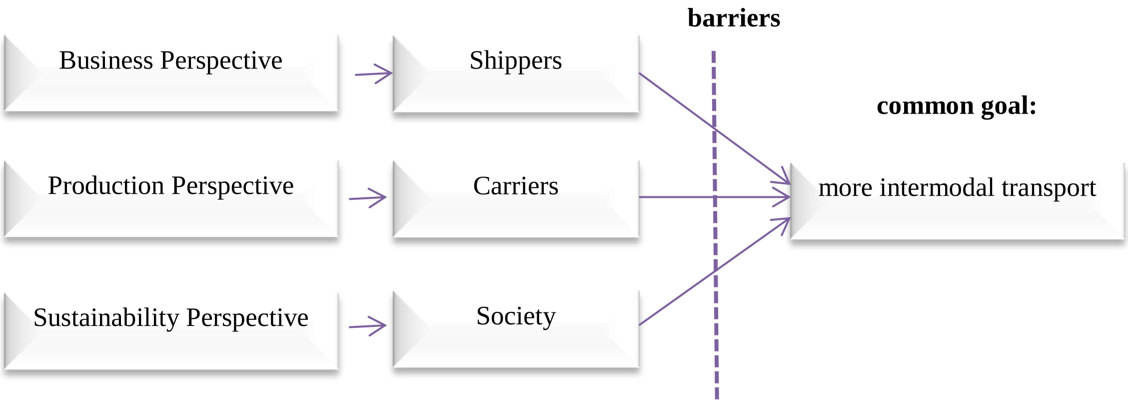


Figure 22. Barriers to intermodal transport

Martinsen & Björklund (2012) study these matches and gaps in the context of the green logistics market concluding that there is a great business potential if the gaps are correctly exploited. For instance increased transparency in carriers' service offerings and shipper demands could increase these common goals from a sustainability perspective. The aim of this Master's Thesis is to reflect the various objectives through the chosen performance measurement criteria evaluated, as shown in table 10.

The European Comission (2013) addresses this potential modal backshift from sea to land-based transport as a result of the introduction of stricter low sulphur standards in the European designated Sulphur Emission Control Area in 2015 in their progress report on "Pollutant emission reduction from maritime transport and the Sustainable Waterborne Transport Toolbox". The potential modal shift is one of the areas being considered within the framework of an accompanying measure "Contribution to European programme for the support of Short Sea Shipping" (SSS).

The European Shortsea Network (ESN) composed of Shortsea Promotion Centres (SPCs) as a first step, is to develop by the end of 2013 a methodology for data collection and assessment of such possible impacts on the shortsea sector in the SECA area. The timeline for European Commissions actions in this regard are shown in table 7 below (European Comission, 2013).

Table 7. European support for Short Sea Shipping

Action	Responsible Actor	Timeline
1. Apply for funding under the 2012 TEN-T Multiannual and Annual Calls for proposals	MS/Industry	Closed 28/02/2013
		CONTINUED

2. Use the opportunities provided by the 2013 Marco Polo Call. *Marco Polo Programme = the granting of financial assistance to improve the environmental performance of the freight transport system*	Industry	1st semester 2013
3. Analyse possible ways of adjusting the criteria of the Marco Polo II Programme in order to better reflect market conditions and enable funding to green shipping projects	EC/MS	Early 2013
4. Ensure better use of the EU transport funding instruments and coordination with other EU instruments i.e. Structural funds, EIB loans, etc.	EC/MS/Industry	Early 2013
5. Ensure continuity of the ESN work related to possible impacts (i.e. modal backshift) on the shortsea sector in the SECA area.	**EC/ ESN/SPCs**	**2013-2014**

Wang et al (2013) study the bunker consumption optimisation methods and stress that it is crucial for shipping companies to reduce bunker consumption while maintaining a certain level of shipping service in view of the high bunker price and concerned shipping emissions today. It goes to show the pressure that shipping operators are under to maintain competitive services. Some of the methodologies used to limit sulphur emissions, particularly in the Finnish context, are discussed under the following heading.

2.3.1 Sulphur emissions control and Finland

As stated by Sovijärvi (2012a) vessels sailing the Baltic will have a very low environmental footprint in the near future. Not only are the sulphur emissions restricted, the nitrogen oxides will have to be reduced by 80 % by 2016, not to mention the tighter regulations on greenhouse gases. Whilst we focus on the reduction of sulphur particulates, table 8 on the following page highlights the alternative methods of reducing the sulphur contents.

Table 8. How to minimise the sulphur contents in ships bunker fuel

How to minimize SO_x	**Advantage**	**Disadvantage**
Change to MGO **- run full time on Marine Gas Oil (MGO)**	- Convenient - No change over	- High operating costs
Convert to LNG **- convert engines to run on liquified natural gas (LNG)**	This solution reduces both SOx and NO2 particulates	- Investment cost - LNG availability
Use Scrubbers **- install an exhaust gas cleaning system (scrubber)**	- works with high % sulphur fuel - lowest total lifecycle cost - use everywhere - easy operation	- ROI depends on fuel oil price - difference between low sulphur and high sulphur fuel oil

Although liquefied natural gas, LNG, is an environmentally friendly fuel meeting the tougher regulations for both sulphur and nitrogen emissions, for practical reasons LNG engines have not been retrofitted in oil-powered ships. At current LNG is supplied for the Finnish market from Sweden where for example Viking Grace bunkers weekly at present. Depending on the development of the LNG shipping, new terminals will be build in the Baltic region (Vartia, 2012a). In fact as highlighted by the ITJ (2012) the Nordic and Baltic ports have teamed up to create the necessary LNG infrastructure for the LNG powered vessels in the near future.

Kauppalehti (2012) emphasises that with the current timetable for the sulphur restrictions, no emissions abatement technologies will be availably fitted to tackle with the increased sea freight costs. The fitting of the scrubbers is a major ammendent and not an alternative for all vessels. The ability to qualify for the EU funding is not guaranteet and the cost of a scrubber varies between one to five million per vessel for which the maximum relief is 50% from a 30 million euro fund proposed, to be applied in 2014 - 2015. At the same time, 8000 vessels require scrubbers by 2015 not to mention the 40000 vessels by the year 2020. Year to date one supplier has fitted a total of twenty sulphur scrubbers.

As well as that, Nikula (2012) discusses the uncertainty of the 30 million euro EU funding which may only total to 8,5 million euros per annum. Nikula (2012) also highlights that the maximum 50 % relief is only applicable if the investment is done five years prior to the foreseen requirements. From its current perspective for the Finnish vessel operators the maximum equivalent is 10 %. Whilst the direct sulphur directive related funding is unclear, other environmentally related funds are simultaneously being cut. In heinseit those funds could have been applied for emissions abatement investments. Nikula (2012b) states however that due to Finland's exeptional position in light of the sulphur restrictions, the Finnish Government is pressuring for EU support to tackle with the cost increase, indicating that Finland should not be left to pay the price of the requirements alone.

At the same time, the emissions abatement technologies are viewed with hesitation on the Finnish market. Jousenlehto (2012) expresses in her article Finnlines' careful consideration of the matter. Finnlines' chairman of the board Grimaldi does not see the equipping of vessels with scrubbers an effective solution. In fact, as brought to light by Pohjanpalo (2013) only one Finnish vessel has been fitted with a sulphur washer. Although one of the market leaders in scrubber production has sold over 40 scrubbers only one of them is under a Finnish flag. It has been argued that technical difficulties with the scrubber use has staled the orders, after over a year and a half the sulphur washer still struggles to service its cause. One of the world's leading scrubber providers, Wärtsilä, argues that a scrubber will pay itself back in upto two years and that the schedule for the sulphur restriction has been clear since 2008. This has indicated a substantial transitional period with very little actions taken by the operators (Demari, 2012). As stated by Jousenlehto (2012) Grimaldi, rather, emphasises the importance on reducing consumption, and urges for the need to concentrate on technologies that reduce fuel consumption and unify fuel grade useability amongst road and sea transportation. Nikula (2012) clarifies the difference in fuel grades; currently sea transportation uses a thousand times dirtier fuel whilst in 2015 the equivalent multiplier is a hundred.

As an effort to further understand the vessel operators' in Finland, an expert interview (appendix 2) and three major vessel operator interviews (appendix 3) were carried out; Finnlines, Transfennica and Viking Line. Due to the sensitive nature of the topic at hand, the questions were answered to an extend that allowed a response without giving away highly confidential substance. Table 9 below is an analysis of the answers received directly from the market.

Table 9. An analysis of expert and vessel operator interviews

Q1-2 APPENDIX 2-3 objective:
Indication of cost increase in 2015

It has been established that
a) currently HFO (85-91%) and MGO (9-15%) are mixed
b) mixing fuel grades contribute towards engine problems
c) reaching 0.1% sulphur contents is not possible by mixing fuel grades
d) since 2006 fuel costs of the total day cost of a ship have increased 14-20%

CONCLUSION

The difference in the price of fuel grades is not a direct trade-off as 9-15% of MGO is already used at present and ought to be considered whilst calculating the price impact of 2015. It is no longer possible to achieve the required emissions standards by mixing with cheaper fuels, indicating increased demand of MGO yet not being able to indicate the impacts on consumption. The decreased engine problems and cleaner fuel suggest lowered consumption through better performance. Between 2006 (30-36 %) and before 2015 (50 %*) the fuel costs share of the total vessel's day costs has increased a ship owners' operational costs substantially already.

* Kalli & Alhosalo, 2012; 9.

Q3 APPENDIX 2-3 objective:
Indication of possibilities to minimize the cost increase in 2015 and subsequent impacts on service standards

It has been established that
a) it is possible to reduce the speed (slow steaming) in order to reduce consumption and therefore monetary impacts. However it is not viewed possible to achieve optimal speed reduction to compensate for the price increase in these types of traffics. Schedule optimization and customer demands become a priority.
b) The use of a scrubber will not accommodate the use of current fuels as the sulphur level is higher in that case.
c) the ports are not able to accept a zero discharge of scrubber waste at current due to the sewage system.

CONCLUSION

The speed and schedule optimization is a ship owners' tool to success and subsequently a matter of high confidentiality. It is possible to outweigh the monetary impacts through slow steaming however the level of speed reduction would indicate an unattractive service schedule and subsequently fleet optimization and customer satisfaction. The use of scrubbers would indicate a substantial decline in a ships' fuel costs, even today. Nevertheless practical obstacles such as a zero discharge of scrubber waste would indicate extra costs involved. There are operational methods that can be used to minimize the monetary impacts of the sulphur restrictions in 2015 however they do not appear feasible by today's service standards.

Q4 APPENDIX 2-3 objective:
Indication of the availability of fuels in 2015 and subsequent price impacts

It has been established that
a) the 2015 demand on fuels is on MGO and high sulphur HFO (vessels with scrubbers). The availability of fuel is not seen a problem as MGO is more profitable for refineries than HFO. It is forecasted that the production of fuel grades will shift in accordance with the demands.

CONCLUSION

In accordance with today's indicators, MGO scarcity will not drive up the fuel price rather availability is viewed in positive light.

CONTINUES

Q5 APPENDIX 2-3 objective:
Indication of the usage of sulphur scrubbers on Finnish vessels in 2015 as a measure to reduce the foreseen cost increases

It has been established that
a) the repetitive challenge relating to the scrubber installation is viewed as the loss of cargo space. Other major challenges are related to the waste treatment, availability of low sulphur HFO required in combination use with abatement equipment, high investment costs and potentially increased running costs.
b) It is not viewed that the current grants towards scrubber investment are adequate enough to initiate investments. It is also viewed that the grants came too late indicating that the designing, manufacturing, installation and approval of scrubbers by the end of 2014 is not possible to implement to provide relief in 2015.

CONCLUSION

It is indicated on the market that the scrubber technology is not convincing enough to initiate investments. The shipping industry is not confident that the technology is developed enough to meet the demands and offer relief in the upcoming challenges. On the other hand, as discussed by Kari (2013) a Transfennica vessel Plyca's performance with a scrubber has initiated an investment decision of 5 more scrubbers in the operator's vessels to combat the sulphur restriction challenges in the future. It is important to bear in mind however that a previous study on the topic shows that Finnish shipping companies indicate that only 30-40 % of the fleet accommodate technically and economically the installation of a scrubber (Kalli & Alhosalo, 2013; 3-4). For the purpose of this Thesis nevertheless it is established that it is likely the monetary impacts of 2015 sulphur restrictions are fuel cost related as it is likely scrubbers will not be installed by then to minimize the fuel cost increase.

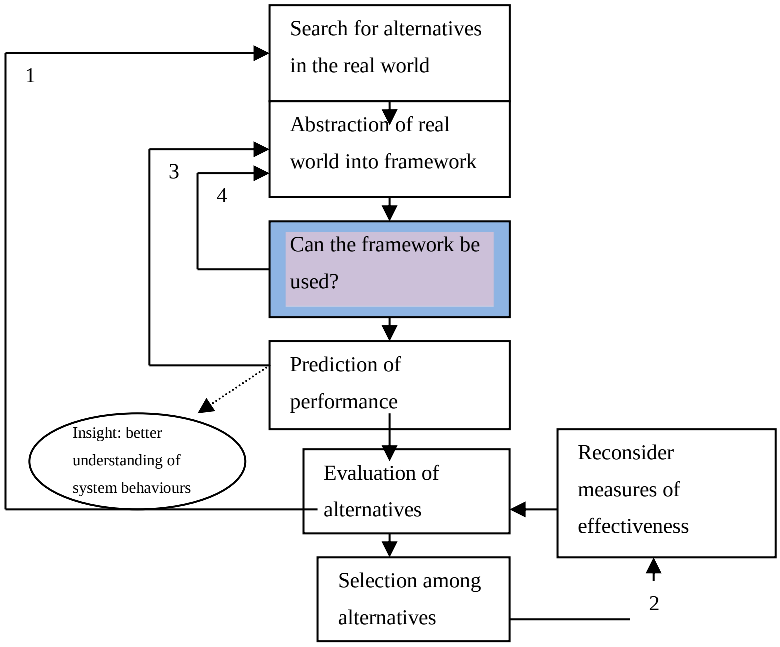
Regardless of the solutions sought, the logistics movements will change in the upcoming years. Kauppalehti (2012) states the likelyhood of transporting smaller lots and thus an increased demand on road transportation after 2015. At the same time, Cargo (2012) reports on the threat of substantial decrease in the number of Finnish commercial drivers in 2014. Simultaneously, Nikula (2012b) reports the probability of the planned schedule going ahead without a possibility for a prolonged transitional period as has been hoped for in Finland. All of the current publicly available information suggests that the implications of the sulphur restrictions are to an extend unknown and the uncertainty surrounding the topic creates a sense of understandable discomfort. At current, there are no absolute solutions and definite answers to seek.

This bridges the Master's Thesis to the research context and methods used in this study as an effort to reach the set objectives.

3 RESEARCH CONTEXT AND METHODS

This section of the paper indicates a step-by-step guideance to how the results of the empirical study were gathered for the analysis provided in the next chapter.

The core methodology used in this reasearch is a transportation system analysis (TSA). The main idea for a transportation systems analysis is to search for real world alternatives. The crucial part of the framework is to look at the predictions for performance for the alternatives, evaluate those and select only alternatives that make sense. The predictions for performance are done by considering the key criteria, as shown in table 10. The figure below shows a framework for systems analysis (Sussman 2000, 129).



1. Does the evaluation suggest other alternatives? 2. Are the measures of effectiveness appropriate?
3. Is the abstraction good at predicting? 4. Develop new abstraction.

Figure 23. A systems analysis framework

Transportation systems analysis is a framework, a qualitative organising principle for analysing a system. When using such qualitative form for an analysis the results are presented in form of words rather than numerical or in equation form. This form of analysis is ideal when the question is of operating a new transportation system optimally whilst maintaining an efficient level of performance.

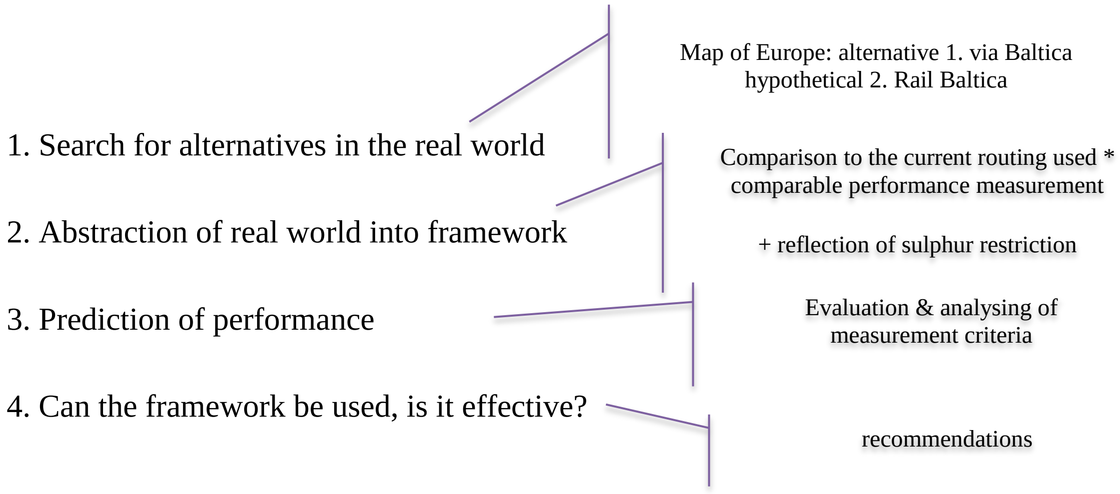
The idea is to begin looking for alternative solutions to the ones currently used in reality. The goal is to search for a better way of doing things or in this case the optimal way whilst changes in the operational environment are predicted with the upcoming increases in the sea freight costs.

The second step is to try and forecast the performance of the alternative. In this case it is possible to use comparison to the existing transportation system; however, it is of essence to identify performance measures or measures of effectiveness that are comparable, criteria for this research are named in table 10.

This brings the analysis to the third step, which is to identify or develop performance measures which can then subsequently be used to analyse and decide whether the new system is operating effectively.

Abstracting real world into the framework is an important step in the process because it is not possible to carry out experimentation in the real world. Although these abstractions are very simplified form of reality, they provide an insight to the way systems perform (Sussman 2000, 115 – 129).

The main line of thought behind the empirical research is shown below together with the four steps of the TSA framework are:


1. Search for alternatives in the real world
2. Abstraction of real world into framework
3. Prediction of performance
4. Can the framework be used, is it effective?

The framework will accommodate the search for the likelihood of the modal backshift from using medium sea segments to shorter ones after an increased sea freight cost, as explained in the theoretical part of the study.

The gathering of the information for the empirical part of the study entailed the process visualised in figure 24 below. A similar path was followed for all of the routes under analysis and comparison, which include the current production methods via Gdynia and Travemünde as opposed to routing via Baltica. An assumed existance of the Rail Baltica Corridors as well as the use of road through the Baltic states onto mainland Europe is studied. After looking at the current status, the calculated conditions in 2015 after the impacts of the sulphur restrictions are evaluated.

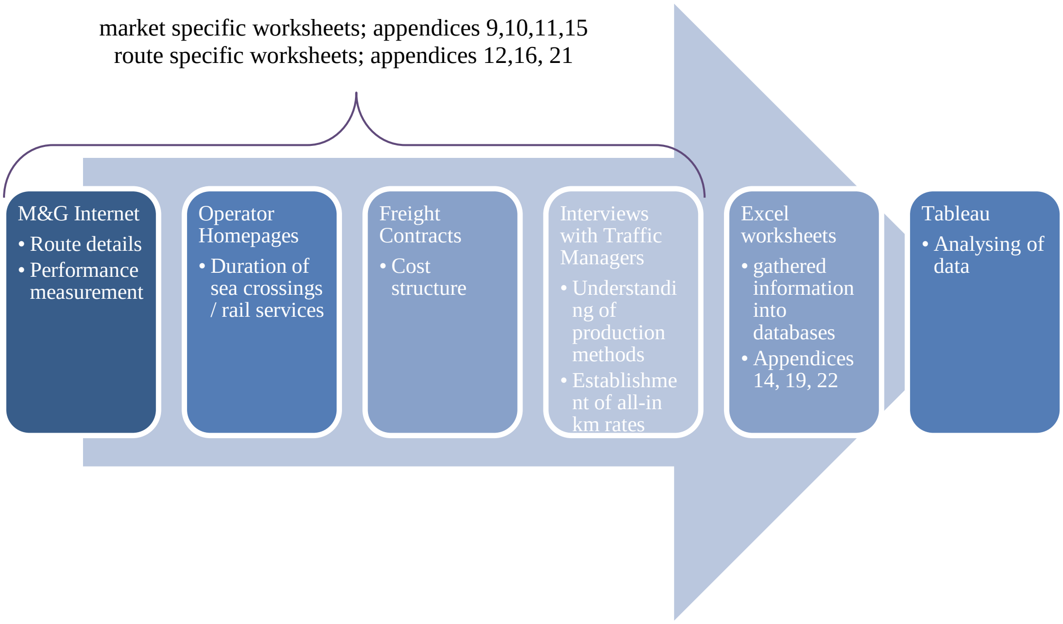


Figure 24. Gathering of the information for the empirical study

The route specific worksheets (appendices 12, 13, 16, 17) are built in such a form that by changing active cell criteria, such as the changes in freight agreement rates or fuel adjustement factors, the sheets can be used as a supportive cost tool in daily transport planning activities.

All of the routes under analysis also followed a consistent path for studying the impacts on performance through selected performance measurements. These measures assist in bringing real world into the equation and thus in evaluating the performance of the routes. Table 10 on the following page shows the key criterion used as a basis for the performance analysis. These performance criteria are discussed next.

Table 10. Key Criterion used as a basis for analysis

Performance Criteria	**TIME**	**INFRASTRUCTURE**	**COST**	**ENVIRONMENT**	**COST VOLATILITY**
Performance Measure	**Route Lenght (km)** The geographical distance from the port to the depot on mainland Europe	**Toll route (km)** the distance of toll routes en route	**Toll costs (€)** the value of toll costs en route	**CO2e (kg)** the amount of CO2 emissions for the total road transportation on mainland Europe	**s.o. seafreight (%)** the value of sea freight costs from the total costs
	Total Journey time (h) the total travel time for the entire intermodal transport chain excluding waiting time	**Motorway** the existance of motorway for the journey	**km cost (€)** the value of haulage cost en route	**Route Lenght (km)** The geographical distance from the port to the depot on mainland Europe	**s.o. BAF (%)** the value of BAF costs from the total costs
	Driving time (h) pure driving time excluding break times breaks are included in the journey time		**total cost (€)** the value of total cost en route		
Impact	SCHEDULED SERVICE	REAL WORLD ALTERNATIVE	SELLING PRICE OF SERVICES	CORPORATE SOCIAL RESPONSIBILITY	SUBJECTIVITY TO SULPHUR RESTRICTIONS
Central issues	Current driver capacity vs schedule	Infrastructure maintenance	causes of modal backshift	Policy making vs air pollution	Impact of bunker fuel price

The **time** parametres of the study have a direct impact on the **service schedule**. Studying the time components allows for the thesis to analyse and demonstrate the alternative routing's capability to accommodate the required time service standards.

The **infrastructure** components allow for the statement that the routing is a **real world alternative**. In heinseit, if the required road network was not in place, the studied alternative would not be a true possibility; as is the case of the Rail Baltica corridor. Studying the rail corridor presence nevertheless accommodates its impact study on the performance measurement criteria.

Time and **cost** often are the central measurement criteria of transportation. The cost parametres accommodate the analysis on the impact of the changes in ultimately the **selling price of the services**. The changes in the cost components have a direct impact on the price of the service.

The **environmental** impact of the routing allows for the analysis of the effectiveness of the International Maritime Organisation's (IMO) regulation as an enhancement towards improved air quality, and furthermore a demonstration of the value of environmental policy making on a wider scale. It also raises the question of corporate social responsibility, a ponder of who is responsible for a possible negative impact; the policy makers, customers or the service providers?

The **cost volatility** on the other hand compares the **impact of the sea segment**, the sulphur regulation, **on the overall production components** of a particular routing. This allows the indication of how likely price fluctuations in ships bunker fuel are to impact the pricing of a specific routing.

The measurement criteria used in the analysis, reflect the five EMSA assesment variables named under section 2.1. on the impact of the new IMO rule as mentioned on page 19 and demonstrated in figure 25 below.

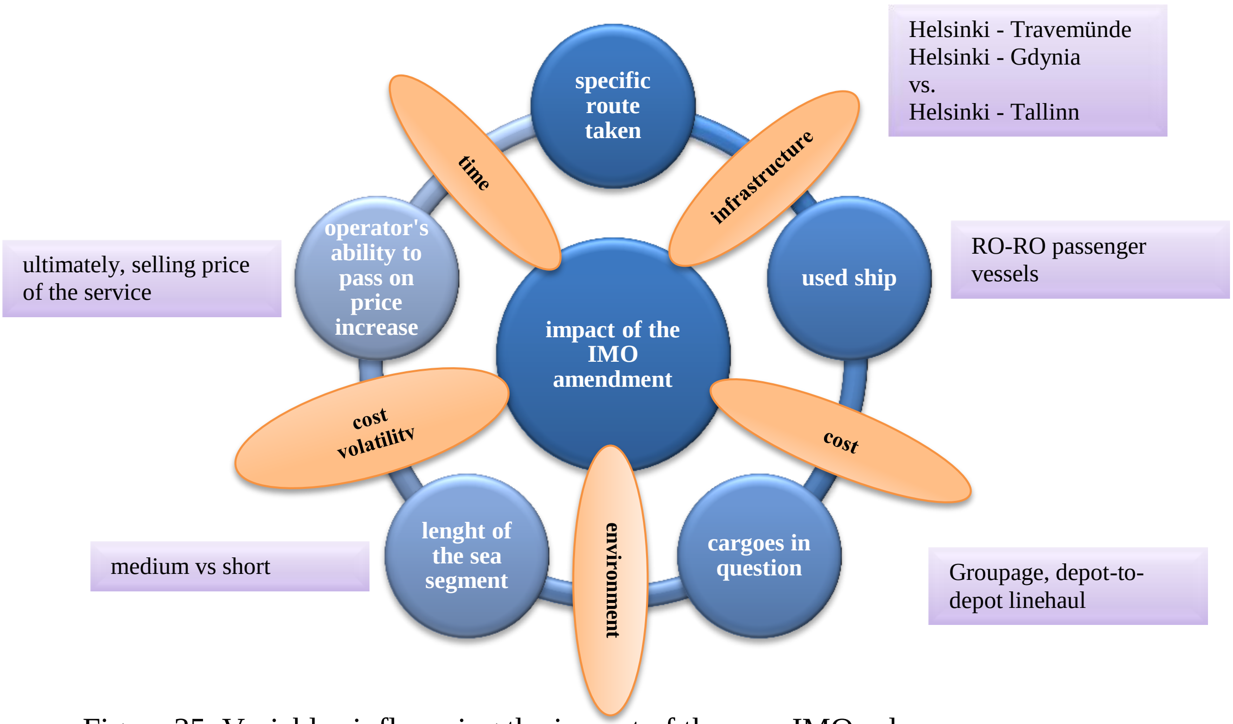


Figure 25. Variables influencing the impact of the new IMO rules

Let us now move on to look at the particular routings that are under analysis in this thesis. The following subheadings will further demonstrate the alternatives compared in chapter 4.

3.1 Direct vessel vs via Baltica 2013

The initial step in the study was to find out the current service ratio between the use of the direct sea crossings and going via Baltica. The combination of using the direct sea crossing entails either the transfer to rail once on mainland Europe or alternatively the use of road to reach the destination. These two production types are the most commonly used methods for scheduled services currently. There are two main flows under analysis, the Eastern flows routed via Gdynia, Poland, accounting for 5 % of the volumes as shown in figures 26 and 27. The rest of the European flows are routed via Travemünde, Germany; the volume distribution amongst the two ports from 2012 figures is shown below.

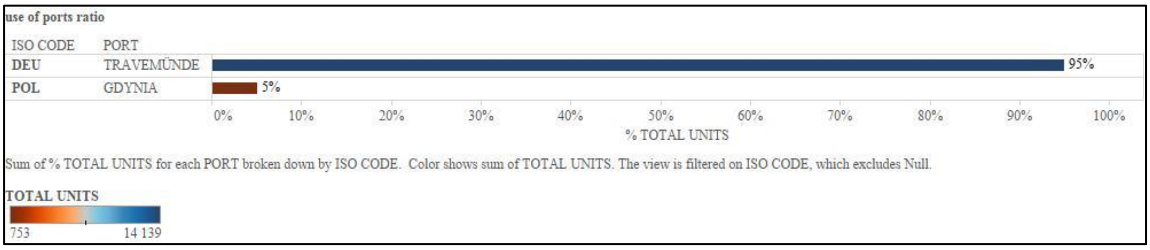


Figure 26. Port distribution of the European production.

The market distribution for the study is shown below in figure 27. The worksheets and gathered databases in the appendices are named in accordance with either the port, route, or the market distribution in an effort to clarify the contents of the material.

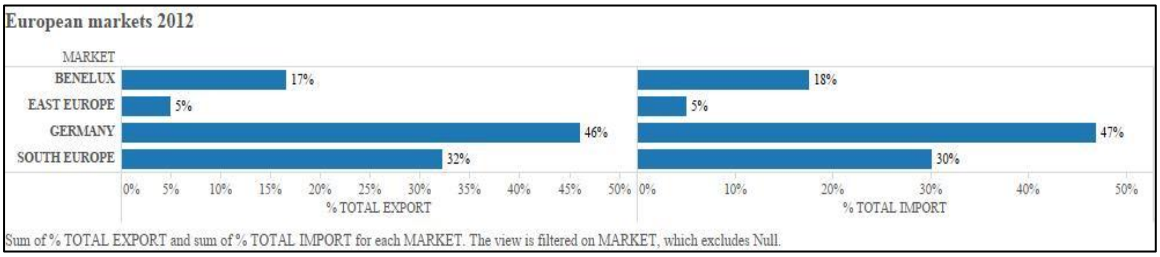
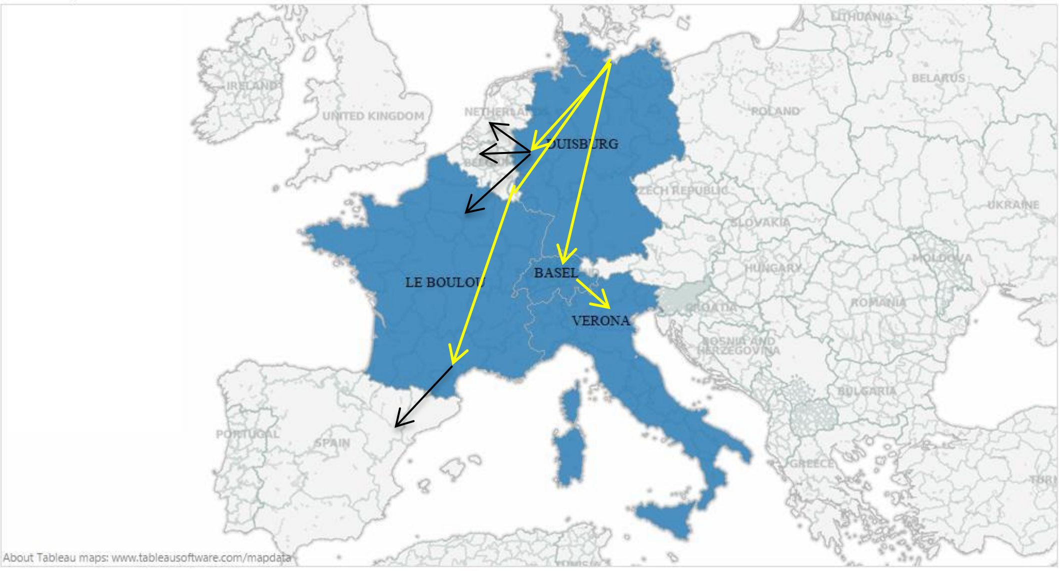


Figure 27. Market distribution of the total European production.

The use of rail on mainland Europe runs alongside the driving capacity. Whilst studying the current production methods and comparing them to that of routing via Baltica, the rail options are analysed as well. The map below indicates the main railway hubs used in Germany, Switzerland, Italy and France; servicing other markets such as the Benelux and Spain as well. Some of the hubs are based on direct rail services from the German port and others such as Le Boulou is a transfer via another rail hub, in its case Luxembourg. The railway lines are shown in yellow arrows below whilst the other service markets through black arrows.

main railway hubs



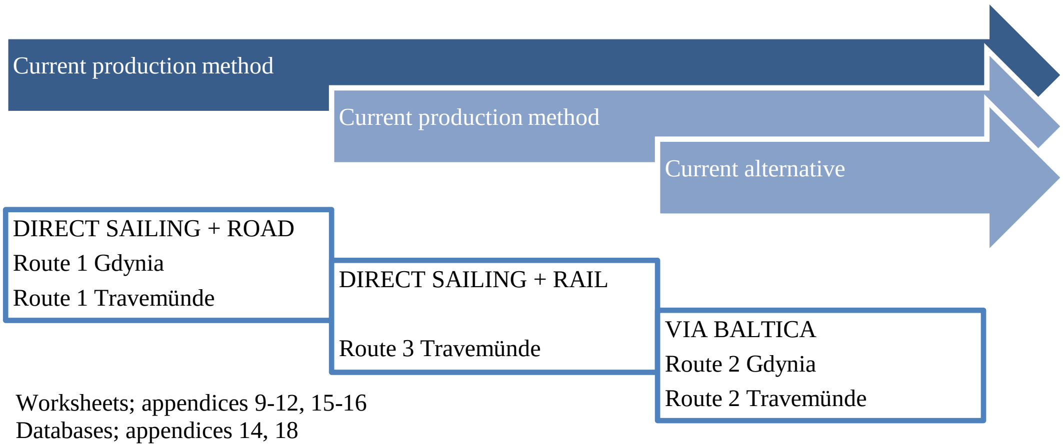
Map based on Longitude (generated) and Latitude (generated). The marks are labeled by railway terminal. Details are shown for iso country code. The view is filtered on Exclusions (iso country code,railway terminal), which keeps 4 members.

Figure 28. Main railway hubs in current production

The use of rail for the traffic flows via Gdynia is not applicable at current. The exploitation of the Rail Baltica Corridors will be looked at when assuming the corridors existance under section 3.1.1 on the next page.

It is important to keep in mind that the waiting time for connective schedules are not included in the journey time calculations for the use of rail. The calculations assume optimal connections, which is often not the case in the real world. It is in fact that all journey time calculations do not include waiting time.

The process of gathering data for the three routing possibilities under evaluation; via Gdynia, Travemünde and Baltica, is demonstrated in figure 24 in the beginning of this chapter. The next figure 29 indicates the route references for each alternative as well as the equivalent appendices for the gathered information.



Worksheets; appendices 9-12, 15-16
Databases; appendices 14, 18

Figure 29. Direct vessel vs via Baltica 2013

The databases are then evaluated and analysed in chapter four prior to making recommendations and conclusions amongst the current routings versus the findings applicable as and from January 2015.

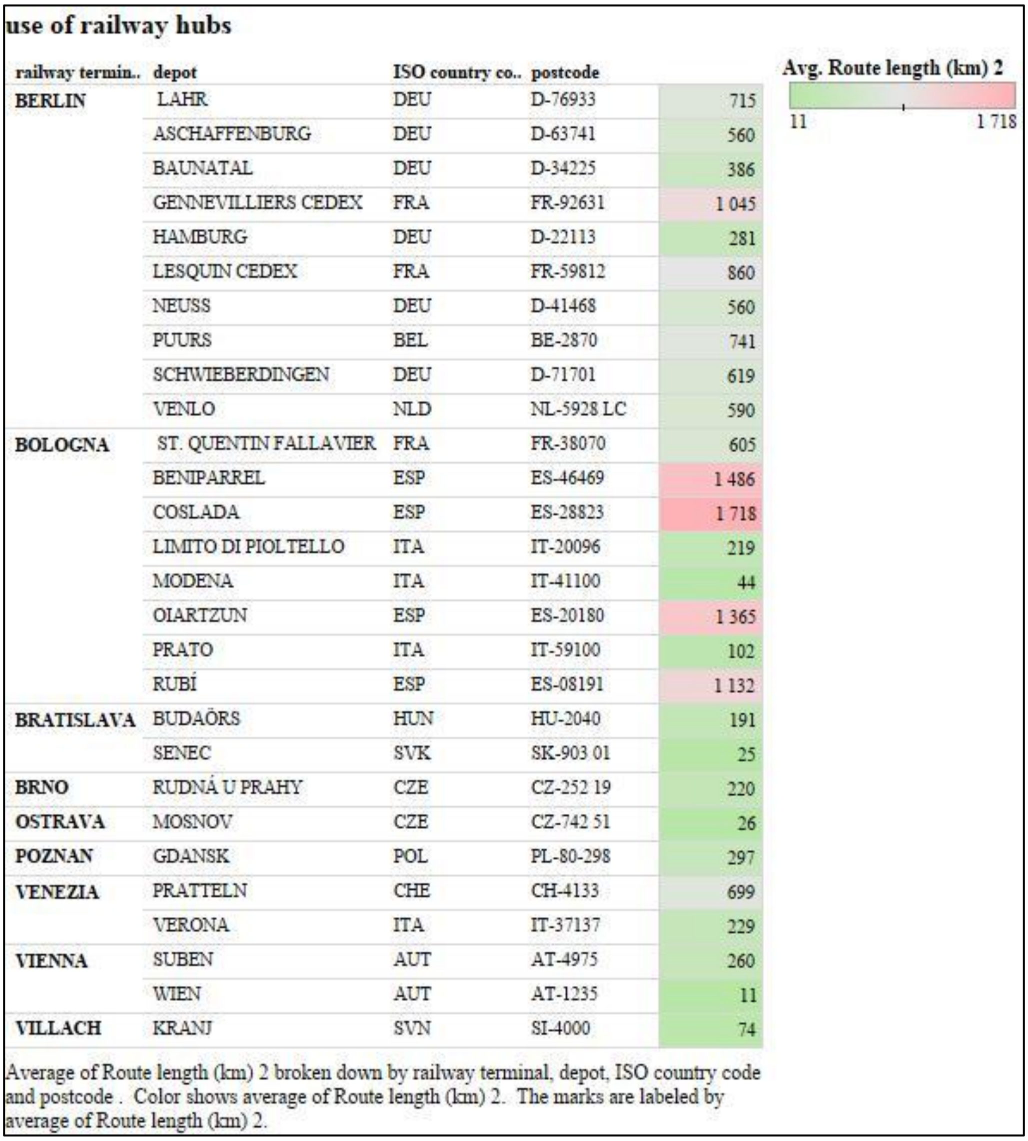
3.1.1 Rail Baltica Corridors

The basis for this part of the study is the assumed presence of the Trans-European Transport Network (TEN-T) corridors. Both, the Rail Baltica Growth Corridor (RBGC), see figure 15, as well as the Baltic-Adriatic Corridor (B-AC), see figure 30 below. The connecting point for the two rail corridors is in Warsaw, Poland.

Figure 30. The Baltic-Adriatic Corridor[6]

The Baltic-Adriatic Corridor accommodates the Southern and Eastern European traffics whilst the Benelux and German markets benefit from the use of the Rail Baltica Growth Corridor reaching as far as Berlin from Tallinn.

The initial step in comparing the road versus rail alternatives via Baltica is to identify an optimal railway hub from the network corridors for each European depot. The optimal depot specific railway hubs are shown in figure 31 together with the distance by road from the railway to the depot.



use of railway hubs

railway termin..	depot	ISO country co..	postcode	
BERLIN	LAHR	DEU	D-76933	715
	ASCHAFFENBURG	DEU	D-63741	560
	BAUNATAL	DEU	D-34225	386
	GENNEVILLIERS CEDEX	FRA	FR-92631	1 045
	HAMBURG	DEU	D-22113	281
	LESQUIN CEDEX	FRA	FR-59812	860
	NEUSS	DEU	D-41468	560
	PUURS	BEL	BE-2870	741
	SCHWIEBERDINGEN	DEU	D-71701	619
	VENLO	NLD	NL-5928 LC	590
BOLOGNA	ST. QUENTIN FALLAVIER	FRA	FR-38070	605
	BENIPARREL	ESP	ES-46469	1 486
	COSLADA	ESP	ES-28823	1 718
	LIMITO DI PIOLTELLO	ITA	IT-20096	219
	MODENA	ITA	IT-41100	44
	OIARTZUN	ESP	ES-20180	1 365
	PRATO	ITA	IT-59100	102
	RUBÍ	ESP	ES-08191	1 132
BRATISLAVA	BUDAÖRS	HUN	HU-2040	191
	SENEC	SVK	SK-903 01	25
BRNO	RUDNÁ U PRAHY	CZE	CZ-252 19	220
OSTRAVA	MOSNOV	CZE	CZ-742 51	26
POZNAN	GDANSK	POL	PL-80-298	297
VENEZIA	PRATTELN	CHE	CH-4133	699
	VERONA	ITA	IT-37137	229
VIENNA	SUBEN	AUT	AT-4975	260
	WIEN	AUT	AT-1235	11
VILLACH	KRANJ	SVN	SI-4000	74

Average of Route length (km) 2 broken down by railway terminal, depot, ISO country code and postcode . Color shows average of Route length (km) 2. The marks are labeled by average of Route length (km) 2.

Figure 31. Optimal depot specific railway hubs

The following steps included both, the theoretical rate for the rail services as well as the duration of the rail journey. The basis for the rate/km/rail was gathered from current rail rate agreements by dividing the number of kilometres covered by rail, see appendix 20 for the rail calculation methodology. An average euro equivalent per rail/km was reached at €0,75/km. The basis for the duration of the rail services on the other hand was formed based on the average freight train speed of 68km/h and the given length of the railway from Tallin to the Polish border at 728 kilometres (Aecom,2011). The basis for the rate and the journey time are shown in figure 32 below.

		km	**rate**	**rate/km**		h (ave 68/h)
Rail Baltica	TALLIN TO POLAND (BORDER)	728	546	0,75		10,38
RBGC	BER	1642	1232	0,75		23,98
B-AC	VEN	2318	1739	0,75		33,86
B-AC	BOL	2471	1853	0,75		36,09
B-AC	BRA	1712	1284	0,75		25,01
B-AC	VIL	2151	1613	0,75		31,42
RBGC	POZ	1380	1035	0,75		20,16
B-AC	OST	1428	1071	0,75		20,86
B-AC	BRN	1596	1197	0,75		23,31
B-AC	VIE	1730	1298	0,75		25,27
RBGC	Rail Baltic Growth Corridor					
B-AC	Baltic-Adriatic Corridor					

Figure 32. Rail Baltica, average all-in rate and duration per location

The below figure indicates the route references for each alternative as well as the equivalent appendices for the gathered information. The current alternative via road through the Baltic States is refereed to as route 1 whilst the Rail Baltica alternative is route 2 in the relevant calculations as shown in the mentioned appendices.

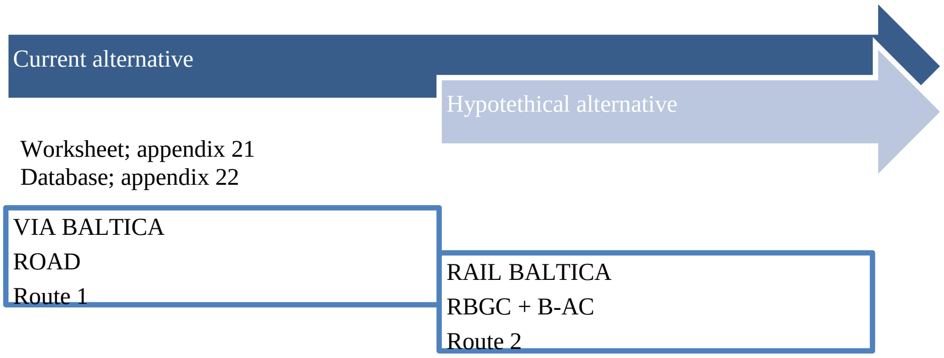


Figure 33. Rail Baltica Corridors

On the basis of the 1) optimal railway hubs and the 2) hypothetical rate and 3) the duration, information was gathered as demonstrated in figure 24 at the beginning of the chapter. The data is analysed in the next chapter, 4.

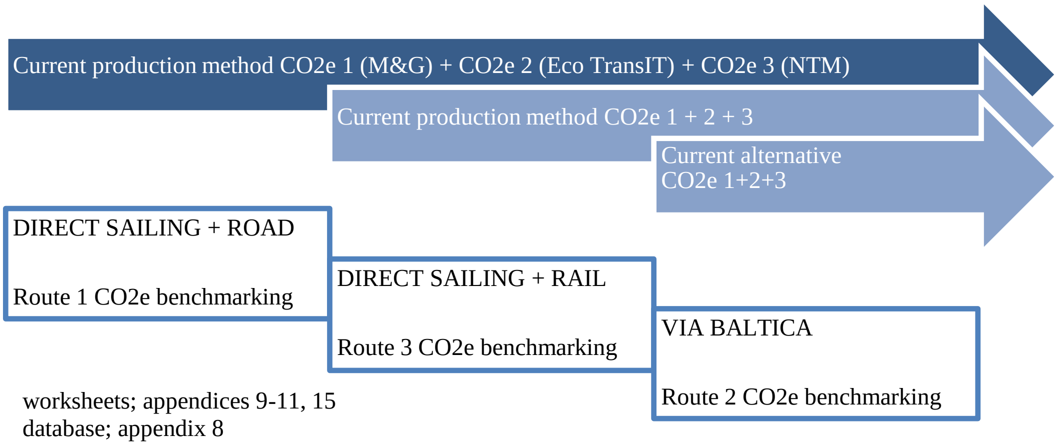
3.1.2 CO2 emissions benchmarking

Alongside the environmental performance measurement of the routings, a secondary analysis is conducted on the use of CO2e calculation tools. An investigation into the benchmarking of various emissions calculation tools available on the market is called for as an effort to identify comparability. The three tools used to compare the emissions were the PTV M&G Internet, Eco TransIT World (2013), and the NTM Calc portals (2011). It is important to highlight that the emissions comparisons were conducted for the road transportation leg on mainland Europe only. Table 11 below describes the specs of the used tools in more detail.

Table 11. Emissions calculation tools used

Tool	**PTV Map&Guide Internet** **Version: 2.2.14086** **Operating system: Win32**	**Eco TransIT World** **Frontend: 109023** **Server: 21923** **Database Name: eco_085**	**NTM Calc** **Version: NTMCalc 3.0**
Emission values	HBEFA 3.1, INFRAS AG, Bern (the Handbook on Emission Factors for Road Transport) *the tool also has an alternative method to choose: prDIN 16258 (energy consumption and greenhouse gases according to the prDIN 16258 draft standard for Europe or regulation No. 2011-1336* for France)	ifeu Heidelberg, INFRAS Bern and IVE mbH Hannover “TREMOD - Transport Emission Model" Adapted to latest scientific findings and further reaching requirements (e. g. EN 16258).	the Network for Transport and Environment (NTM) acts for a common and accepted method for calculation of emissions (non profit organization, common base of values)
Factor contributors	- Vehicle characteristics (Euro4) - Load weight (GVWR (t): 40, maximum axle load (t): 10.00 default) - Route profile (gradient)	- Transport mode - Truck (Euro5 default) - Load weight & type of goods (23 tons of average goods) - Origin & Destination	- Vehicle type (Truck & trailer) - Shipment weight, tons (23) - Distance (km)
Map basis	PTV Europe City Map Premium 2012.1N (NAVTEQ / AND)	huge geo-information database	Distance based
Example	Appendix 5	Appendix 6	Appendix 7

The basis for the emissions calculations databases are the direct vessel versus via Baltica 2013 routings. All of the three emissions calculators were used for the European depots within the current routing alternatives; direct vessel (route 1), use of train on mainland Europe (route 3) and going via the Baltics (route 2), as shown in figure 34 below, together with the relevant appendices for the emissions data gathered.



worksheets; appendices 9-11, 15
database; appendix 8

Figure 34. CO_2e Benchmarking

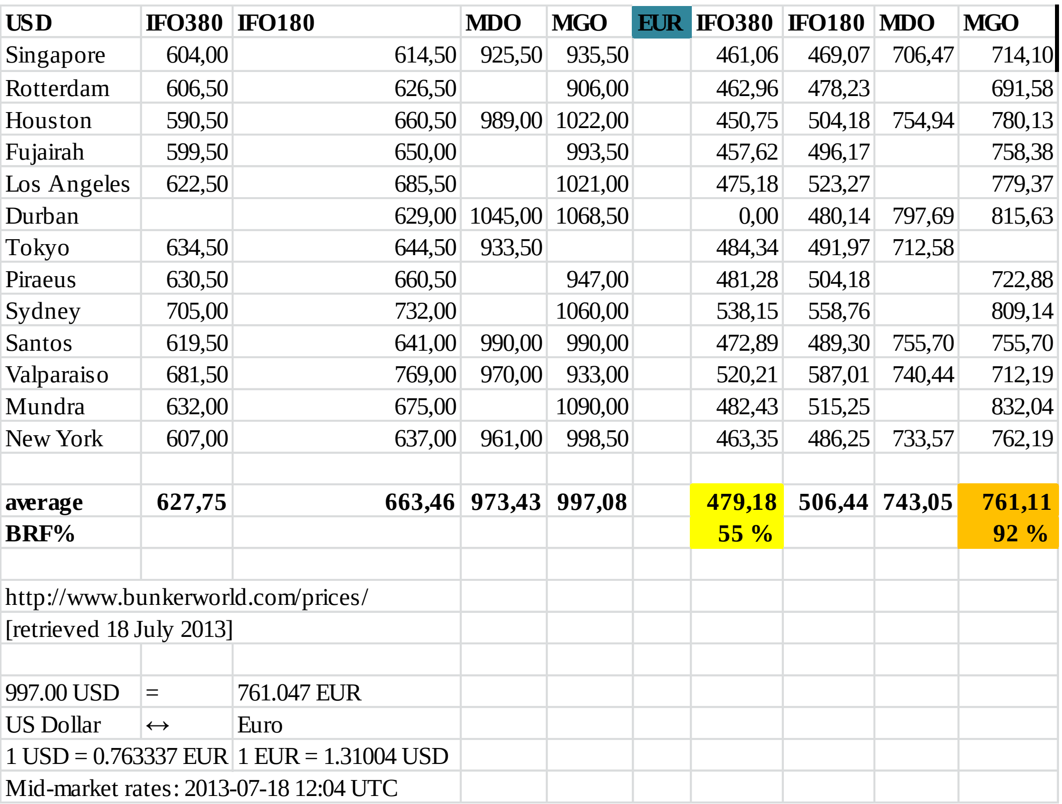
The findings of the emissions benchmarking is shown in the next chapter.

3.2 Direct vessel vs via Baltica 2015

Whilst the previous research identifies the service ratios between the production methods in the present time, including a hypothetical presence of the Rail Baltica infrastructure, the main focus of the study becomes concrete in this part of the Master's Thesis, as it is where the impact of the Sulphur content in ships bunker fuel in 2015 is lightened.

The method used to reflect the impact of the higher fuel cost is by comparing the costs of the fuel grades in the present time. The US Dollar equivalents are converted into euro and compared against the current Bunker Adjustment Factor (BAF) key, see appendix 23. The current euro average for the lowest fuel grade (380) provides the present BAF percentage charged on top of the sea freight, 55 %. The cleaner fuel, MGO, prices are then euro averaged, giving us a present

BAF of 92 %. The market rates are shown in figure 35 below, and the BAF key in appendix 23 at the back of the thesis.



USD	**IFO380**	**IFO180**	**MDO**	**MGO**	**EUR**	**IFO380**	**IFO180**	**MDO**	**MGO**
Singapore	604,00	614,50	925,50	935,50		461,06	469,07	706,47	714,10
Rotterdam	606,50	626,50		906,00		462,96	478,23		691,58
Houston	590,50	660,50	989,00	1022,00		450,75	504,18	754,94	780,13
Fujairah	599,50	650,00		993,50		457,62	496,17		758,38
Los Angeles	622,50	685,50		1021,00		475,18	523,27		779,37
Durban		629,00	1045,00	1068,50		0,00	480,14	797,69	815,63
Tokyo	634,50	644,50	933,50			484,34	491,97	712,58	
Piraeus	630,50	660,50		947,00		481,28	504,18		722,88
Sydney	705,00	732,00		1060,00		538,15	558,76		809,14
Santos	619,50	641,00	990,00	990,00		472,89	489,30	755,70	755,70
Valparaiso	681,50	769,00	970,00	933,00		520,21	587,01	740,44	712,19
Mundra	632,00	675,00		1090,00		482,43	515,25		832,04
New York	607,00	637,00	961,00	998,50		463,35	486,25	733,57	762,19
average	**627,75**	**663,46**	**973,43**	**997,08**		**479,18**	**506,44**	**743,05**	**761,11**
BRF%						**55 %**			**92 %**
http://www.bunkerworld.com/prices/									
[retrieved 18 July 2013]									
997.00 USD	=	761.047 EUR							
US Dollar	↔	Euro							
1 USD = 0.763337 EUR		1 EUR = 1.31004 USD							
Mid-market rates: 2013-07-18 12:04 UTC									

Figure 35. The impact of the sulphur emissions restriction in 2015

This method indicates that the BAF percentage will rise by 37 % influencing the cost of the sea freight to increase consequently.

This method does not take into consideration the changes in fuel consumption or other factor contributors impacting the fuel prices as discussed earlier in the thesis. This is a simplified method of comparing the present price difference and assuming that the ratio remains on a similar level in 2015, therefore no other cost increases are estimated. The aim is to indicate the cause of the more expensive fuel grade only, providing one factor contributor alone. Nevertheless, Kalli and Alhosalo (2012; 11) conducted a study on the effects of sulphur emission restrictions on transport costs via the port of Hanko, and their method to calculate the cost increase resulted in a 33 % rise in sea freight costs in 2015. The study also suggests that the 33 % maritime cost increase is valid for all of the routes studied. This comparison suggests that the simplified method used in this Master's Thesis is a useable method for presenting findings.

The route worksheets, shown in appendix 13 and 17, are then updated with the new BAF percentage of 92, indicating the change in the current production costs thus reflecting the predicted ratio between the present and the year 2015.

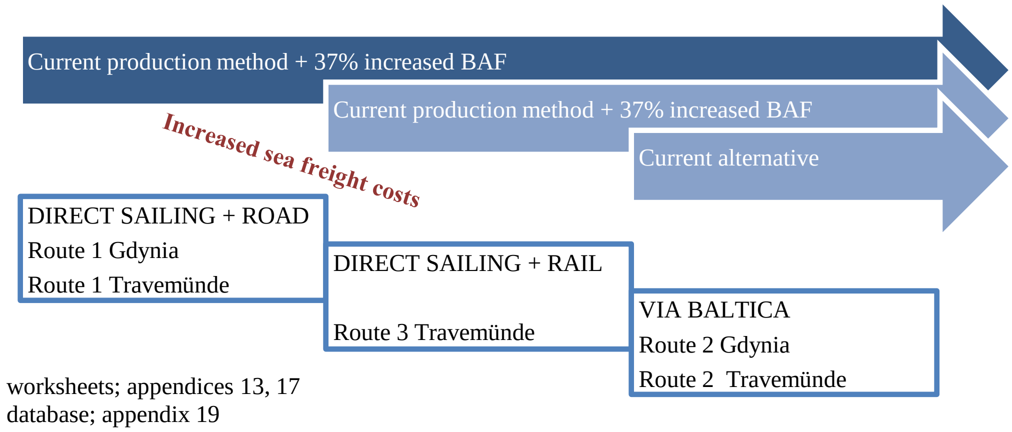


Figure 36. Direct vessel vs via Baltica 2015

The above figure indicates the route references for each alternative as well as the equivalent appendices for the gathered information. The findings are provided in the following chapter together with, ultimately, the recommendations for depot-to-depot linehaul in 2015.

4 IMPACTS OF THE NEW IMO REGULATIONS ON TRANSPORT SERVICE PRODUCTION

The empirical part of this study focuses on scheduled depot-to-depot linehaul production between Finland and Mainland Europe. The idea is to measure the implications of the changes applicable in 2015 on the transportation system and to estimate the probability of the use of alternative routings in service production. The study concentrates on comparing the use of the direct sea services to that of routing via the Baltics. The study also predicts the impact of the assumed Rail Baltica infrastructure in the service production.

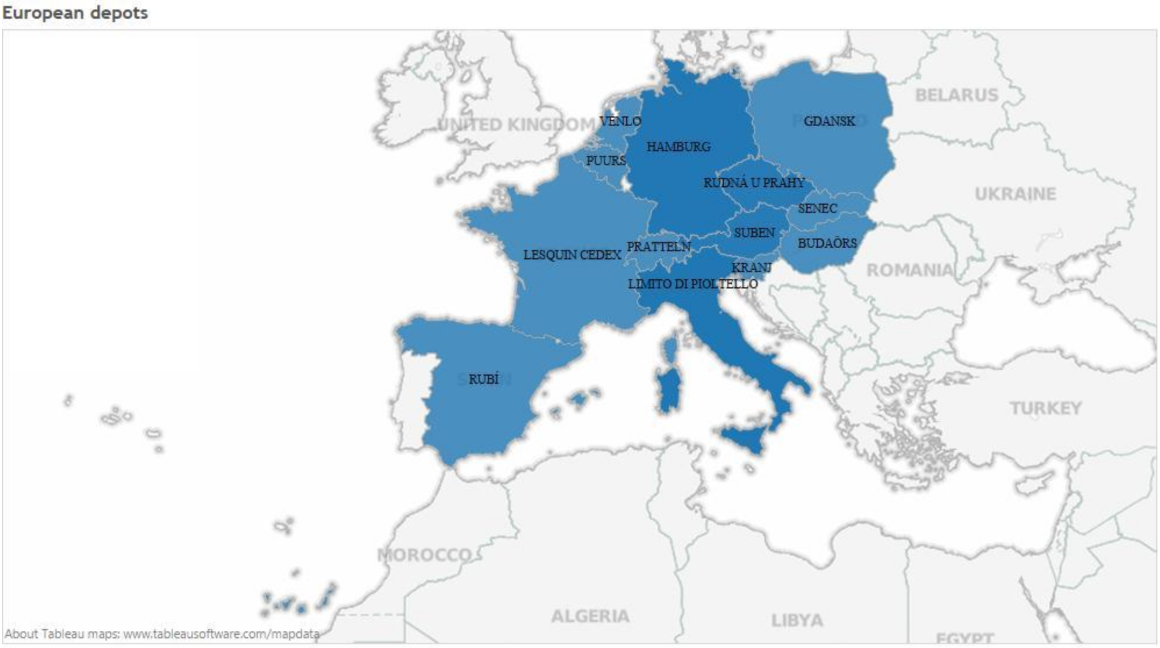
The case study is conducted for DSV Road Oy, a subsidiary of DSV A/S its Danish parent listed on the NASDAQ OMX Copenhagen. DSV is a global transportation and logistics solutions provider with an annual turnover of 6 billion euros in 2012. DSV is divided into three service areas; Road, Air & Sea and Solutions. DSV Road is one of the three major players on the European market with a fleet of over 17 000 trucks. On a European scale DSV Road employs around 10 000 persons (DSV, 2013a). DSV Road Oy's share of that is aproximately 230 employees and a turnover of 127 million euros in Finland (DSV, 2013b).

To give an indication of the scope of the study for DSV Road Oy, the volumes, in transportation units, for the equivalent markets in 2012 concists of 24 300 units including 14 900 DSV's own fleet, as demonstrated in more detail in table 12 below (DSV, 2012).

Table 12. European unit volumes in 2012, DSV Road Oy [confidential]

[redacted]

The study includes the main European depots from the Finnish traffic flows perspective, some of these depots are named in their retrospective countries in the below figure 37.


European depots

Map based on Longitude (generated) and Latitude (generated). The marks are labeled by depot. Details are shown for ISO country code . The view is filtered on Exclusions (depot,ISO country code), which keeps 20 members.

Figure 37. European countries included in the study

To commence the comparison between the use of the current routes as opposed to routing via the Baltics after the sulphur restrictions become applicable in 2015, it is of essence to establish the current proposition of the alternatives as analysed under the following sub-heading.

4.1 Direct vessel vs via Baltica 2013

With the rise of fuel prices, alternative routing solutions such as the use of Baltica have already proven to be competitive on some markets. This gap will naturally continue to evolve once the fuel prices further increase reflecting a raising trend in the Bunker Adjustement Factor (BAF) and subsequently higher seafreight costs. The bigger the proportion of the seafreight costs of the total production costs, the bigger the likelyhood of finding alternative routings with shorter sea segments. It is important to mention that some of the current volumes, particularly that of the Eastern countries, is already routed via the Baltic States. They are included in the study to further understand the impact of Rail Baltica for those markets.

4.1.1 Scheduled service

An important factor of transport service production is on time deliveries and the ability to keep to promised service schedules. Therefore, an alteration in the production method is not to alter the product.

When the total journey time parametres are compared between the various production methods, it is established that both methods of the current production, road and train, on a total European average are within a variance of 3 %. It indicates that the use of train as opposed to travelling by road does not jeopardise the required schedule of the service. On the other hand, going via the Baltica increases the average total journey time by 70 %. The average driving time and driving including the break times increase considrably, indicating that with one driver capacity the providing for the scheduled service standards would be jeopardised by shifting current production with current driver capacity via Baltica. Figure 38 below demonstrates the time parametrer comparison as explained above for the current production via Travemünde and the current alternative via Baltica.

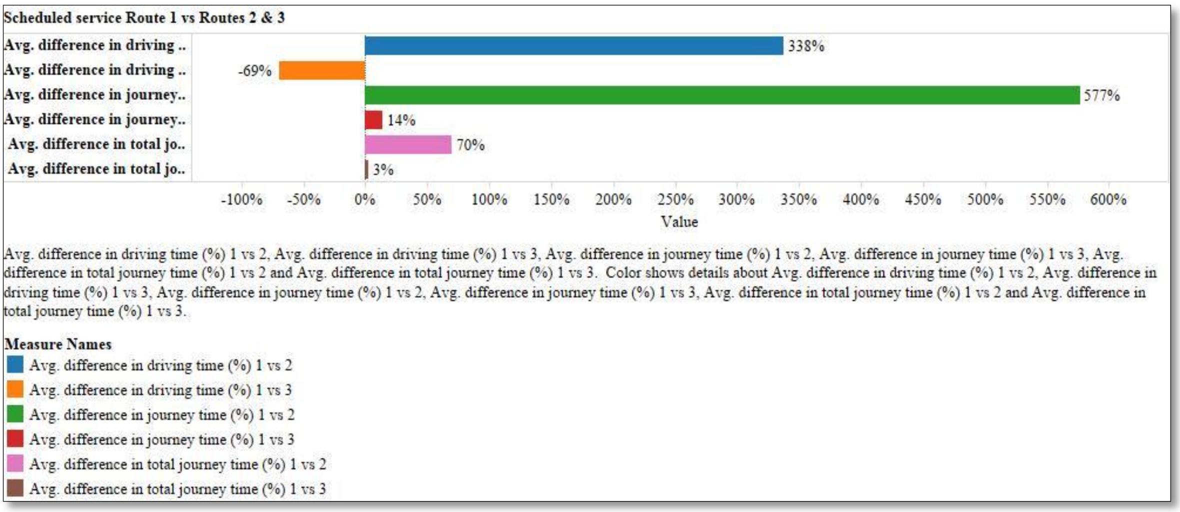


Figure 38. Time parametre comparison for Travemünde database

In order to establish a clearer indication on a more specific level, the time parametres need comparison at market level. By looking at the total market averages it is seen that the Spanish and Italian flows are considerably less affected by increased journey time, at 45-49%, than the average European increase of 70%. This suggests that with a two driver capacity the scheduled service production to those markets accommodates the schedule service requirements, making Spain and Italy a likely candidate for modal backshift in comparison to other European locations currently produced via the German ports.

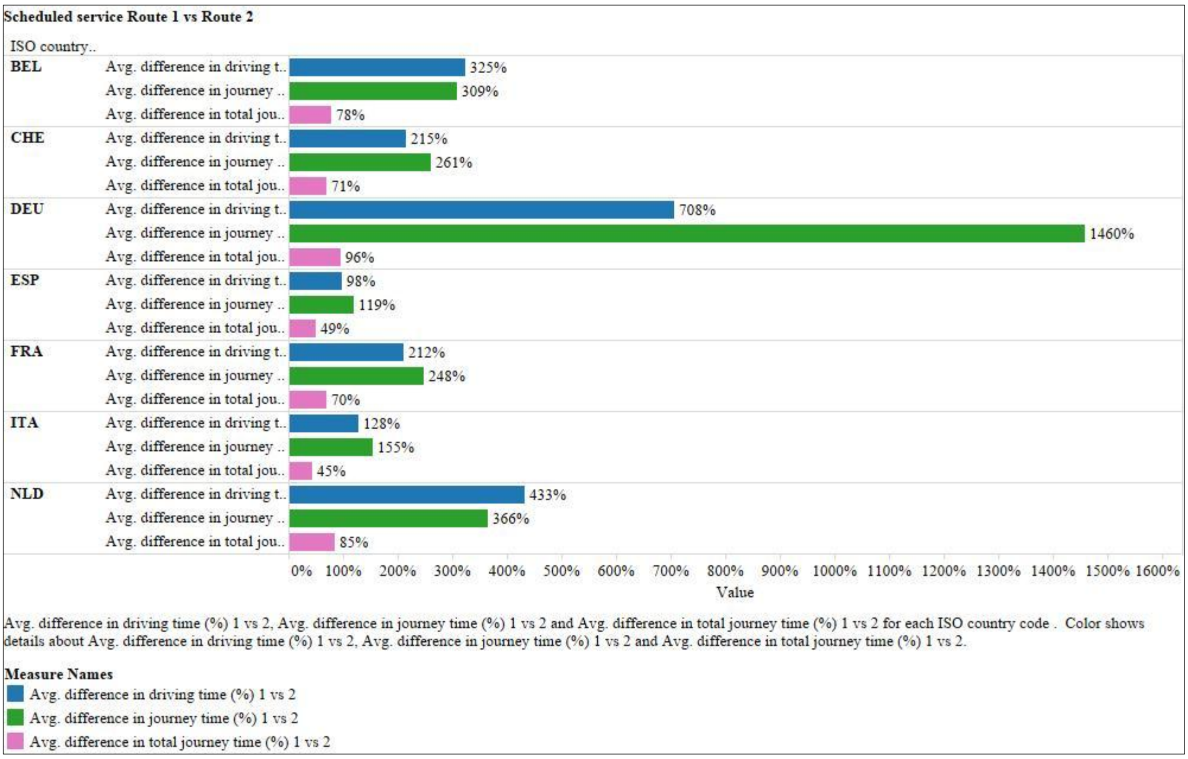


Figure 39. Schedule impact is lower than average for Italy and Spain

By comparing similar data for the production via Gdynia routing to that of going via Baltica, it is established that although the driving time increases considerably, the average total journey time by less than one third, at 27%, as shown below in figure 40.

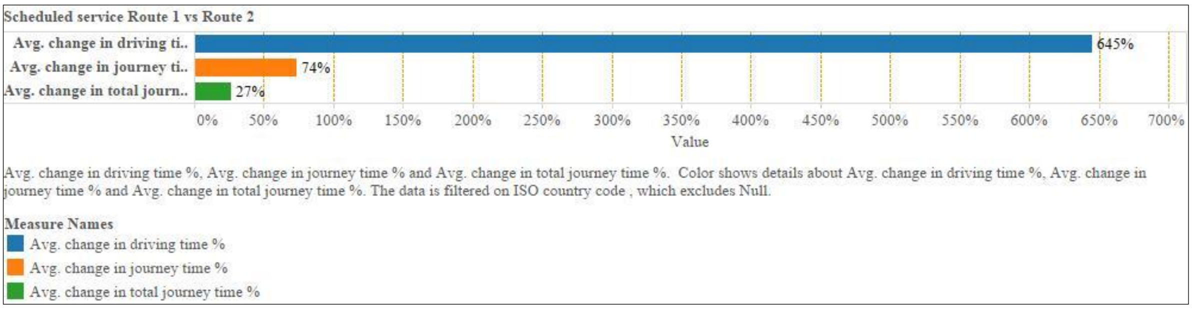


Figure 40. Time parametre comparison for Gdynia database

The connection patterns between mainland Europe and Finland become central at this point. Although the study does not include waiting time at any given point of the transport chain, it is crucial to explain that all in all, the Eastern European scheduled service production is not jeopardised by routing via the Baltic States. Although the total journey time increases, the connection patterns between Helsinki and Tallin are considerably more frequent than those between Helsinki and Gdynia. If the waiting time at the port was included for the Gdynian production, the overall journey time for the two production methods would be neck and neck. To demonstrate this on a more specific level, it becomes evident that Poland considerably increases the overall average time with a 61% increase via Baltica due to its location next to the Gdynian port, as shown in figure 41.

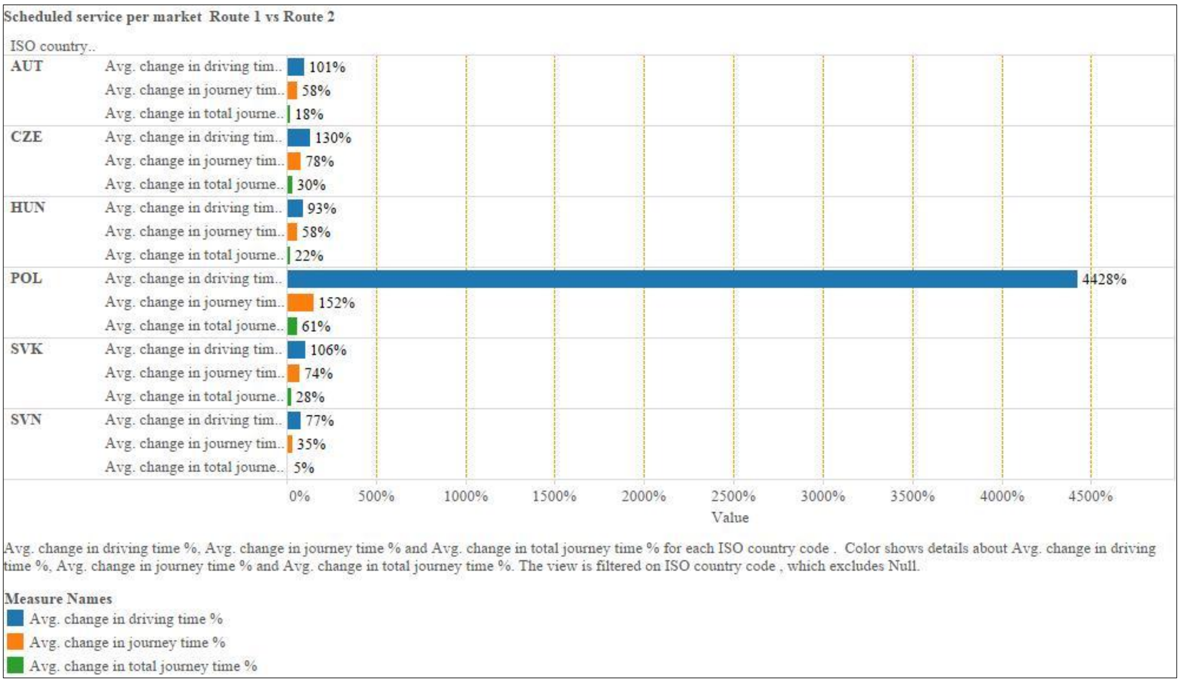


Figure 41. Average schedule impact is considerably increased by Poland

To conclude the comparison of the time parametres for the direct sea lanes versus routing via Baltica has shown that the required schedule standards are not influenced in the case of the Eastern European production. For other European locations, travelling via road with current driver capacity has proven to challenge the service standard. Overall however, the Southern European locations, Italy and Spain, have indicated a higher likelihood for modal backshift with time increases feasible to tackle with a two driver set-up.

4.1.2 Infrastructure

Whilst focusing on real world alternatives, it is self-evident that an adequate infrastructure must be in place. This research only scratches surface on the topic of infrastructure by stating that a motorway network is available in the case of both current routings and the alternative routings. The only three incidents indicating the lack of motorway are whilst moving the unit from a railway hub to Hamburg and Verona depots as well as the port shunt to Gdansk depot. In all of these cases the lack of motorway is a natural cause due to the short distance movements. This is shown in figures 42 below and 43 on the following page.

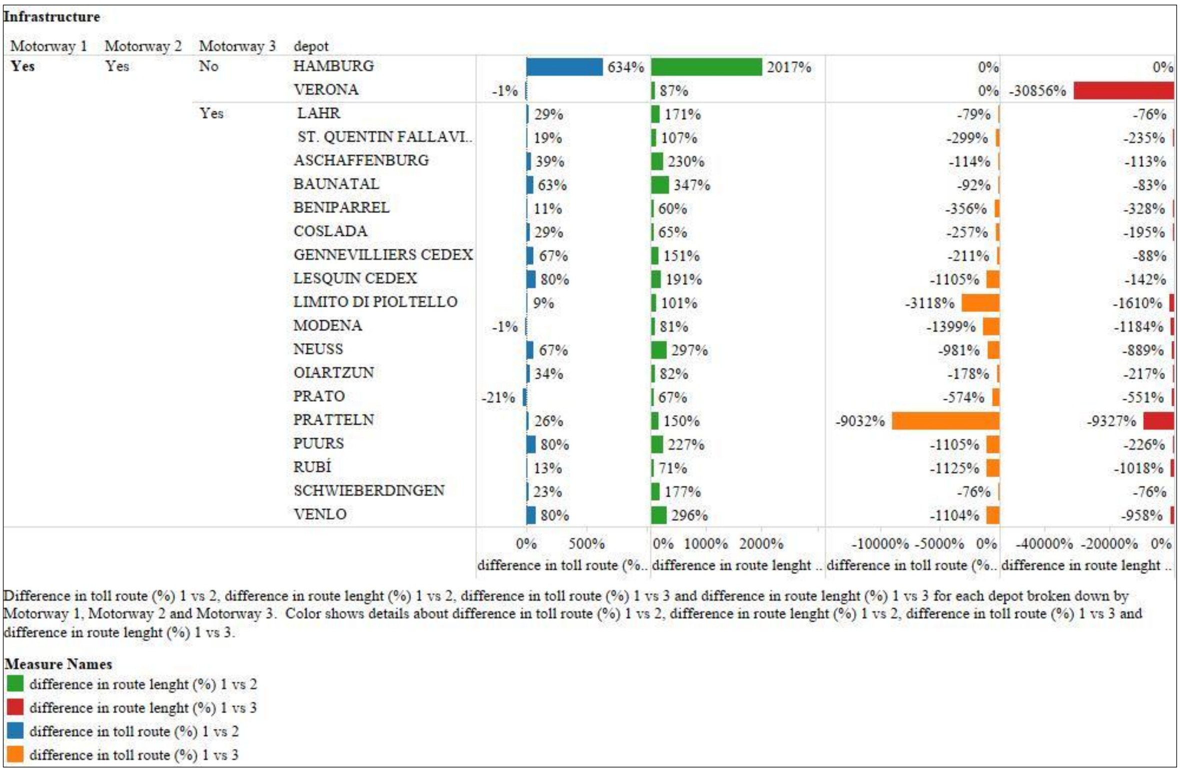
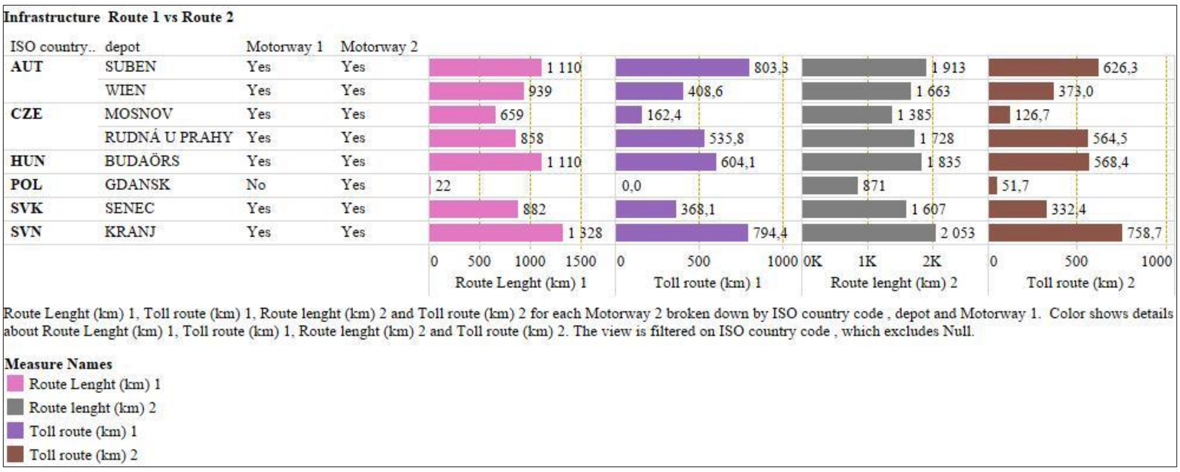


Figure 42. Change in ratio of route length and toll routes

Therefore it is fair to state that an infrastructure is in place to indicate a real world potential without making suggestions on its ability to cater for added volumes or on its condition in general. If the focus, however, is on the amount of toll routes, for the purpose of this study reflecting the maintenance level of the road infrastructure, it is argued that the rise in the number of driven kilometres is not supported by the same degree of maintenance. These ratios are also shown in figures 42 and 43. For instance the difference in route length for Lahr is 171% whilst the toll route merely increases by 29%.



Infrastructure Route 1 vs Route 2

ISO country..	depot	Motorway 1	Motorway 2	Route Lenght (km) 1	Toll route (km) 1	Route lenght (km) 2	Toll route (km) 2
AUT	SUBEN	Yes	Yes	1 110	803,3	1 913	626,3
	WIEN	Yes	Yes	939	408,6	1 663	373,0
CZE	MOSNOV	Yes	Yes	659	162,4	1 385	126,7
	RUDNÁ U PRAHY	Yes	Yes	858	535,8	1 728	564,5
HUN	BUDAÖRS	Yes	Yes	1 110	604,1	1 835	568,4
POL	GDANSK	No	Yes	22	0,0	871	51,7
SVK	SENEC	Yes	Yes	882	368,1	1 607	332,4
SVN	KRANJ	Yes	Yes	1 328	794,4	2 053	758,7

Route Lenght (km) 1, Toll route (km) 1, Route lenght (km) 2 and Toll route (km) 2 for each Motorway 2 broken down by ISO country code , depot and Motorway 1. Color shows details about Route Lenght (km) 1, Toll route (km) 1, Route lenght (km) 2 and Toll route (km) 2. The view is filtered on ISO country code , which excludes Null.

Measure Names

- ■ Route Lenght (km) 1
- ■ Route lenght (km) 2
- ■ Toll route (km) 1
- ■ Toll route (km) 2

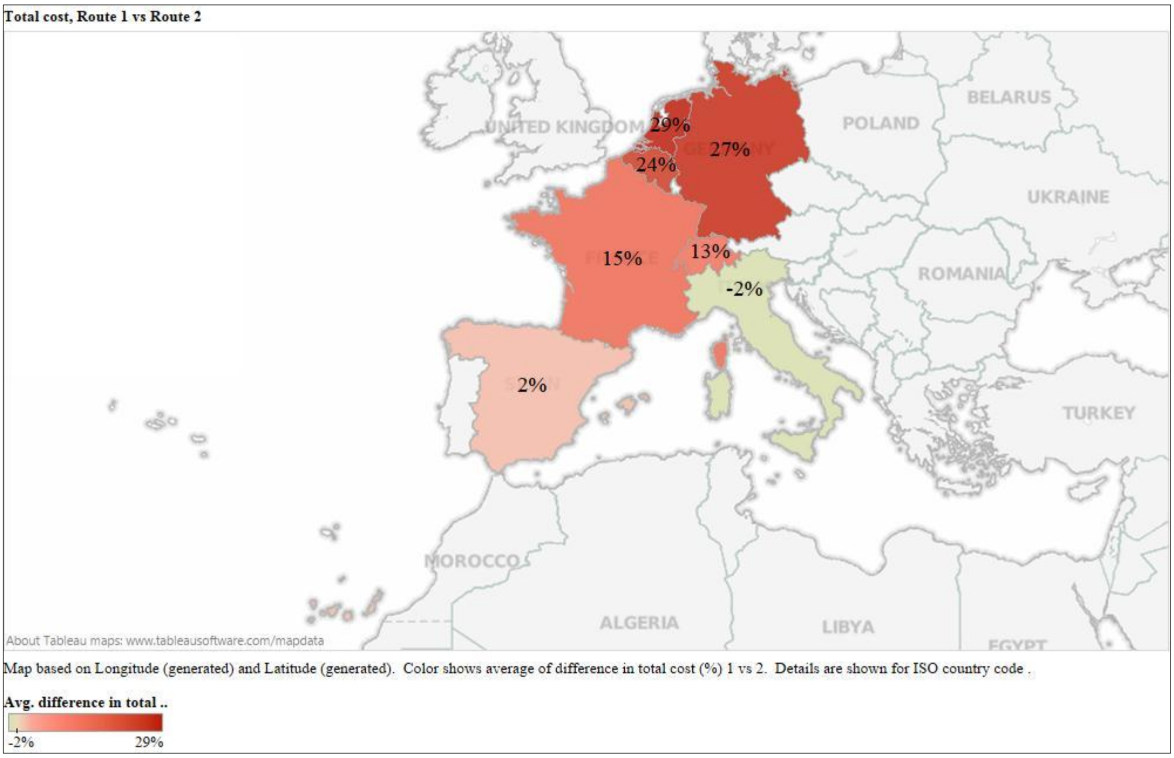
Figure 43. Change in route lenght and toll routes in km.

To conclude, it has been shown that a motorway infrastructure is in place for the alternative routings via Baltica. However, by making a quick assumption, an added wear and tear on the Baltic road network suggests an increased need for maintenance, not to speculate on capacity. Therefore by moving the pressure from the current roads onto new ones, at minimum it could reflect a similar ratio for future toll route lenghts and subsequently substantial increases in toll costs. It was also mentioned before that a modal backshift runs counter to EU policy, enhancing the likelyhood of increased tolls and under the circumstances grounds for assumptions on penalties is not viewed far fetched, bridging back to figure 20 on page 31.

4.1.3 Cost parametres

The selling price of a service is determined by the cost structure. It is safe to say that within standard service production, cost competitiveness is one of the most important carrier criteria. This places considerable emphases on minimizing production costs whilst searching for alternative routing solutions and production methods. A decision to change production method in itself does not give grounds for changes in service contracts and freight agreements.

An effort to move the via Travemünde flows to production via Tallinn at current cost levels would indicate an average cost increase of over 15% for the seven European traffics routed through Germany at present. Once again, it is vital to look at the matter on a more specific level in order to draw market specific conclusions. A closer look indicates that, on average, servicing the traffic flows between the Italian depots and Finland is already at present more cost efficient through the Baltic States. Like that too, Spain is near break-even point, at 2% more expensive via Baltica, as demonstrated in figure 44 below. Interesting enough, it was the same two countries that indicated likelihood for modal backshift whilst the focus was on the time parametres.


Total cost, Route 1 vs Route 2

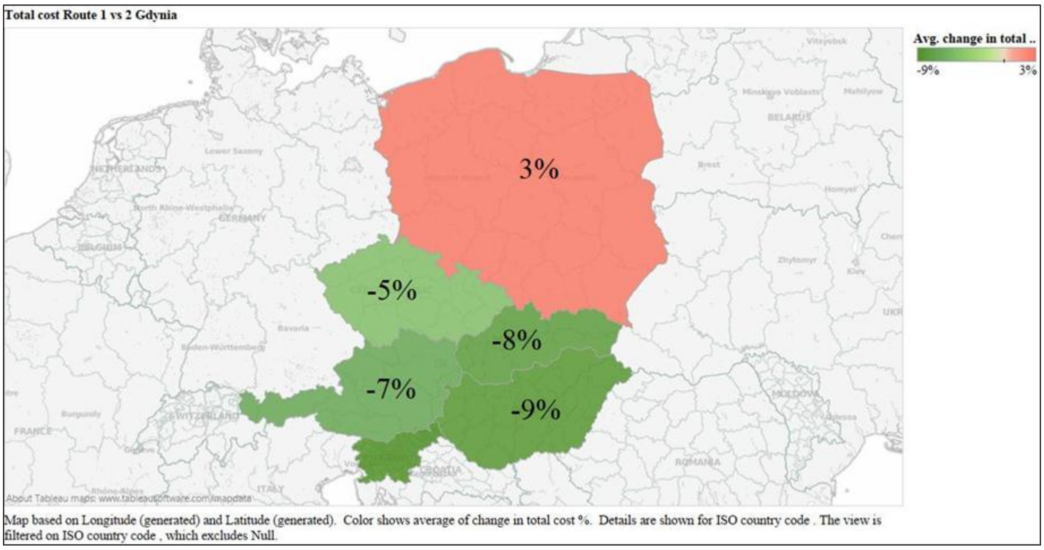
Map based on Longitude (generated) and Latitude (generated). Color shows average of difference in total cost (%) 1 vs 2. Details are shown for ISO country code .

About Tableau maps: www.tableausoftware.com/mapdata

Figure 44. Cost impact for shifting production from Travemünde to Tallinn

Countries closest to the port hubs, Germany and the Benelux, on the other hand show a lower likelihood for production shift, indicating an average cost increase of 27%. This is also the case for the Gdynian production and the Polish traffic flows, although the cost increase is near break-even point at 3%, as shown in figure 45, which is substantially lower than the Benelux and German equivalents.

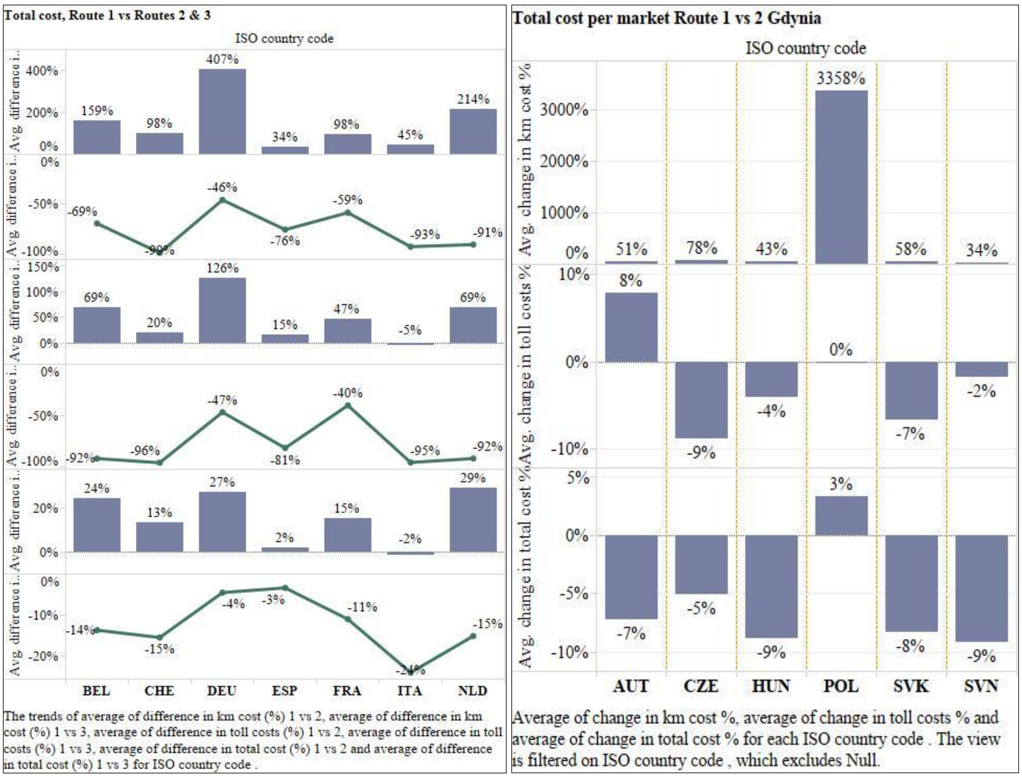
Apart from Poland however the Eastern European flows are roughly 5% cheaper when routed via Tallinn, see figure 45 on the following page. From a time and cost perspective therefore, the Eastern European market is most efficiently produced through the Baltic States rather than by using the direct sea crossing to and from Poland.



Map based on Longitude (generated) and Latitude (generated). Color shows average of change in total cost %. Details are shown for ISO country code . The view is filtered on ISO country code , which excludes Null.

Figure 45. Average cost impact for shifting production from Gdynia to Tallinn

Although the haulage costs increase substantially amongst the thirteen markets, the overall average cost increase is only around 6%. This does not only assist in highlighting the magnitude of the impact of the seafreight in the total production cost but also brings to light the excess capacity of drivers required to cater for the potential backshift. The line-graph on below left shows the cost parametres for the use of the train, the change in km, toll and total costs are shown at market level.



The trends of average of difference in km cost (%) 1 vs 2, average of difference in km cost (%) 1 vs 3, average of difference in toll costs (%) 1 vs 2, average of difference in toll costs (%) 1 vs 3, average of difference in total cost (%) 1 vs 2 and average of difference in total cost (%) 1 vs 3 for ISO country code .

Average of change in km cost %, average of change in toll costs % and average of change in total cost % for each ISO country code . The view is filtered on ISO country code , which excludes Null.

Figure 46. Change in km, toll and total costs

It has been established that cost efficiency for some of the European markets already exists to support modal backshift. From the perspective of green logistics, the environmental impact of increasing road transportation as opposed to sea and rail is a threatening one. The environmental aspect of the potential routing is analysed under the next sub-heading.

4.1.4 Environmental impact

An important aspect of the study is the environmental impact of the transport service production. The emissions restrictions on the sulphur levels of marine transportation were restricted due to air pollution and ultimately the human health. It is therefore important to study what happens to the emissions caused by the shifts in transportation by road.

It has been brought to light that the majority of the Eastern European production is routed via the Baltic States due to both time and cost parametres. The impacts on CO_2 emissions on the other hand are less attractive. In fact in the case of each depot, the emissions are more than doubled per trip made. The emissions by road are most increased in the case of the Gdansk depot with 2850% as it is located only just over twenty kilometres from the Gdynia port. Figure 47 visualizes the increased CO_2e per location.

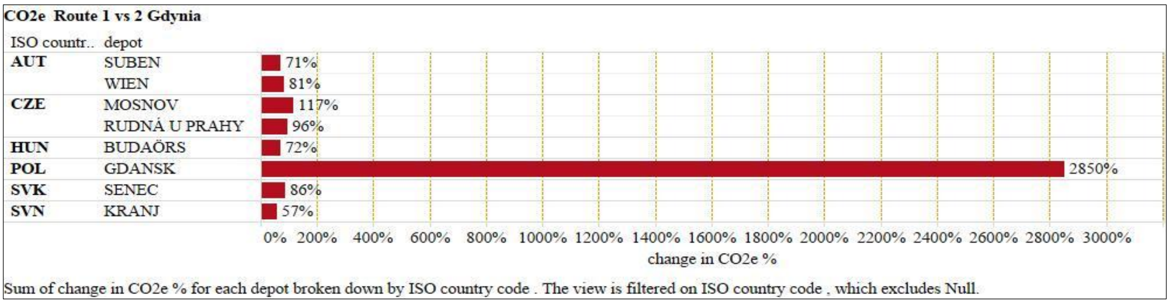


Figure 47. Increase in CO_2e by routing via Tallinn

The emissions figure for the potential volume shift is noneoftheless positive. For Southern European countries where the current distances travelled by road are already substantial, the changes in CO_2e levels are logically less extreme. For depots subject to most added kilometres driven, such as Germany and the Benelux countries, the emissions increases are at worrying levels. For instance, the current

CO_2e produced whilst making a trip to Hamburg increases over 20 times via Baltica. Figure 48 below indicates the CO_2 emissions increases at European depot level per trip made.

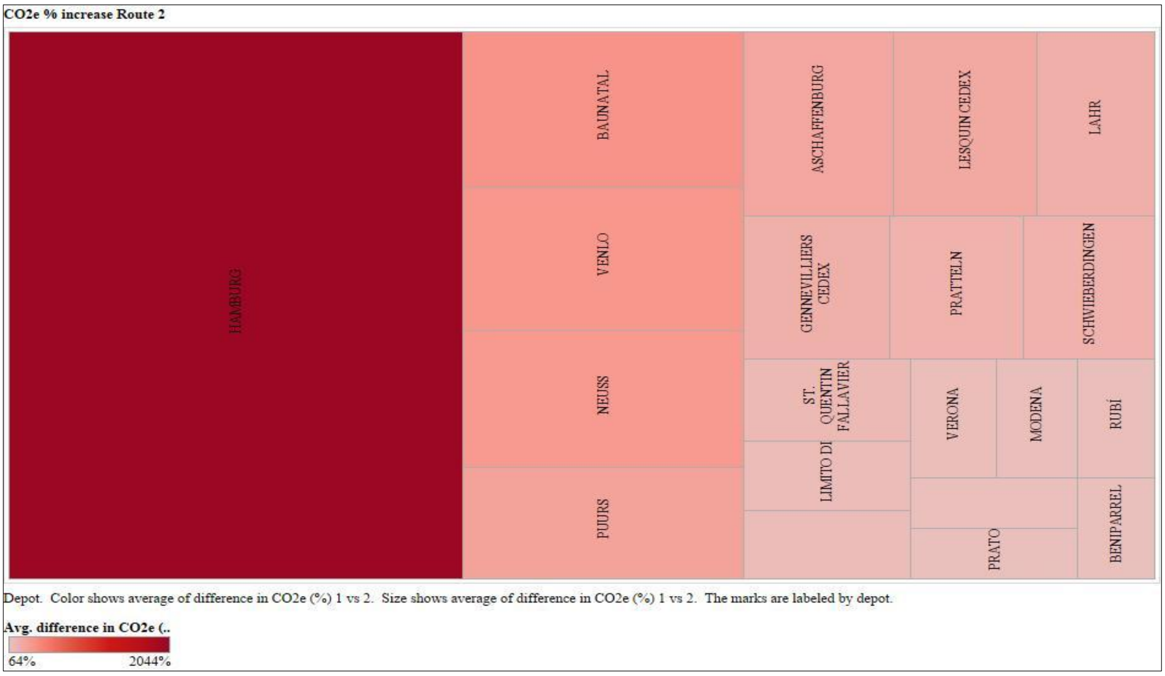


Figure 48. CO_2e increase at depot level per trip

It is important to look at what the use of rail can do to assist in emissions control, see figure 49 below for the comparison of emissions in current production road versus the use of rail on mainland Europe.

Figure 49. CO_2e decrease by use of rail at depot level per trip

Through the demonstrations in figures 48-49, it is possible to state that the CO_2e can be reduced by a considerable amount through lifting the units onto rail. If the impacts of the increased CO_2e could be minimised by the use of rail, going via Baltica would certainly become more attractive from an environmental aspect. Later on in the paper, the use of the Rail Baltica Corridors is looked at in more detail in an effort to realize the offerings better, in light of the potential modal backshift.

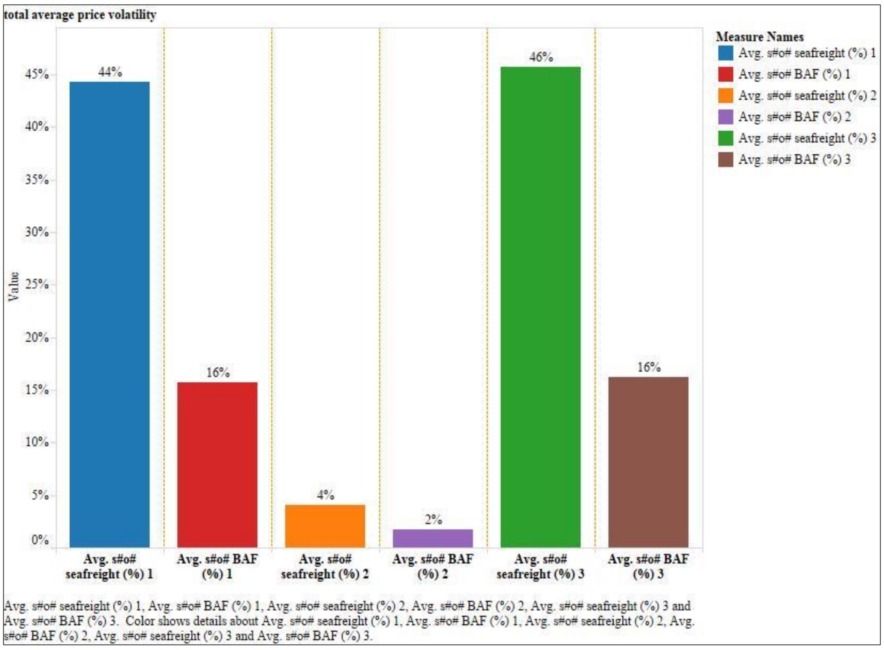
The cost of increased CO_2 emissions from road transportation has not outweighed the value of monetary and time implifications on service standards. It has been shown that routing via the Baltic States adds burden on the environment. The least added impact is from the Southern European production that is already at current the most environmentally burdening market area. In that light, the minimum emissions changes from both Italian and Spanish traffics indicate likelihood for modal backshift.

Overall from an environmental perspective, the role of policy making in emission control comes to light. On one hand, emissions restrictions pressure marine pollution control and on the other hand road pollution and increased emissions are caused. It leads to a ponder of which is the worst case scenario, from a human health aspect and what service criteria outweights the other, and whom is it to decide. There appears to be no easy answer.

4.1.5 Cost volatility to sulphur restrictions

It has been established in chapter two that the increased fuel prices are incorporated in full in the seafreight costs. The fluctuation in the price of seafreight therefore causes volatility and the uncertainty challenges forecasting. In tight economical situations, cost volatility can lead to excess pressure in an operational environment. With the geographical location of Finland, the share of the seafreight en route to European ports is high and the monetary value of the annual change in the bunker adjustement factor can be over 200 euros for a single journey. Therefore the cost volatility is a matter of substance when considering routing possibilities.

The analysis shows that the total price volatility or route subjectivity to the impact of the sulphur restriction is on a similar level for both routings via Travemünde, road (route 1), and the use of the train (route 3). This is due to a similar production cost structure regardless of whether the last leg of the journey is conducted by road or train. On the other hand, the Baltica routing (route 2) indicates a substantially lower subjectivity to the fluctuations of the bunker price, being a considerably shorter sea segment. With the short sea distance, the ratio between the various cost contributors changes dramatically. Meaning that, if the traffic is produced with a short sea leg, the price volatility is minimized, the share of the sea freight and the fluctuating bunker adjustement factor (BAF) is not great enough to make a considerable difference. This is illustrated in figure 50, showing that the total average share of the sea freight for production via the Baltic States for the seven European countries in question is 4%.



Avg. s#o# seafreight (%) 1, Avg. s#o# BAF (%) 1, Avg. s#o# seafreight (%) 2, Avg. s#o# BAF (%) 2, Avg. s#o# seafreight (%) 3 and Avg. s#o# BAF (%) 3. Color shows details about Avg. s#o# seafreight (%) 1, Avg. s#o# BAF (%) 1, Avg. s#o# seafreight (%) 2, Avg. s#o# BAF (%) 2, Avg. s#o# seafreight (%) 3 and Avg. s#o# BAF (%) 3.

Figure 50. Total average share of sea freight & BAF per routing

When this figure is broken down at market level, it is possible to establish that some of the countries are more volatile than others to changes in the bunker fuel price. For instance, if the focus is on the Benelux market and Germany, sea freight on average accounts for 56% of the total production cost, indicating that over half of the costs are cumulated through the sea segment. This percentage is even higher at 60% if the train is used due to the slightly lowered cost on mainland

Europe. These markets are affected most by the increases in bunker fuel price, more than the other European destinations. At the same time, routing via Baltica means that the share of sea freight from the total costs is minimized the most. Although at minimal margins, routing the Southern European destinations; France, Italy, Spain and Switzerland via the Baltic States, minimizes the impact of the sea freight the most. For example, in the case of Spain, the impact of the sea freight is on average 3% of the total production costs as shown in figure 51 below.

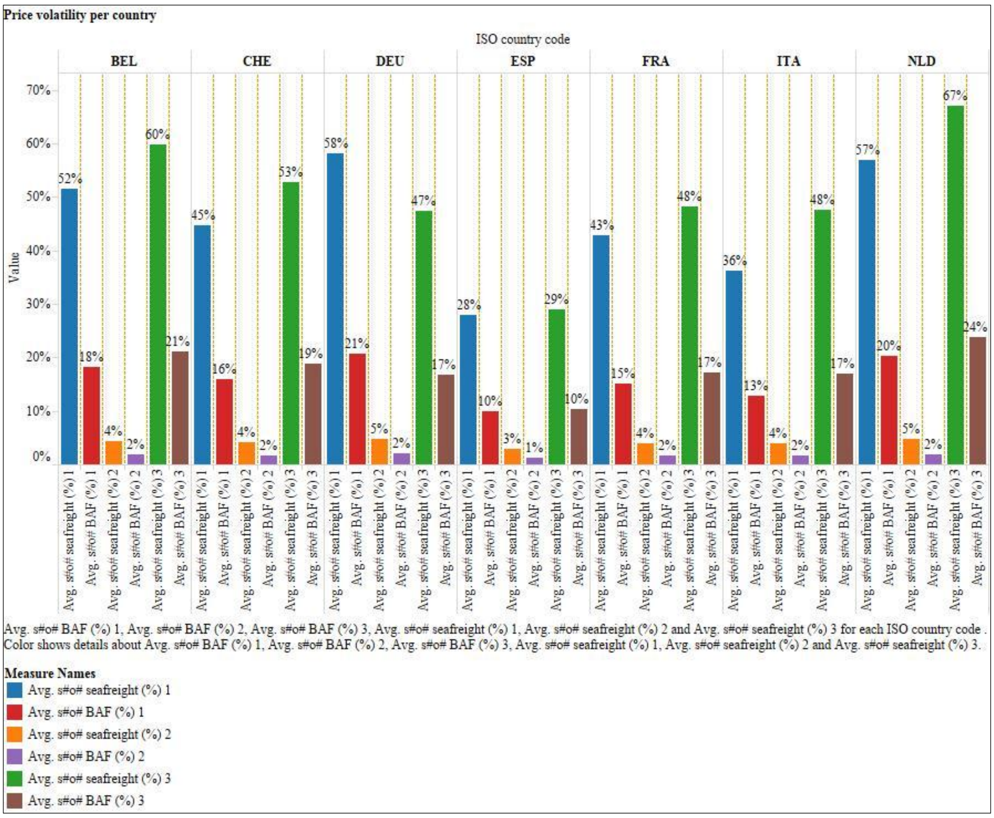


Figure 51. Total average share of sea freight & BAF per routing per market

If the same is done for the production via Gdynia, it is seen that the total average share of sea freight is higher, at 52%, than for the production via Travemünde, at 44%, as shown in figures 50 and 52. This is due to both the shorter distance on road to the Eastern European markets as well as Poland's impact on the average of the markets. The Polish depot is located 20 kilometres from the port, making the seafreights share for depot to depot linehaul a substantial 82% as shown in figure 53 on page 68. The following figure however shows the market average for the seafreight, 52% for the direct sea lane (Gdynia route 1) and 10% for routing via Baltica (route 2).

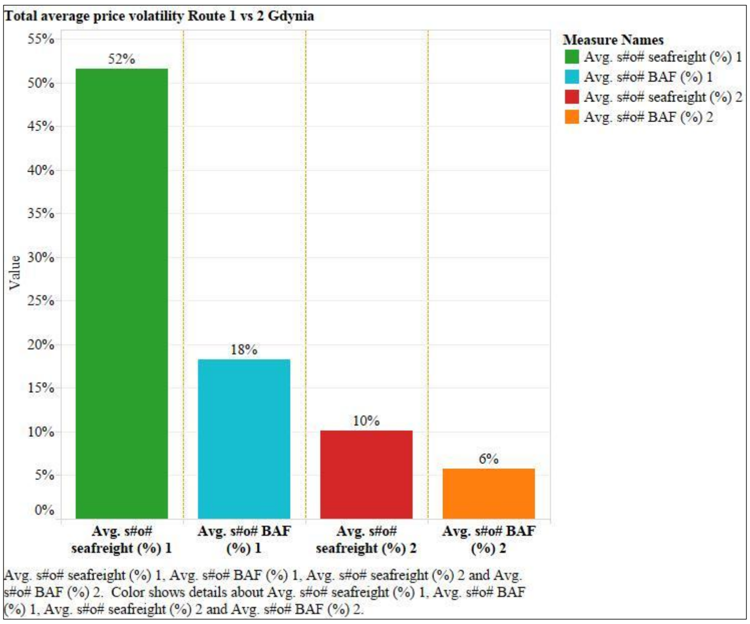


Figure 52. Total average share of sea freight & BAF per routing

It is important to appreciate that without Poland, the average share of the sea freight drops to 46% which is the same as for the traffic routed via the Travemünde port. The Eastern European market specific seafreight indicators are shown in figure 53 below.

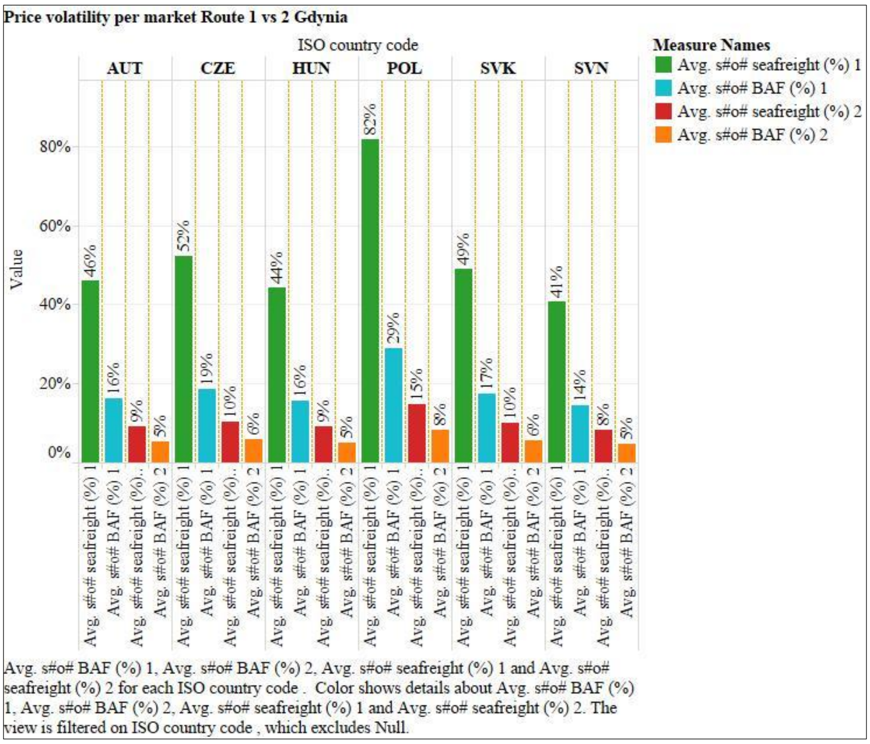


Figure 53. Total average share of sea freight & BAF per routing per market

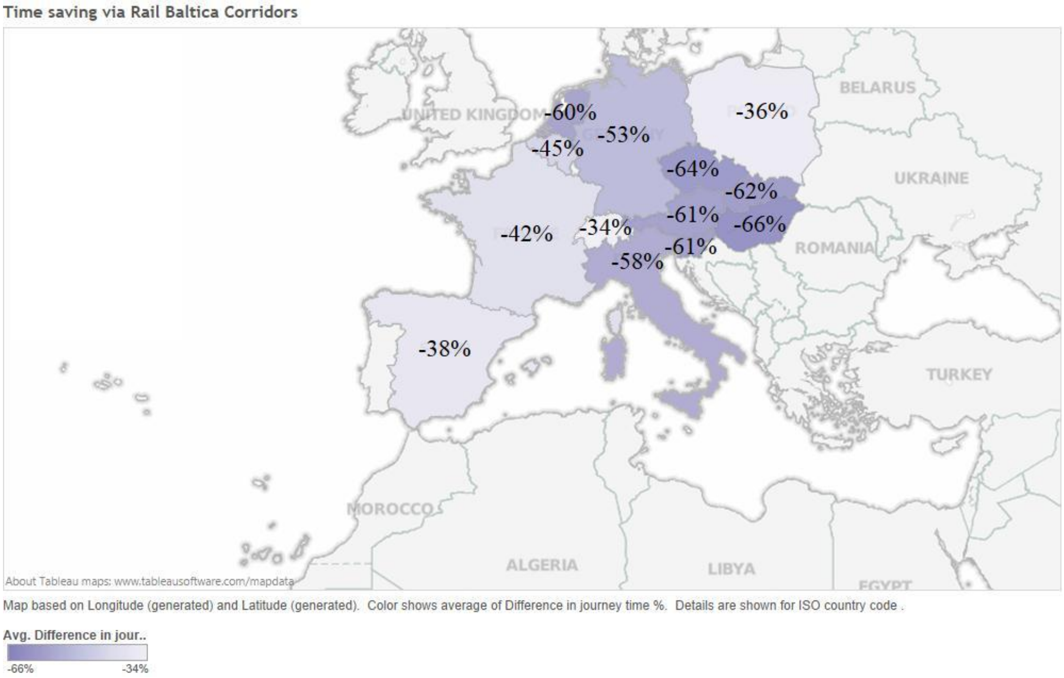
To conclude the analysis on the subjectivity to the fluctuations of bunker fuel price, it is shown to decrease considerably by using the short sea segment. In other words, the routing via Baltica decreases the cost volatility substantially, indicating a more stable environment for long-term monetary planning.

4.2 Rail Baltica Corridors

This part of the analysis focuses on the impact of the presence of the Rail Baltica Corridors, Rail Baltic Gateway Corridor (RBGC) and the Baltic Adrianic Corridor (B-AC), on the routing via the Baltic States. By making comparison to travelling by road via Baltica it is possible to establish the impact of the rail corridors on the performance measurement criteria.

4.2.1 Time impact

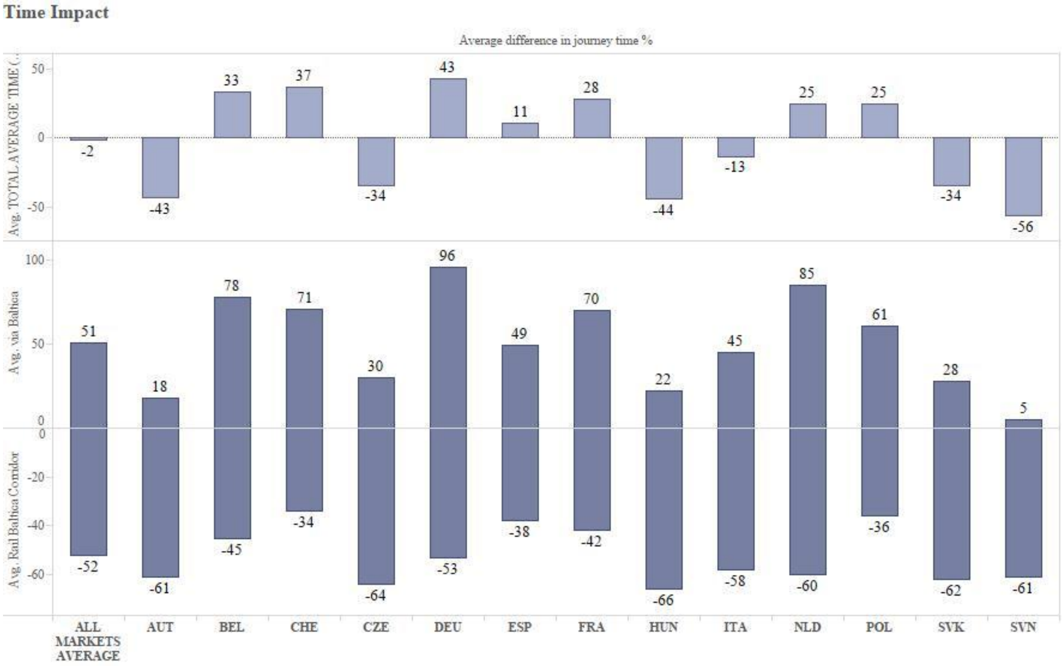
Whilst looking at routing via road, it was concluded that one of the biggest challenges for exploiting Baltica at present is the increased driving time and subsequently the necessary break times, increasing the total journey time considerably. By lifting a unit onto a rail carriage, the break times are eliminated from the production and subsequently the time burden reduced by 34-66% as shown below in figure 54.


Time saving via Rail Baltica Corridors

Map based on Longitude (generated) and Latitude (generated). Color shows average of Difference in journey time %. Details are shown for ISO country code .

Figure 54. Time impact via rail

Once the deduction in the total average journey time is considered, it is possible to establish that all markets benefit from the Rail Baltica network enough to cater for the current schedule requirements, with the exeption of some German depots. It is important to be reminded that the waiting time is not considered in the calculations and that, as explained earlier, the frequency of the short sea crossing eliminates standing time at the port area. On a practical level however the results shown require for an optimal train schedule. Nevertheless, if the journey time is increased by a quarter or a third, it is reasonable to assume that with one driver capacity it is possible to reach the particular day required. The total average time reduced by the use of rail for all of the 13 markets analysed is 2% as shown below in figure 55.



Average of TOTAL AVERAGE TIME (h) %, average of via Baltica and average of Rail Baltica Corridor for each Average difference in journey time %.

Figure 55. Total average time impact Rail Baltica

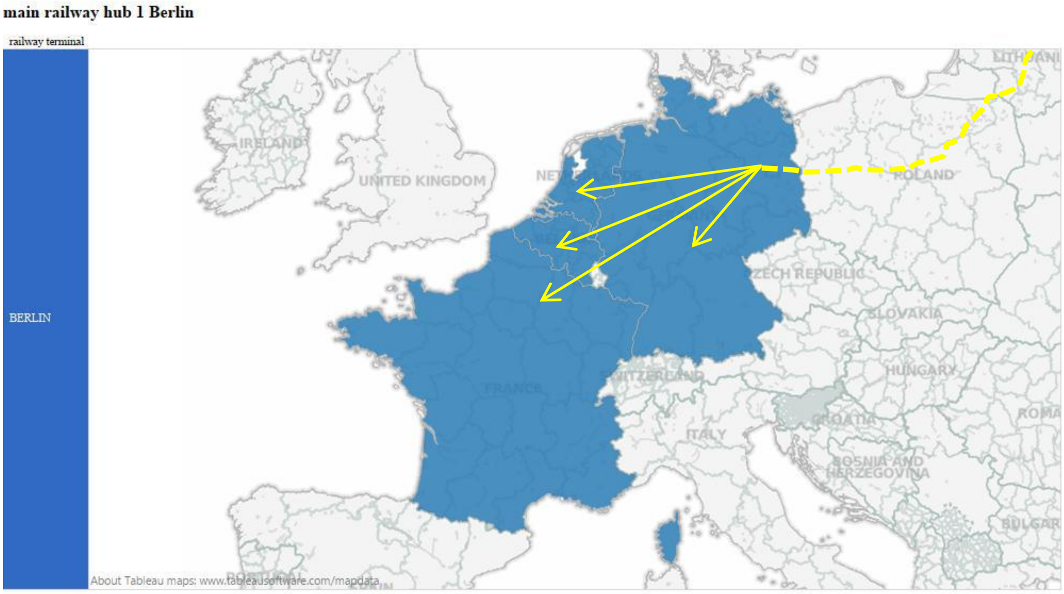
The top bars indicate the total average change in time per market and the bottom pillars indicate the increased time of travelling by road (middle) with the time reduction of rail (bottom).

The study therefore concludes to suggest that production via Baltica for the current scheduled services and with the one driver capacity is accommodable with the presence of the Rail Baltica infrastructures.

4.2.2 Infrastructure impact on haulage centres

Infrastructure is not studied in an indepth manner as the presence of a motorway network is assumed as adequate infrastructure for the purpose of the research. Rather than focusing on the physical infrastructure itself, the focus is on how the usage of the railway corridors reflects on the demand of haulage capacity, referred to as centres. By haulage centres, the reference is on geographical locations where from and to drivers begin and end their roundtrip journeys, meaning the first pick-up point of a unit on mainland Europe or in reverse-flows the last drop-off point.

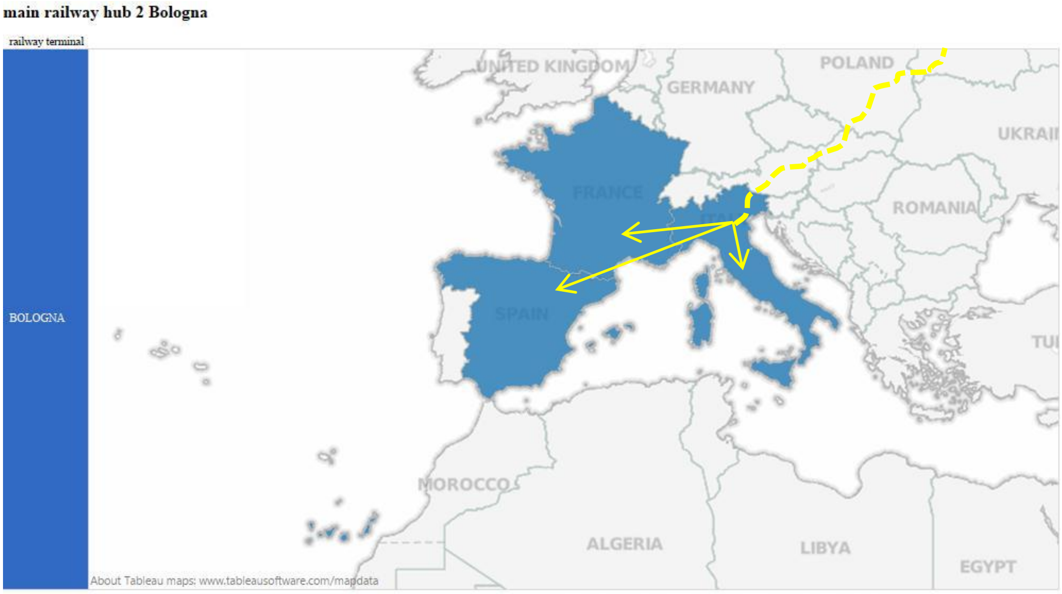
The study of the Trans-European Transport Networks (TEN-T) suggests that the main railway hubs for the depot to depot linehaul production lie in Germany and Italy, bridging back to figure 31 under section 3.1.1 on the Rail Baltica research methods and context. These hubs, Berlin and Bologna, are better visualized in figures 56 and 57.



Map based on Longitude (generated) and Latitude (generated) broken down by railway terminal. Details are shown for ISO country code . The view is filtered on railway terminal, which keeps BERLIN.

Figure 56. Main railway hub 1 Berlin, Germany

In the depot to depot linehaul production, the Berlin railway hub accommodates the Benelux, German and the majority of the French locations. This is because it is the closest railway hub along the Rail Baltica Corridors to the depots, connecting Tallinn to the mentioned markets. Bologna on the other hand provides a centre for the Italian, Spanish and some of the French locations due to the same reasons mentioned above. This indicates a need for haulage capacity, haulage centres in both Berlin and Bologna for the in- and out-going volumes.



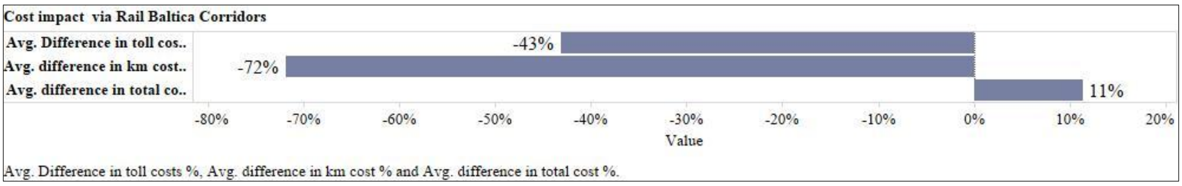
Map based on Longitude (generated) and Latitude (generated) broken down by railway terminal. Details are shown for ISO country code . The view is filtered on railway terminal, which keeps BOLOGNA.

Figure 57. Main railway hub 2 Bologna, Italy

These shifts in haulage centres suggest that some of the current capacity needs to move from the port gateways to more Southern European locations.

4.2.3 Cost impact

The cost impact of Rail Baltica is purely theoretical, as explained in chapter 3. Through reflecting the average rate of 0,75€/rail kilometre (appendix 20) it is possible to determine that the average total cost increases by 11%, as shown in figure 58. What is of more interest, through the benchmarking, is that it is established that in order for the railway network to be cost competitive, the rail service is required at an maximum all-in service rate of 0,65€/rail km.



Avg. Difference in toll costs %, Avg. difference in km cost % and Avg. difference in total cost %.

Figure 58. Cost parametres Rail Baltica Corridors

On the other hand, if the cost comparison is distributed at a more specific level, it is possible to determine that the cost competitiveness of the rail services at the calculated average (0,75€/rail km) materializes, for instance in the case of Italy, reducing the total average cost by 8-19% as shown below.

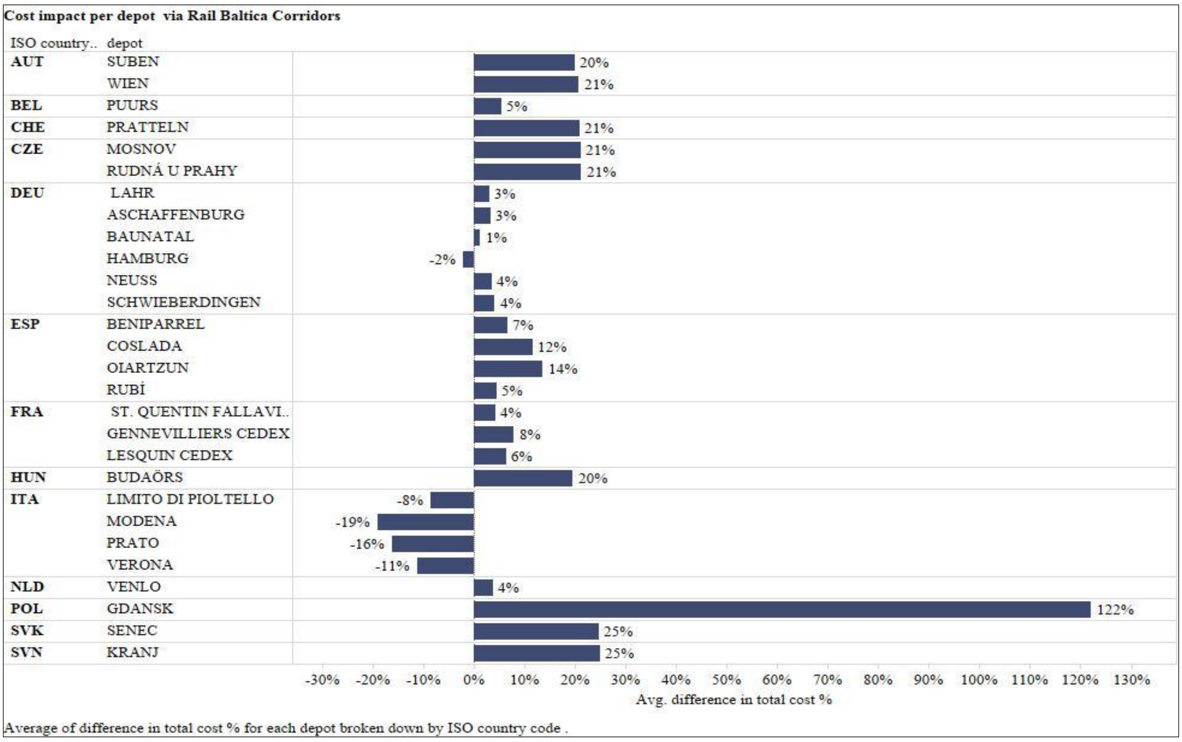
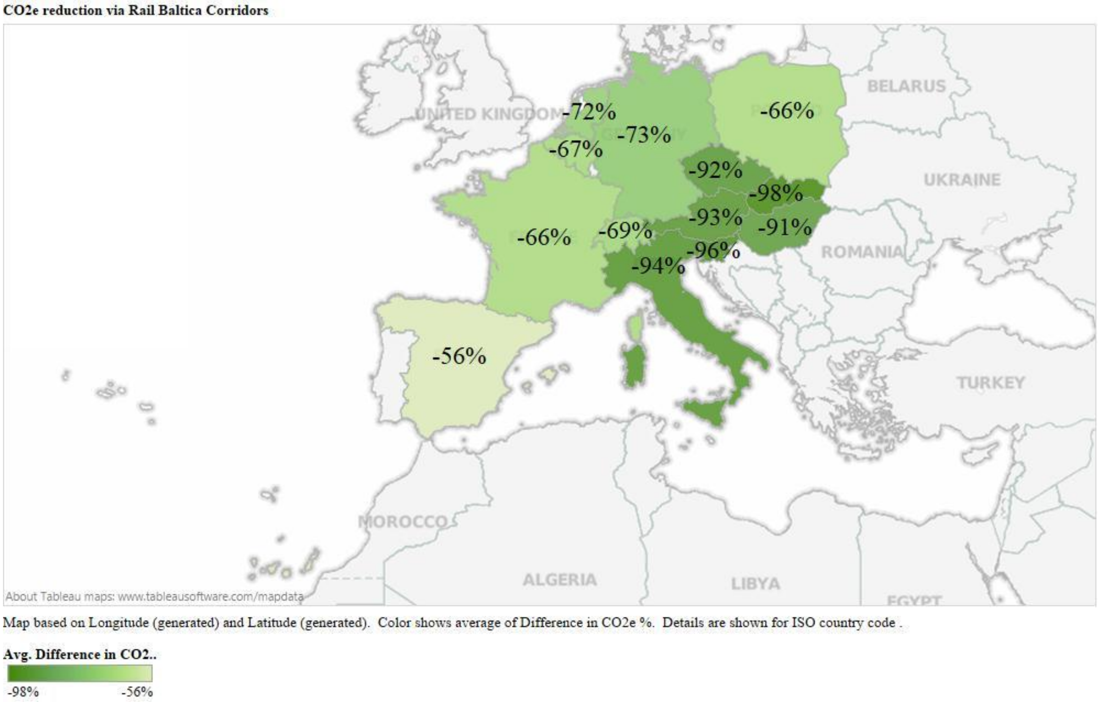


Figure 59. Cost impact per depot via Rail Baltica Corridors

Likewise, markets that are least attractive via Baltica by road, such as the Benelux markets (cost increase of 24-29%, see figure 44), become more attractive with the use of rail, indicating a 4-5% cost variance from the use of direct sea lanes as shown in figure 59. However, the cost volatility or the subjectivity to the bunker price for the routing via the Baltic States, whether it is by road or rail, remains at a similar level. This is due to the same, short, sea segment used in both cases.

4.2.4 Environmental impact

The environmental impacts together with the time parametres are what make the use of rail stand out. Rail is the answer to the detrimental environmental burden posed by the modal backshift via the Baltic States. As shown in figure 54 the time reduction accommodated by lifting the unit from road to rail via the Baltic States is between 34-66%. Figure 60 on the other hand shows the 56-98% potential reduction of CO_2e through the use of the Rail Baltica Corridors.



Map based on Longitude (generated) and Latitude (generated). Color shows average of Difference in CO2e %. Details are shown for ISO country code .

Figure 60. CO_2e reduction by lifting production to rail via Baltica

By reducing the number of driven kilometres, the CO_2e caused by road transportation are reduced by a total average of 77%. By comparing the reduction in CO_2e kg for the current routings versus routing via Baltica by rail, on an annual level, based on 2012 volumes in DSV's own production, the emissions reductions reflect healthy indicators as shown in figure 61 on the following page. For instance, in the case of Italy the reduceable CO_2e kg potential is over 2 million.

On some markets, however, the use of Rail Baltica does not reduce emissions as the nearest railway hubs are further than the currently used port hubs. This is particularly evident for the Benelux and German markets whereby Travemünde (port hub) is closer than Berlin (railway hub) indicating an overall increase of CO_2 emissions, as shown in figure 61. Nevertheless, the overall reduction potential outweights the potential market specific increase of emissions by road.

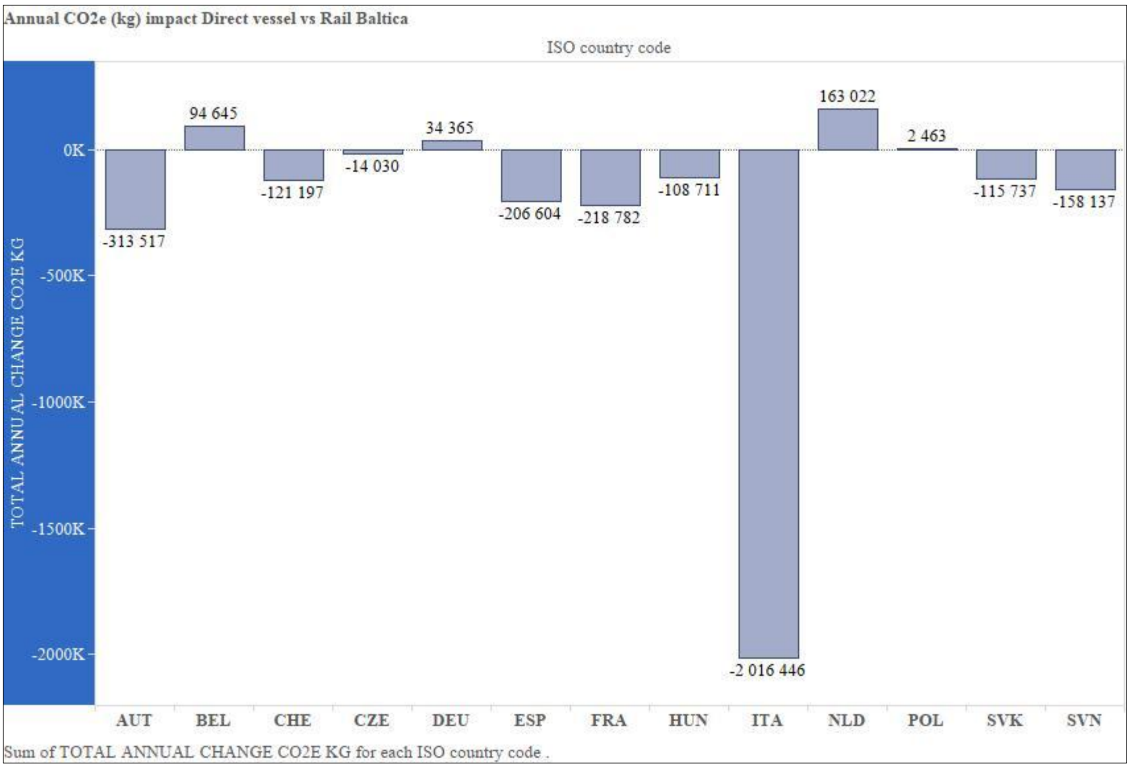


Figure 61. Direct vessel vs Rail baltica, CO_2e kg change based on 2012 volumes

The study on the impact of the Rail Baltica corridors on the CO_2 emissions shows that an overall emissions reduction is possible via Baltica, with the exception of the Benelux market and parts of Germany. Once again, the Southern European locations most benefit from the potential reduction of CO2e through the use of rail.

To recap on the findings of the impact of the assumed infrastructure of the Rail Baltica Corridors whilst routing via Tallinn;

- ✓ Time burden is reduced substantially
- ✓ Haulage centres distribute between the port areas and the two main railway hubs; Berlin and Bologna
- ✓ Cost is required to come in at a maximum all-in level of 0,65€/rail-km
- ✓ Environmental burden is reduced substantially

The main objective in this part of the Master's Thesis is to point out that routing via the Baltica does not have to indicate an increased emissions hazard or a modal backshift once the correct infrastructure is in place, thus reflecting the importance of developing cross-border infrastructure.

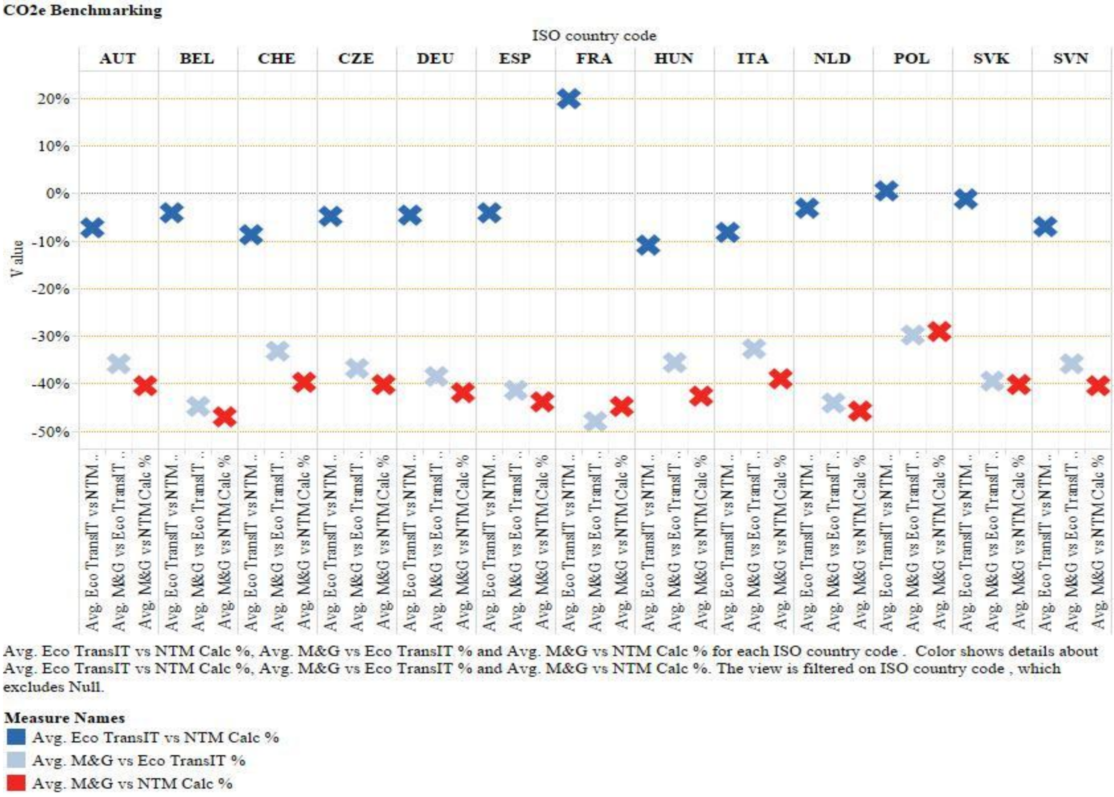
4.3 CO$_2$ emissions benchmarking

The results show, for the benchmarking as explained in section 3.1.2, the average variation for the total data gathered creates some cause for concern. The Eco TransIT and the NTM Calc tools indicated an acceptable tolerance of 4%. The M&G levels, however, were clearly not comparable with an average difference of over 40% in relation to the other tools as shown below.

Table 13. Variation between emissions calculation tools

M&G vs Eco TransIT %	M&G vs NTM Calc %	Eco TransIT vs NTM Calc %
-40 %	-42 %	-4 %

A more detailed market specific analysis of the CO$_2$ emissions tools comparisons is demonstrated in figure 62 below.



Avg. Eco TransIT vs NTM Calc %, Avg. M&G vs Eco TransIT % and Avg. M&G vs NTM Calc % for each ISO country code . Color shows details about Avg. Eco TransIT vs NTM Calc %, Avg. M&G vs Eco TransIT % and Avg. M&G vs NTM Calc %. The view is filtered on ISO country code , which excludes Null.

Figure 62. Market specific comparison of CO2 emissions calculation tools

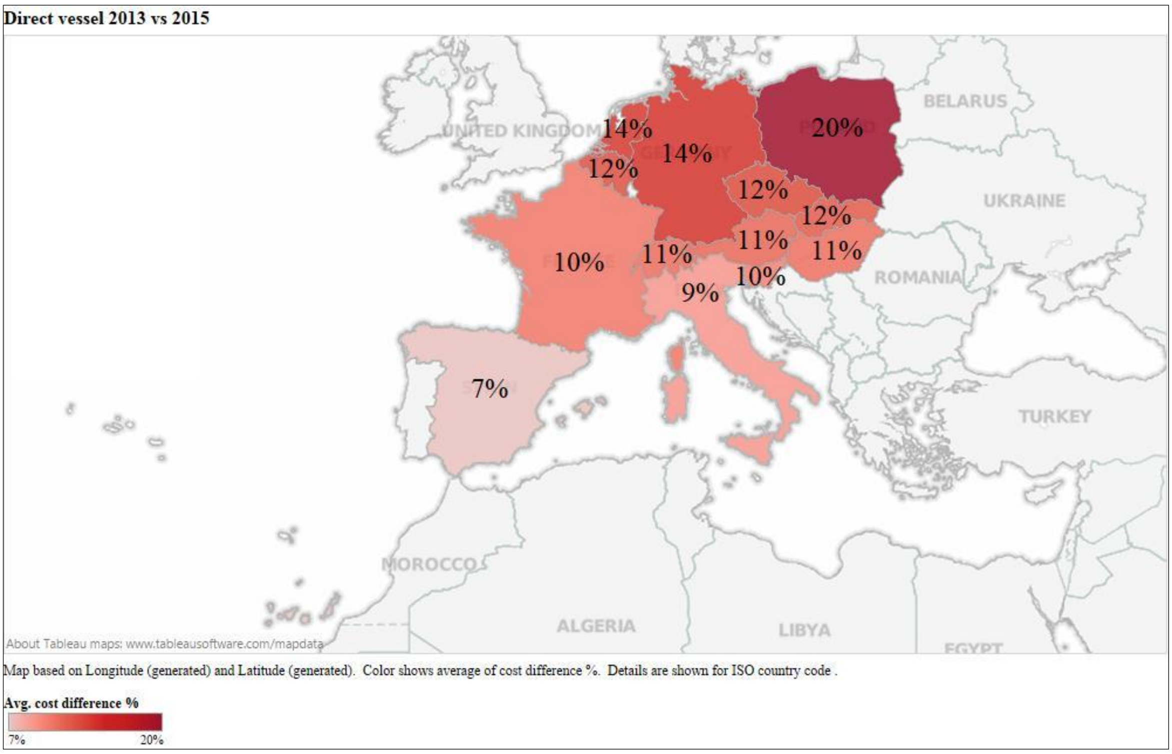
With a growing emphasis on environmental responsibility the comparability of emissions calculation tools and methodologies becomes an increasingly valuable issue.

4.4 Direct vessel vs via Baltica 2015

Whilst focusing on the impact of the sulphur emissions restrictions in the Sulphur Emissions Control Area (SECA), it is important to realize that it is only the cost factors that are influenced, unlike any other performance measurement criteria analysed. The time, infrastructural and environmental contributors remain on the same level as at present, therefore, this section of the paper compares only the cost parametres and the impacts on the cost volatility due to the changes in the fuel grades and prices required to comply with the 0,1% sulphur allowance in 2015.

4.4.1 Cost parametres

As explained in chapter 3, a simple method was used to calculate the rise in price for the finer fuel grade, reflecting an increase of 37% in the bunker adjustement factor (BAF). That increased cost contributor consequates an average total production cost increase of 11% accross the European market. As shown previously (figures 50-53), countries with a higher cost volatility experience a higher than average production cost increase, as shown in figure 63.



Map based on Longitude (generated) and Latitude (generated). Color shows average of cost difference %. Details are shown for ISO country code .

Figure 63. Direct sailing, average cost increase per market from 37% raise in BAF

Poland has the biggest impact from the sulphur restrictions, a 20% total production cost increase, due to the geographical location of the depot, 20 kms from the port. The German average is greatly influenced by the Hamburg and partly the Baunatal and Neuss locations, with the BAF accounting for 30-40% of the production cost, shown in figure 64. Benelux is also in the most hit areas. A direct correlation to the rate of increase is visible through looking at the share of seafreight in the production cost, the bigger the share, the greater the impact. Figure 64 indicates the share of sea freight at a depot specific level, on the right hand side is indicated the equivalent shares for routing via Baltica (route 2).

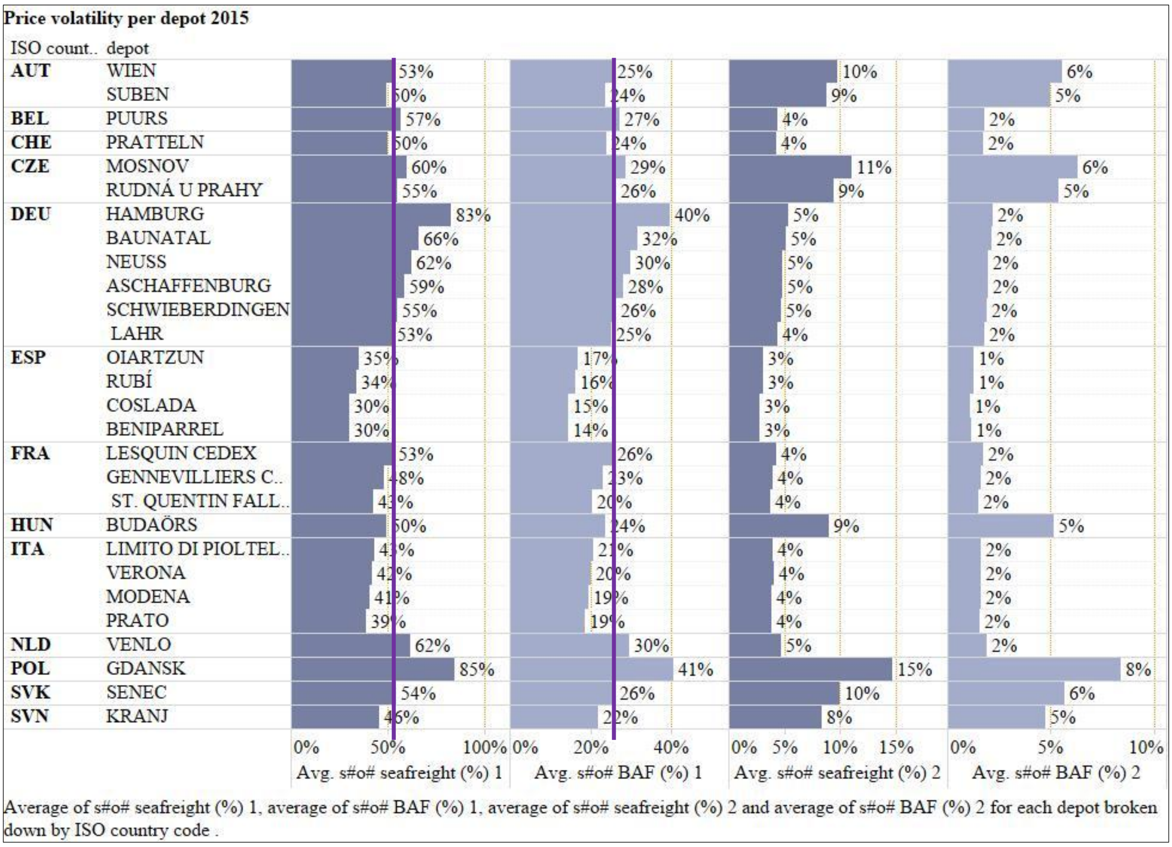


Figure 64. share of sea freight and BAF per location in 2015

For the production via the direct sea lanes (route 1), it is possible to state that a likely modal backshift, as will be show in more detail later, will take place for all of the locations with a total sea freight share of less than 53% of the production costs, concisting of less than 25% BAF. The total averages give a realistic indication that more depots steer towards production via Baltica than not. It is the case that if the share of the sea freight is over more than half of the total production costs, its share should increase substantially; near enough double before the modal backshift becomes an attractive alternative. This will be looked at in more detail under the next heading.

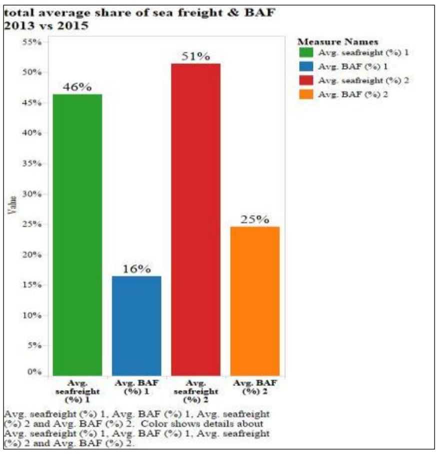


Figure 65. Share of sea freight and BAF from total cost 2013 vs 2015

4.4.2 Modal backshift

Once the increased sea freight is considered (figure 65) and compared against the routing via Baltica, it becomes evident that parts of Germany, the Benelux and Northern France remain cost competitive with the use of the direct vessel services. Eastern Europe becomes increasinly efficient via Baltica and Southern Europe a likely candidate for continuos steering from Baltica, as shown in figure 66 below.

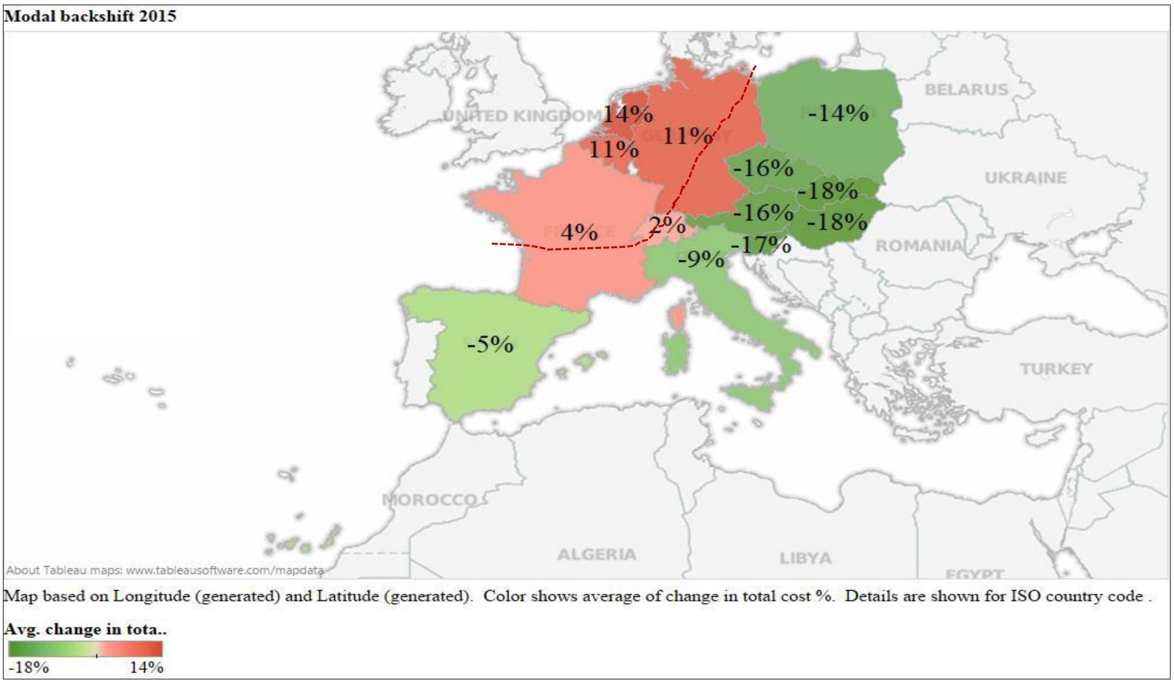


Figure 66. Modal backshift 2015

In order to get a clearer vision of the potential shift to production via Tallinn through exploitation of the short sea segment it is in order to take a closer look at the depot specific production cost change. As mentioned earlier in the thesis, the geographical location is one of the key criteria for the potential shift. Figure 67 indicates the depots that are cheaper to produce via the Baltic States in 2015 after an increase of 37% in the BAF.

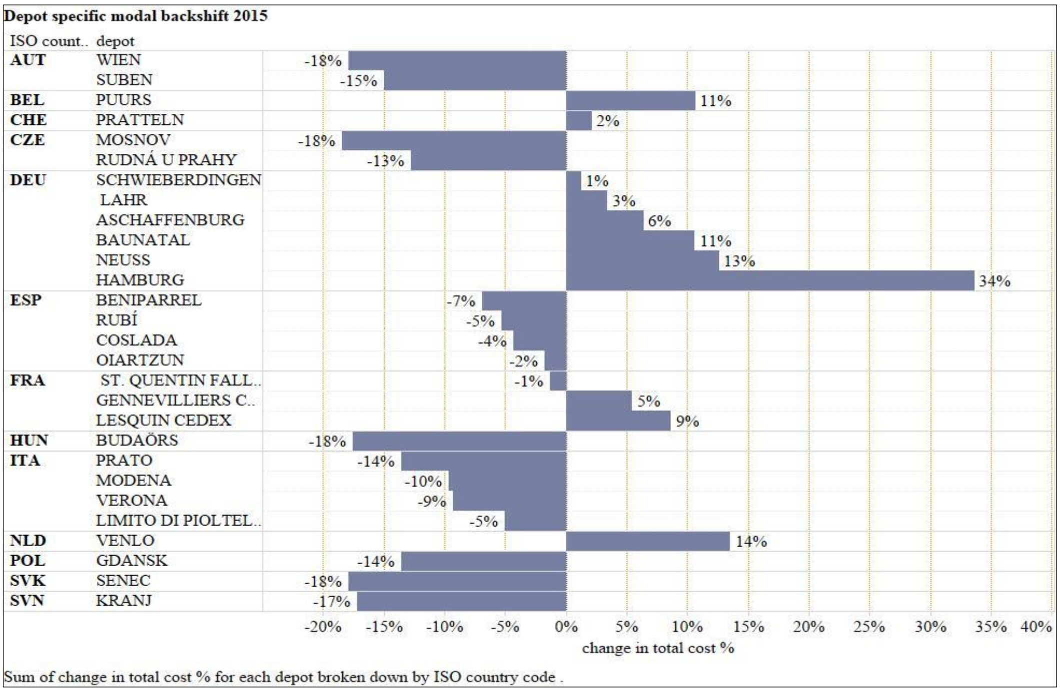


Figure 67. Depot specific modal backshift 2015

As expressed earlier, mainly the Benelux, German and Northern France markets have the tendency to gear towards the cost competitiveness whilst using the direct sea services. The depots that are not competitive via Baltica are nevertheless within a 15% range of reaching the potential shift as shown below.

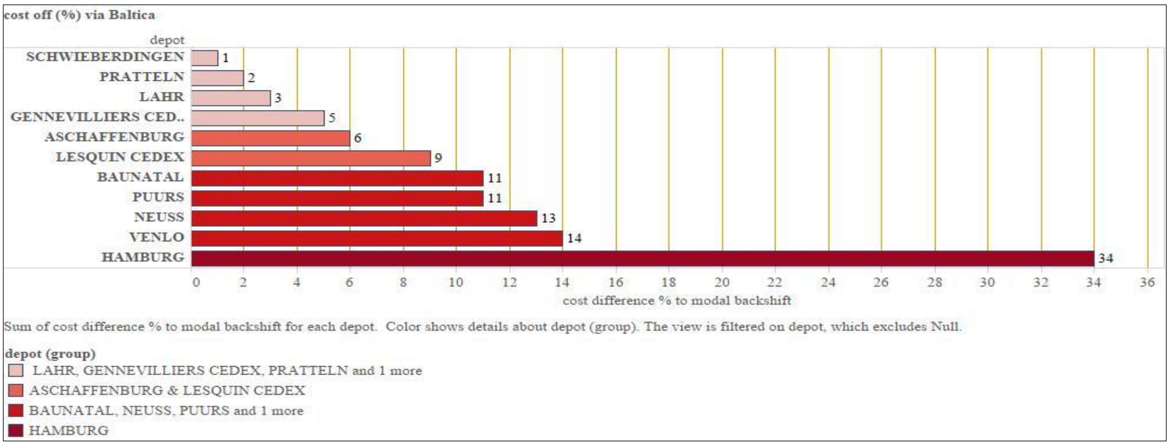
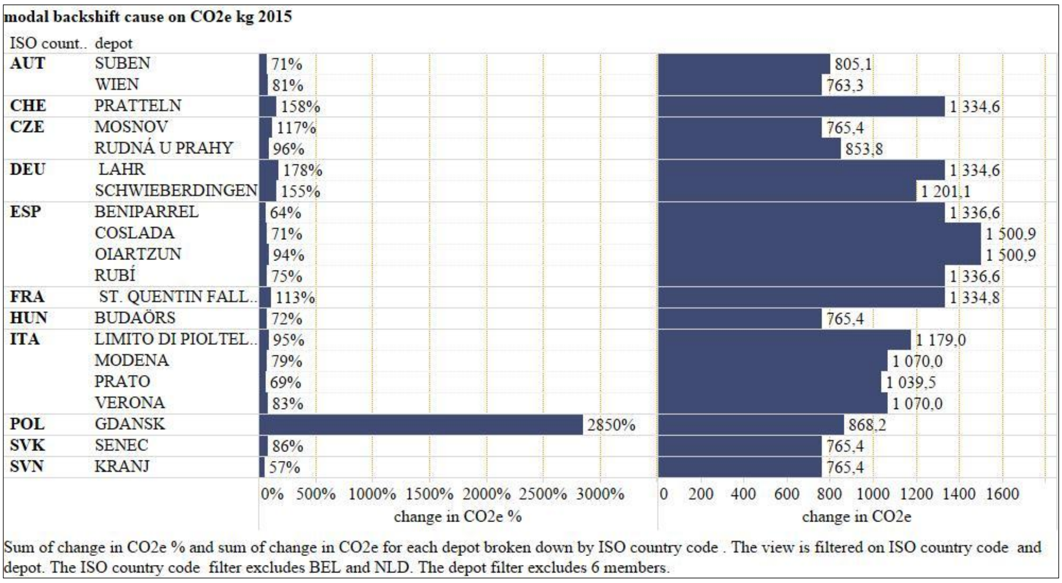


Figure 68. Range of reaching the potential shift

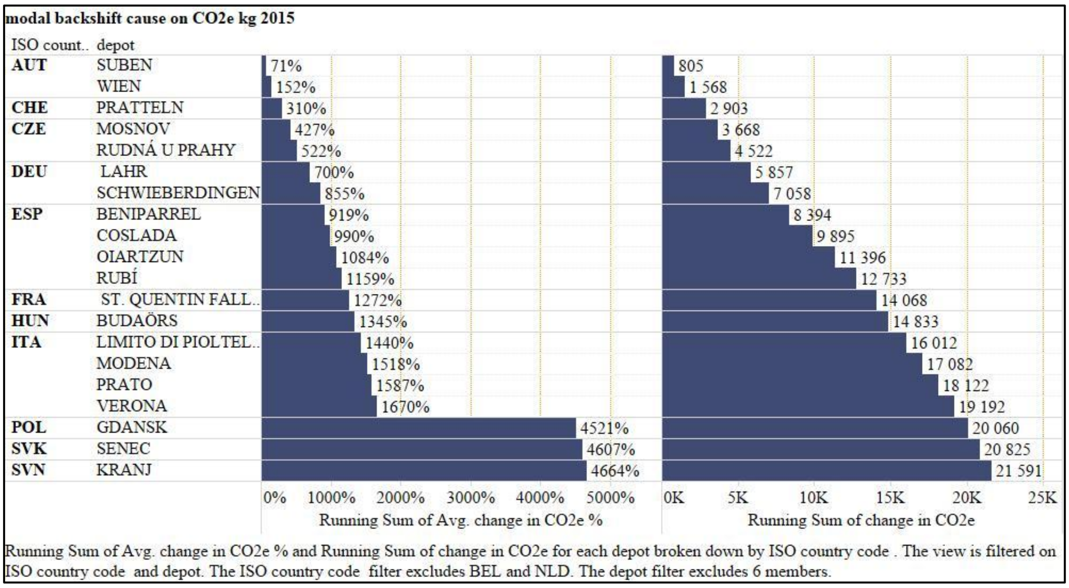
The likelihood of further production shift is high for parts of Germany and France as well as Switzerland, near break-even point, as shown in figure 68. With the likelihood of the modal backshift in 2015 for more locations than not, it is important to make conclusions on its implications on the environment.

4.4.3 Modal Backshift and the environment

After determining the likely cases for production change, it is possible to calculate the changes in CO_2e for those locations. The below figures show the increase in emissions caused for each European location likely to route via Tallinn.



Sum of change in CO2e % and sum of change in CO2e for each depot broken down by ISO country code . The view is filtered on ISO country code and depot. The ISO country code filter excludes BEL and NLD. The depot filter excludes 6 members.



Running Sum of Avg. change in CO2e % and Running Sum of change in CO2e for each depot broken down by ISO country code . The view is filtered on ISO country code and depot. The ISO country code filter excludes BEL and NLD. The depot filter excludes 6 members.

Figures 69-70. Change and running sum of increased CO_2e

As indicated in the figures it is established that considerable increases in the CO_2 emission levels for each European location is inevitable whilst routing the traffics via Tallinn. This impact as explained earlier can be minimized with the presence of the Rail Baltica Corridors; nevertheless, until the networks are exploitable the added environmental burden is caused.

4.5 Recommendations

This section of the thesis outlines the recommendations to the case company DSV Road Oy. The findings are categorized in accordance with the performance measurement criteria analysed and reflected on a route specific basis. Table 14 draws together the recommendations as shown below.

Table 14. Recommendations outlined

Recommendation	Via Baltica	Rail Baltica Corridors	Via Baltica 2015
Schedule **- Eastern Europe** **- Southern Europe: Planning ahead to increase driver capacity per vehicle** **- Stressed importance of railway corridors in Baltica**	Suitable markets: - Eastern Europe - Italy - Spain } 2 driver	Accommodates schedule in all European markets (exception; some German locations)	As before (time components are not influenced by the sulphur restriction, and therefore remain at current levels)
Infrastructure **- Southern Europe: Planning ahead for foreseeable changes in haulage centres**	Haulage centre: Tallinn -Motorway network available	Haulage centres: Berlin, Bologna -compatible rail gauge; work-in-progress >commitment? >deadline?	As before (infrastructure components are not influenced by the sulphur restriction on a short-term or immediate basis)
Cost **-Eastern and Southern Europe** **> European zoning for planning purposes**	Eastern Europe (Poland) Italy (Spain)	0,75€/rail/km all-in: Italy Cost ↑competitiveness of other markets > 0,65€/rail/km all-in	Eastern Europe South of France Italy Spain (Switzerland) +increased competitiveness of rail infrastructure
Environment **- Customer pricing (FTL), transparency**	Considerable increase in CO2e kgs! >impact on human health!	Answer to modal backshift, increase reduced by ave. 77%	As before (environmental comparison of the routings remains at

of emissions vs price = customer choice **- Comparable emissions calculators, methodologies!** **- Stressed importance of railway corridors in Baltica**	Least impact on Italy and Spain, at current heavy burden on emissions		current levels)
Cost volatility	Subjectivity to bunker price decreases considerably on all markets	As before (use of the train has no impact on the sea segment)	Use of short sea segment in production reduces cost volatility substantially

The recommendations are discussed in more detail under the following paragraphs.

Routing via the Baltic States

The research shows that as well as the Eastern European markets, some of the Southern locations are at current competitive via Tallinn. It is recommended that the Italian production and some Spanish locations are routed via Baltica already at present. These Southern markets are not only cost efficient via Tallinn but also the least influenced by environmental and time parametres with the change in production. The use of the routing also safeguards the production from the impact of the sulphur restrictions through minimized proportion of the sea segments impact on the total production costs.

The planning ahead for the applicable changes is recommended to commence in the near future. There are two central items emphasized;

a) Driver capacity per vehicle

   i. In order for the production to meet required service schedules the number of drivers per vehicle needs to be increased to two

   ii. or, alternative rotation / swapping point for units (southbound / northbound flows) researched to tackle the added driving hours

b) Shift in haulage centre

i. Capacity needs to be shifted towards Tallinn from Travemünde or alternative rotation / swapping point of units.

These haulage centres are illustrated in more detail in figures 71, 72, 73 as the recommended European planning zones.

After 2015 the emphasis of shifting the Southern European traffics to be routed via Tallinn will become more central, when the geographical area will increase from Italy and Spain to reach the Southern French and Swiss locations. By that time a trial use of the routing will support in finetuning the exploitation of the Baltic States. It is shown that the Southern European markets are most likely candidates for the modal backshift after the sulphur restrictions, bearing in mind that Eastern European locations prioritise the routing via Baltica already at present. These changes in the routings will have a direct impact on the European planning which is discussed under **disponent** later in the chapter.

Rail Baltica

The findings of the research indicate that the Rail Baltica Corridor is a vitally beneficial piece of the puzzle whilst focusing on the Eastern routing. The major parametres positively influenced are the environmental and time components, infact the railway network is shown to reduce the negative impact of both measurement criteria. The presence of Rail Baltica reduces both the added CO_2 emissions and journey time, making the routing attractive to most European locations, emphasizing the efficiency of the Southern markets.

The research indicates that the cost of the rail service is required to be at an average all inclusive level of 0,65 euros per rail kilometre in order to make the use of it cost efficient by current standards. This is not an impossible equation, as indicated by Kalli and Alhosalo (2012; 17) the use of rail, in comparison to road, is approximately 30% cheaper. This suggests that reaching the required price level is within range.

The presence of the railway network, as it is planned, indicates that the haulage centres shift and distribute between Travemünde (sea hub), Berlin and Bologna (rail hubs), the railway hubs most suitable for DSV Oy's European depots.

Although the research indicates impacts of the railway corridor's presence, the commitment and timeline to finish the project is not set in stone. At current it therefore does not offer an alternative solution to tackle the impacts of the sulphur restrictions. On the other hand, however, it strengthens the view on how important the Rail Baltica network is for DSV Road Oy in relation to the European service production.

The Environment

It is evident that the impact of the sulphur restrictions will lead to added burden on the environment through increased CO_2 emissions caused by modal backshift. It is recommended that this environmental burden is made transparent and the implications reflected as customer choice. The service parametres; time, cost and environment should be provided in freight offers, giving customers the possibility to choose the service most suitable for their product whilst shifting the corporate social responsibility from the carrier to the customer. The schedule, price and emissions calculations ought to be provided as a standard freight offer package, particularly in full load flows in an effort to build more sustainable solutions whenever possible. New and green service offerings and business potentials ought to be seeked as shown in figure 21 on page 32.

Exploitation of short sea segments

It is shown in the research that the use of short sea segments accommodates the safeguarding of the service production from the impacts of the price fluctuations of the ships bunker fuel. It is therefore recommended that where effective and cost efficient, the favouring of routings with shorter sea segments should be prioritized as an effort to minimize the cost volatility.

Disponent

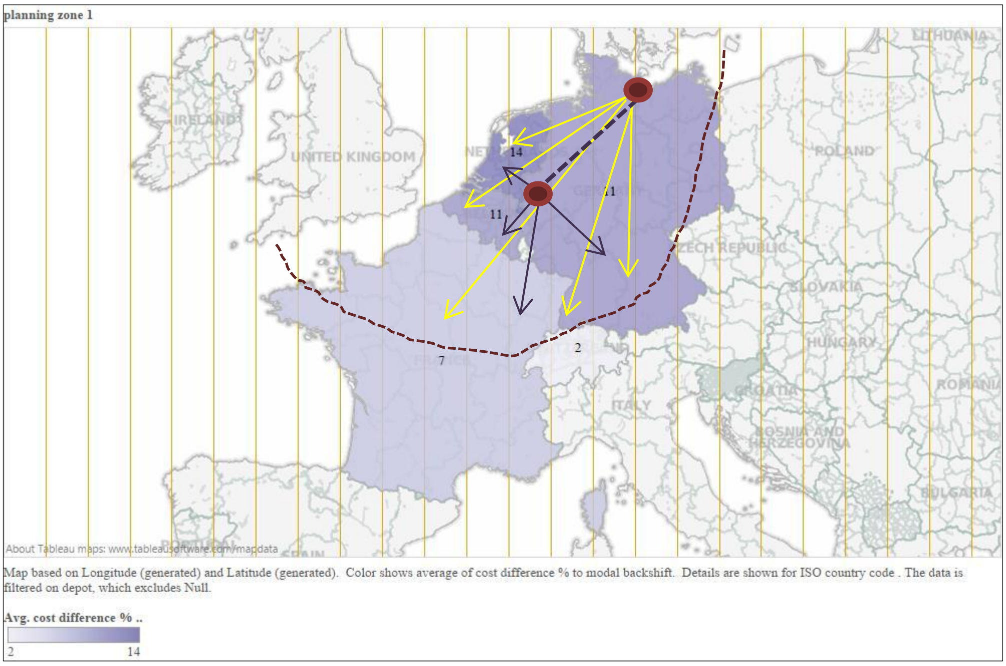
The research has shown that there are some probable changes in the future routings used for European linehaul service production. The knowledge base of the Master's Thesis also indicates that the sulphur restrictions will become applicape in the Sulphur Emission Control Area in January 2015. It is therefore recommended that a futures planning will commence in the near future as an effort to minimize the cost impacts and prepare the production capacity gradually. A gradual shift will accommodate the overcoming and sorting of challenges along the way.

The main foreseeable change is a requirement to allocate haulage centres in their optimal locations on mainland Europe. These haulage centres will accommodate the planning of haulage in Europe and the optimal servicing of three European production zones.

Zone 1. Benelux, Germany, Northern France

The markets most likely to remain on the direct vessel between Finland and Germany ought to create a unified European zone in order to supply enough volumes for increased planning options. At present, the Benelux markets are not planned for haulage from Finland, making the only exeption in European haulage terms. It is recommended that the inclusion of the Benelux markets on the centralized disponent function is further analysed and pursued.

The use of the haulage centres in the Travemünde area and Duisburg remain central in 2015, servicing the Benelux, German and Northern French flows as shown in figure 71 below. Both the use of the railway corridor in Duisburg as well as the road network from the Travemünde will remain important hubs in Europe.



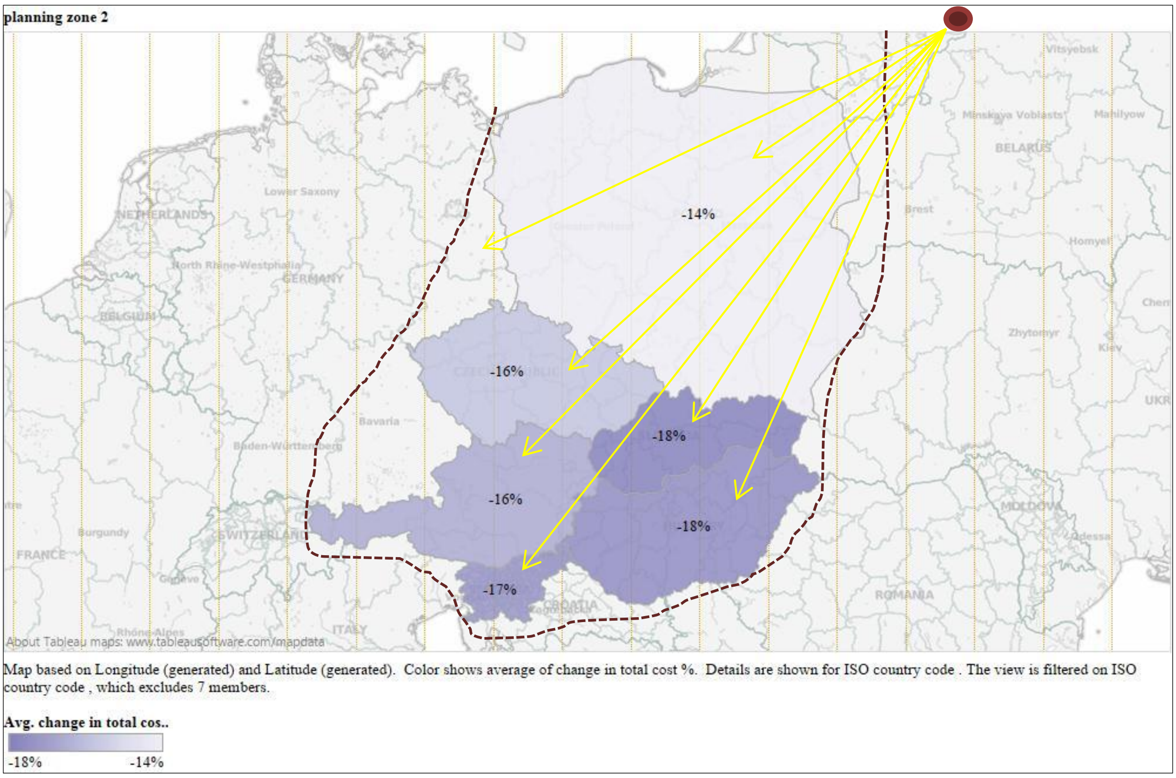
Map based on Longitude (generated) and Latitude (generated). Color shows average of cost difference % to modal backshift. Details are shown for ISO country code . The data is filtered on depot, which excludes Null.

Figure 71. Zone 1 Europe: Benelux, Germany, North of France

From DSV as an entity's perspective, the area of Duisburg will have an increasingly important role in the future. As reported in ITJ (2012a) DSV is investing and expanding in Germany with a new logistics facility in Krefeld-Fichtenhain, only 40 kilometres from Duisburg. From 2014 onwards the facility will become the centre of all of the surrounding DSV locations for all of the three DSV divisions. From that point of view the development of the connection between the Travemünde and Lübeck ports and Duisburg via rail is central, as is the haulage centre development in the area of Duisburg.

Zone 2. Eastern Europe

The Eastern European markets, including Austria will become increasingly competitive via the Baltic States. The main haulage centre to service those markets will locate in Tallinn. It is recommended that these markets continue to seek haulage synergies as they are most similar in cost structures in comparison with other European locations that will seek towards the use of Tallinn as an entry point to mainland. This zone is visualized in figure 72 underneath.

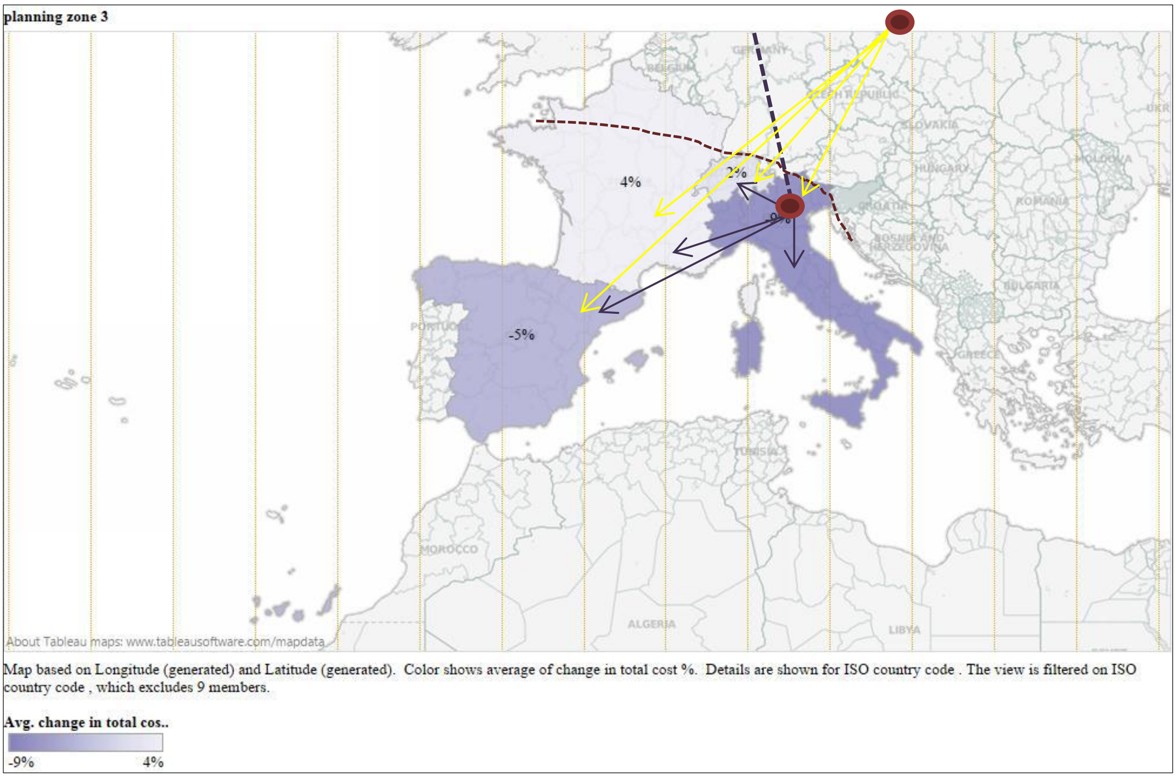


Map based on Longitude (generated) and Latitude (generated). Color shows average of change in total cost %. Details are shown for ISO country code . The view is filtered on ISO country code , which excludes 7 members.

Figure 72. Zone 2 Europe: Eastern Europe

Zone 3. Italy, Spain, France and Switzerland

The central haulage centres for the Southern European locations will develop towards Tallinn and Verona in the future. The sulphur restrictions will continue to enhance the cost efficiency of the Eastern routing. The use of the Verona railway hub will remain to support the Southern production; these are shown in figure 73 below.



Map based on Longitude (generated) and Latitude (generated). Color shows average of change in total cost %. Details are shown for ISO country code . The view is filtered on ISO country code , which excludes 9 members.

Figure 73. Zone 3 Europe: Italy, Spain, France and Switzerland

It is recommended that the future shifts in the routings and subsequently the haulage centres are analysed and planned for in advance with a centralized focus.

Further study

It is recommended that the use of the direct sea segment between Finland and Poland, Gdynia, is further analysed. Using Gdynia may also contribute beneficially to the European service production. By reducing the sea segment from Germany to Poland, as shown in figure 74, an attractive routing solution may arise for some of the European locations. Initial calculations (appendix 24) indicate that routing via Poland is more cost efficient in 2015 than Germany although not as cost efficient as exploiting the Baltic States.

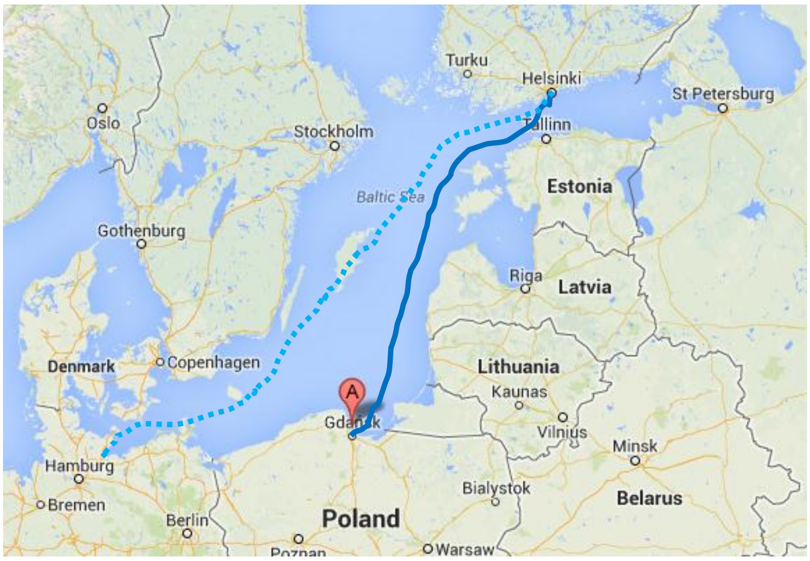


Figure 74. Routing via Poland

Gdynia could, in particular, potentially benefit markets that are not cost competitive via the Baltics, such as the Benelux markets and parts of Germany. This indicates that by finetuning the sea freight and km costs, as well as schedule optimization, routing via Poland may become central in the future. For example Belgium and Holland are only on average €250 more expensive via Gdynia whereas the equivalent figure via the Baltics is €1350, as shown in appendix 24 in the initial cost comparison 2015 Gdynia vs Germany and the Baltics. The exploitation of the Gdynian routing requires the vessel operators' willingness to enhance the service schedules from the current standards.

As well as taking a further look at Gdynia, the obvious alternative solutions via Hanko and Sweden require an in depth analysis. As concluded by Kalli and Alhosalo (2012; 17) due to the shortest distance from Hanko to mainland European ports, the Port of Hanko will benefit cost advantage in 2015, indicating that the distance travelled to and from Hanko by road will increase in 2015 once the sea freight becomes more expensive. The impacts ought a further look from DSV Road Oy's production perspectives. As well as that, routing via Sweden for locations geographically near the Western entry and exits ought to be analysed as preparation for the changes in 2015.

5 CONCLUSIONS

The **first objective** of the Master's Thesis was to identify the meaning and the impact of the sulphur restriction in the context of transport service production between Finland and mainland Europe. This was done by comparing the current price difference of the ships' bunker fuel grades and reflecting the difference by increasing the bunker adjustement factor. The impact was identified as a 37% increase on the sea freight fuel surcharge, subsequently indicating a substantial rise in the sea freight costs in the Sulphur Emissions Control Area. This is supported by a Ministry of Transport and Communications Finland publication (2009) of an estimated price rise of 35-41% on freight charges for lorry transportation. It is further supported by a Centre for Maritime Studies (Kalli & Alhosalo, 2012) indication of a 33 % price rise for maritime costs after the application of the sulphur restriction on the SECA area. It is important to emphasise however, that the increase in the sea freight cost is merely one component of the total production costs in the linehaul for groupage services, indicating an average total cost increase of 11% for the 13 European locations analysed. The total average market specific depot-to-depot cost increases are shown in figure 75 below.

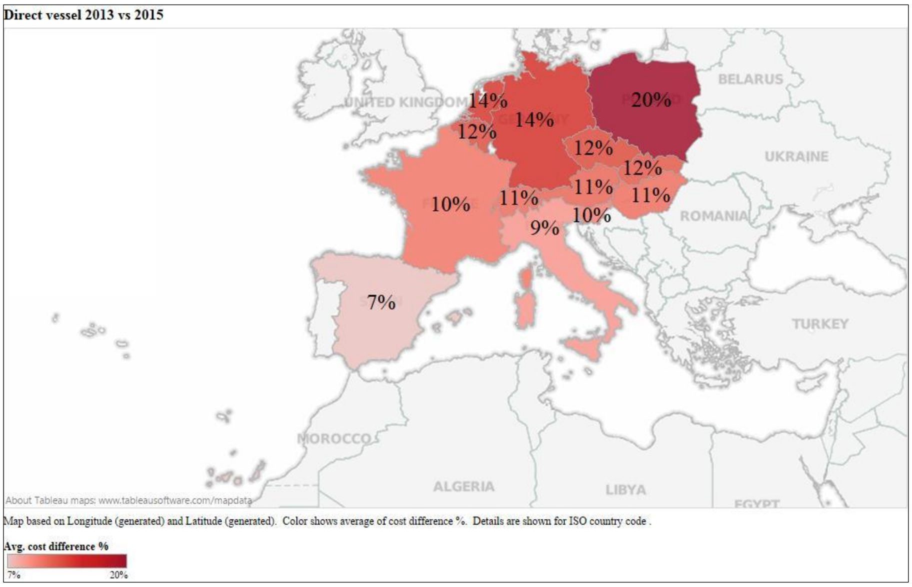
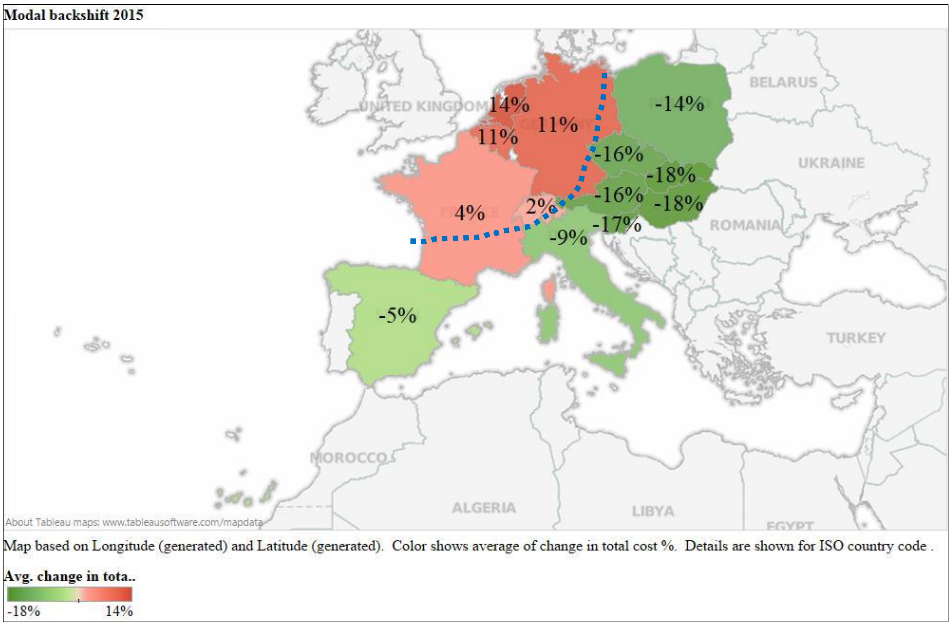


Figure 75. Total average market specific cost increase in 2015

The location specific total cost increase is heavily dependent on the proportion of the sea freight in the total production cost components. This finding is supported by Kalli and Alhosalo (2012; 11) in their study on the effects of sulphur emission restrictions on transport costs via the port of Hanko, where they conclude to suggest that the increase of transport cost varies depending on the distance on land and sea, the variation is found between 20 % depending on the route used. A European Maritime Safety Agency's study on the impacts of the suplur restrictions identified 5 major influencers; 1) the specific route taken, 2) the ship used, 3) the cargoes in question, 4) the length of the sea segment, and 5) whether a ship operator can pass on increased fuel prices to the customers. As rising fuel costs are incorporated in their entirety in sea freight costs, and with the type of ship used as well as the cargoes in question remaining stable throughout the research, it is concluded therefore that the emphasis of the sulphur restriction impact is on the specific route taken, the geographical position of the location, and the lenght of the sea segment used en route. As shown in figure 75, the Benelux, German and Polish locations have an average total cost increase of 15% which is higher than the European average due to the larger impact of the sea segment in the total production cost components.

The **second objective** of the Master's Thesis was to outline the alternative routing solution via Baltica and make comparison, through performance criteria, to the existing service production methods for major European locations, including the assumed infrastructure of Rail Baltica Corridors. The performance measurement criteria used fall under 5 categories; 1) time, 2) infrastructure, 3) cost, 4) environment, and 5) cost volatility. The hypothetical analysis of the Rail Baltica Corridor was based on the 2011 Rail Baltica Final Report, an Aecom Transportation Executive Summary co-financed by the European Union, on the latest indicators of the chosen execution for the completion of the railway network. The benchmarking of the routings was based on the current production methods and cost agreements. The benchmarking of the performance categories accommodates the indication of whether an alteration in the production method, in this case routing, leads to alterations in the product itself, in this case depot to depot linehaul for European groupage services.

After a combination of comparing the performance criteria and reflecting the 37% fuel surcharge increase, this Master's Thesis shows that the upcoming sulphur restrictions is likely to reflect as modal backshift for parts of the European depot to depot linehaul production. The findings of the Thesis are supported by a study conducted by the Swedish Maritime Administration (2009) on the consequences of the new IMO marine fuel sulphur regulations. The Swedish study, although conducted in the Swedish context, also saw a potential increase of Finnish volumes onto Mainland Europe via Sweden. These findings are counter to an European Maritime Safety Agency's assesment on the revised International Maritime Organization's regulation. The EMSA assesment concluded to find that the shipping routes which are competitive using 1,5% HFO will remain so even after the 0,1% limit applicable in 2015. This is supported by the European Comission's relaxed approach towards the potential modal backshift whereby it is not considered a serious worry (European Comission, 2011). Figure 76 below indicates the markets prone for the potential modal backshift for a proportion of the market's service production.



Map based on Longitude (generated) and Latitude (generated). Color shows average of change in total cost %. Details are shown for ISO country code .

Figure 76. Potential modal backshift 2015

The environmental impact of the potential modal back shift is however substantial in its negative sense. Although the sulphur emissions from the sea freight are reduced in accordance with the new 2015 requirements, the increased CO_2 emissions from road transportation are greater, as discussed under section 4.5.3 modal backshift and the environment. A single journey to 19 European depots will increase the CO_2 emissions by an average of 95% as shown on figure 69 on page 81. This environmental consequence partly defeats the purpose of the sulphur restriction, which is after all initiated with an objective to ensure better air quality surrounding the Suphur Emissions Control Area. In fact, the European Commission considers the sulphur regulation to be the most considerable health related amendment in years.

As the 2015 roll-out of the 0,1% sulphur restriction is limited to the SECA area, specific markets like Finland experience more pressure to find solutions that are competitive. This pressure leaves no alternatives but to losen on other performance criteria, such as the environment, and focus on enhanced cost parametres. Therefore it is no longer merely an environmental question but a question of finding a balance between environmental measures and fair competition.

The Master's Thesis shows that the presence of the Rail Baltica Corridor provides crucial relief to the environmental burden caused by the probable modal backshift. The Rail Baltica Corridor also provides relief to the increased total journey time caused by the longer driving time and subsequent driver break times. In fact, the driver capacity per vehicle is required to be increased to two without the presence of the railway infrastructure. Although the Rail Baltica Corridor offers the potential to tackle the challenges brought on by a) the sulphur directive, b) the ash clouds, and c) the stevedores strike actions in the Finnish ports, it is not due to be ready until 2022 at earliest, offering no relief in 2015. The connection between Helsinki and Tallinn on the otherhand received 11,3 million euros in 2013 to further develop the seabridge and port areas by 2015 (Taloussanomat, 2013).

The **third objective** of the Master's Thesis was to make recommendations to routings and identify a break-point for the impact of the cost increase reflected by the sulphur restriction. The cost increase break-points for modal backshift are shown in figure 77 on the following page. These were achieved by comparing the current cost levels of a) the direct ferry and b) routing via the Baltic States.

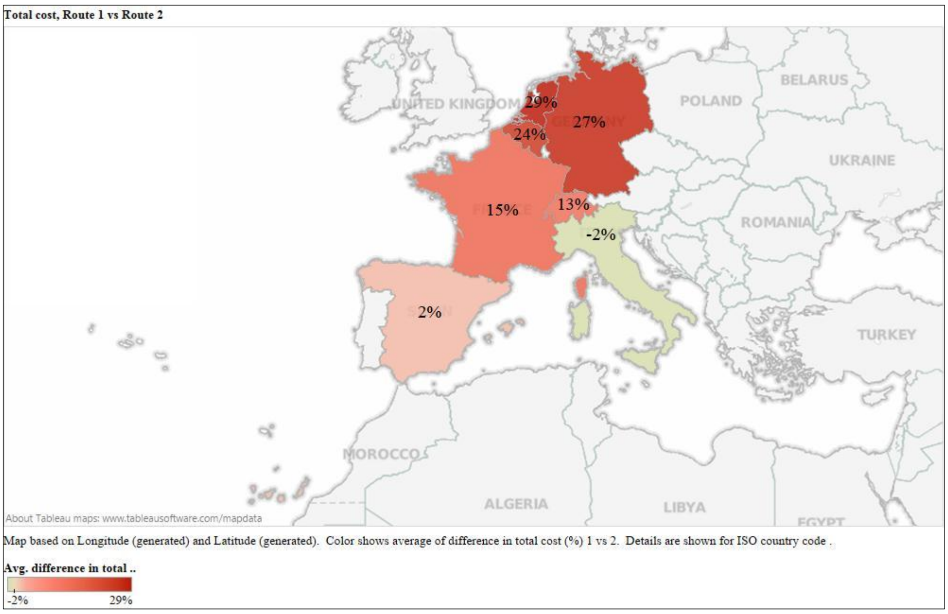


Figure 77. Break-point for modal backshift

The research shows that in the case of the Benelux markets and Germany, the total production costs need to increase by 26,6 % as a consequence of the sulphur restriction before the modal backshift becomes a cost efficient alternative. The figure is over 10 % more than the European average cost increase required to initiate a change in routing. As shown in figure 45 on page 62, the Eastern European locations are already cost efficiently routed via the Baltic States.

It has been established that the developments in 2015 will mold the production of Southern European services without jeopardising the current service standards whilst minimising the impacts of the cost increases. It is recommended that the planning and the addressing of the upcoming changes is initiated in the near future as there are no indicators of exemptions from the sulphur restrictions or a prolonged application to the year 2025 as Finland had hoped for.

The bottom line in the face of the upcoming challenges for transport service production is the ability to maintain cost competitiveness. This line of thought is supported by Kari (2013) whilst forecasting that the vessel operators' most capable of minimising the cost impacts of the 2015 sulphur restrictions will survive the competition best in the coming years. Nevertheless, a proactive approach to environmental awareness rather than a reactive compliance with regulations, particularly when the core business is an environmental impact, becomes an element of differentiation as we move forward to the future.

REFERENCES

Written references

Abdelkader, S. & Eglese, R. 2009. Combinatorial optimization and Green Logistics. Springer Science+Business Media, LLC 2009, 159-175.

Ahokainen, O. 2011. Elintarvikekuljetusten päästövaikutukset Italiasta Suomeen (Impact of Transport-related Emissions on Food Transport from Italy to Finland, case: Keslog Oy Ltd), Bachelor's Thesis, Lahti University of Applied Sciences 2011.

Bask, A. & Laine, J., 2000. Coordination of Container Transport Chains (Konttikuljetusketjujen koordinointi), Helsinki School of Economics and Business Administration, Publications of the Ministry of Transport and Communications 46/2000, Edita Ltd, Helsinki

Blanchard, D. 2010. Supply Chain Management, Best Practices, 2nd edition, John Wiley & Sons Inc., New Jersey 2010.

Browne, M., Cooper, J. & Peters, M., 1994. European Logistics, markets, management and strategy, Second edition, Blackwell Publishers Ltd, Oxford

Byrne, P. & Deeb, A. 1993. Logistics must meet the green challenge, Transportation & Distribution; Feb 1993; 34, 2; ABI/INFORM Complete, 33.

Cargo, 2012. Ammattikuljettajien määrä uhkaa romahtaa 2014 *(number of truck drivers to plummet in 2014)*. DSV-yhtiöiden asiakaslehti, 2/2012, 9.

Cargo, 2012a. Rail Baltica rakennetaan Suomen vientiteollisuudelle *(Rail Baltica is build for the Finnish export industries)*, DSV-yhtiöiden asiakaslehti, 4/2012, 12-13.

Cargo, 2012a. Metsäteollisuus tutkii vaihtoehtoja *(the Forest Industry is searching for alternatives)*, DSV-yhtiöiden asiakaslehti, 4/2012, 13.

Chang, C. & Chen, Y. 2013. Green organizational identity and green innovation, Management Decision Vol. 51 No. 5, 2013 pp. 1056-1070, Emerald Group Publishing Limited

Eng-Larsson, F. & Kohn, C. 2012. Modal shift for greener logistics - the shipper's perspective, International Journal of Physical Distribution & Logistics Management Vol. 42 No. 1, 2012 pp. 36-59, Emerald Group Publishing Limited

Helsingin Sanomat, 2012. Rikkidirektiivi tarjoaa metsäteollisuudelle myös uusia mahdollisuuksia *(the sulphur directive offers the timber industry new opportunities)*. C5, 10 kesäkuuta 2012.

Helsingin Sanomat, 2012a. Rikkisavut pestävä pois Itämeren yltä *(sulphur smoke to be wiped from above the Baltic Sea)*. A2, 1 heinäkuuta 2012.

Herrala, O. 2012. Rail Baltica voitto Suomen viennille *(Rail Baltica a win for Finnish export)*. Kauppalehti, N:O 125/2012, 4-5A.

Höfer, R. 2009. Sustainable Solutions for Modern Economies, RSC Green Chemistry, RSC Publishing, Cambridge 2009.

International Transport Journal, 2012. Alliance to promote alternative fuel, Baltic LNG partnership. ITJ 27-30, 20 July, 36.

International Transport Journal, 2012a. DSV investing in the future. ITJ 47-48, 23 November, 11.

International Transport Journal, 2012b. Positive outlook for Baltic ports. ITJ 43-44, 26 October, 34.

International Transport Journal, 2013. World's longest railway tunnel under the Baltic Sea?. ITJ 15-16, 12 April, 38.

Isaksson, K. & Huge-Brodin, M. 2013. Understanding efficiencies behind logistics service providers' green offerings, Management Research Review Vol. 36 No. 3, 2013 pp. 216-238, Emerald Group Publishing Limited

Jouslehto, M. 2012. Finnlinesin Grimaldi ei innostu rikkipesureista *(Finnlines' Grimaldi is not excited about the sulphur washers)*. Kauppalehti, N:O 162/2012, 6.

Kajander, S. & Karvonen, T., 2001. From Road to Sea Concept (maanteiltä vesiteille), Centre for Maritime Studies University of Turku, Publication of the Ministry of Transport and Communications 47/2001, Oyj Edita Abp, Helsinki

Kalenoja, H. & Kuukka-Ruotsalainen, V., 2001. Environmental Effects of Road Transport Telematics (Tiekuljetusten telematiikan ympäristövaikutukset), Publications of the Ministry of Transport and Communications 43/2001, Oyj Edita Abp, Helsinki

Kalima, T. 2012. A steep rise in transport costs. Port of Helsinki, 2/2012, 26-27.

Kalli, J. & Alhosalo, M. 2012. Effects of Sulphur Emission Restrictions on Transport Costs via the Port of Hanko, Centre for Maritime Studies, University of Turku, 4 September 2012.

Kauppalehti, 2012. Rikkidirektiiviä on vaikea kompensoida *(sulphur directive is difficult to compensate)*. Kauppalehti, pääkirjoitus N:O163/2012, 3A.

Lukkari, E. 2012. Ruotsissa toivotaan yrityksille poikkeuslupia rikkidirektiivissä *(Sweden hopes for special permits to tackle with the sulphur directive)*. Kauppalehti, N:O 245/2012, 5A.

Lättilä, L. Henttu, V. & Hilmola, O-P. 2013. Hinterland operations of sea ports do matter: Dry port usage effects on transportation costs and CO2 emissions, Transportation Research Part E 55 (2013) 23–42

Martinsen, U. & Björklund, M. 2012. Matches and gaps in the green logistics market, International Journal of Physical Distribution & Logistics Management Vol. 42 No. 6, 2012 pp. 562-583, Emerald Group Publishing Limited

McKinnon, A. et al. 2010. Green Logistics, Improving the environmental sustainability of logistics, The Chartered Institute of Logistics and Transport (UK), Kogan Page Ltd, London 2010.

Moves, 2012. DSV Road Takes the Train, DSV A/S, Moves 2/2012 #34, 10-11.

Nikula, P. 2012. Varustamoiden EU-tuki voi jäädä 8,5 miljoonaan *(vessel operators' EU funding may be reduced to 8,5 million)*. Kauppalehti, N:O 103/2012, 4-5A.

Nikula, P. 2012a. Logistiikkareitit muuttumassa *(logistics routings are changing)*. Kauppalehti, N:O 103/2012, 5A.

Nikula, P. 2012b. Varustamoille tarjotaan uutta EU-tukea *(vessel operators' are offered EU funding)*. Kauppalehti, N:O 93/2012, 4-5A.

Nykänen, K. 2011. Lähetyskohtaisen hiilijalanjäljen määrittäminen kappaletavaraliikenteessä (Defining Shipment Level Carbon Footprint in LTL-Transportation), Bachelor's Thesis, Jyväskylä University of Applied Sciences 2011.

Phyper, J. & MacLean, P. 2009. Good to Green, Managing Business Risks and Opportunities in the Age of Environmental Awareness, John Wiley & Sons Canada Ltd., Ontario 2009.

Pöysä, J. 2012. Rikkidirektiivin pehmentämisestä tulossa kova pähkinä *(softening the sulphur directive is going to be a hard nut to crack)*. Kauppalehti, N:O 161/2012, A6-7A.

Pöysä, J. 2012a. Sahoja ei saa päästää kaatumaan *(wooden mills are not to be let down)*. Kauppalehti, N:O 160/2012, 13B.

Pöysä, J. 2012b. Sahat kilpailevat itsensä hengiltä *(wooden mills are competing themselves dr*y). Kauppalehti, N:O 156/2012, 4-5A.

Ravantti, H. 2012. Societal Change and Foresight Methods (HAMK), individual assignment *(background study for Master's Thesis)*, 27 November 2012, Lahti University of Applied Sciences course work.

Sinervä, I. 2013. Aasian konttirahteihin tulossa jättikorotukset *(Asian container freight facing massive increases)*. Kauppalehti, N:O 121/2013, 6.

Szymankiewicz, J. 1993. Going green: the logistics dilemma, Logistics Information Management 6.3 (1993): 36.

Sovijärvi, M. 2012. Tougher regulations, cleaner shipping. Port of Helsinki, 2/2012, 8-11.

Sussman, J. 2000. Introduction to Transportation Systems. Boston. Artech House Inc.

van Hoek, R. 1999. From reversed logistics to green supply chains, Supply Chain Management 4.3 (1999): 129.

Vartia, A. 2012. Schedule for Baltic LNG infrastructure unfolds. Port of Helsinki, 2/2012, 12-14.

Vartia, A. 2012. Wärtsilä believes scrubbers are the solution to sulphur. Port of Helsinki, 2/2012, 15-17.

Vartia, A. 2012. No easy ride for the pioneer. Port of Helsinki, 2/2012, 18-20.

Vautrain, J. 2008. New regs require lower bunker fuel sulfur levels, Oil & Gas Journal; Nov 24, 2008; 106, 44; ABI/INFORM Complete, 46.

Wang, S. et al 2013. Bunker consumption optimization methods in shipping: a critical review and extensions. Transportation Research, Elsevier Ltd. Part E 53/2013, 49-62.

Wu, H. & Dunn, S. 1994. Environmentally responsible logistics systems, International Journal of Physical Distribution & Logistics Management, Vol. 25 No. 2, 1995, pp. 20-38. © MCB University Press

Laws, statutes, decrees, committee reports and standards

Aecom, 2011. Rail Baltica Final Report. Executive Summary 31 May 2011. Co-financed by the European Union Trans European Transport Network (TEN-T). [referenced 16 July 2013]. http://www.sam.gov.lv/images/modules/items/PDF/item_3195_Rail_Baltica_Final_Report_Executive_Summary_31_05_11_FINAL_v2.pdf

European Commission, 2013. Report from the commission to the European parliament and the council, first progress report on the implementation of the commission staff working paper, "Pollutant emission reduction from maritime transport and the sustainable waterborne transport toolbox", COM(2013) 475 final, Brussels 28.6.2013 [referenced 15 September 2013]. http://ec.europa.eu/commission_2010-2014/kallas/headlines/news/2013/06/doc/com(2013)475_en.pdf

European Commission, 2011. Commission staff working paper, Impact Assessment, accompanying the document, Proposal for a Directive of the European Parliament and of the Council amending Directive 1999/32/EC as regards the sulphur content of marine fuels, SEC(2011) 918 final, publication of the European Commission, Brussels 15.7.2011 [referenced 21 July 2013]. http://ec.europa.eu/environment/air/transport/pdf/ships/sec_2011_918_en.pdf

European Community Shipowners' Association, 2010. Analysis of the Consequences of Low Sulphur Fuel Requirements, Final 29 January 2010 [referenced 20 July 2013]. http://www.schonescheepvaart.nl/downloads/rapporten/doc_1361790123.pdf

European Maritime Safety Agency, 2010. The 0.1% sulphur in fuel requirement as from 1 January 2015 in SECAs - An assessment of available impact studies and alternative means of compliance, technical report 2010 [referenced 19 July 2013]. http://ec.europa.eu/environment/air/transport/pdf/Report_Sulphur_Requirement.pdf

Ministry of Transport and Communications Finland, 2009. Sulphur content in ships bunker fuel in 2015, a study on the impacts of the new IMO regulations on transportation costs, publication of the Ministry of Transport and Communications 31/2009, Helsinki 2009 [referenced 21 July 2013]. http://www.lvm.fi/c/document_library/get_file?folderId=339549&name=DLFE-8042.pdf&title=Julkaisuja 31-2009

Swedish Maritime Administration, 2009. Consequences of the IMO's new marine fuel sulphur regulation, Norrköping 2009 [referenced 15 September 2013] http://anchortime.com/portal/images/stories/PDF/Consequences%20of%20the%20IMOs%20New%20Marine%20Fuel%20Sulphur%20Regulations.pdf

Electronic Sources

Bunkerworld, 2013. About Bunkerworld [referenced 8 September 2013]. http://www.bunkerworld.com/home/about

Demari, 2011. Jaakonsaari: Suomi nukkui, kun rikkidirektiiviä sorvattiin *(Jaakonsaari: Finland slept when the sulphur directive was being implemented)* [updated 18 November 2011, referenced 3 August 2013]. http://www.demari.fi/politiikka/uutiset/4261-jaakonsaari-suomi-nukkui-kun-rikkidirektiivia-sorvattiin

Demari, 2012. Wärtsilä: Rikkipesuri maksaa itsensä jopa 2 vuodessa - "Rikkidirektiivi tulee ottaa vakavasti" *(Wärtsilä: sulphur washer will pay itself back in 2 years - " sulphur directive is to be taken seriously")* [updated 7 September 2012, referenced 2 August 2013]. http://www.demari.fi/politiikka/uutiset/7581-wartsila-rikkipesuri-maksaa-itsensa-jopa-2-vuodessa-rikkidirektiivi-tulee-ottaa-vakavasti

DSV. 2013a. About DSV [referenced 21 July 2013]. http://www.dsv.com/About-DSV

DSV. 2013b. DSV Road Organisation [updated 13 February 2013, referenced 21 July 2013]. http://dnet/PaivittainenToiminta/DSVFinland/Henkilosto/organisaatiot/Pages/default.aspx

Eco TransIT World, 2013. Ecological Transport Information Tool for Worldwide Transports. Methodology and Data Update. IFEU Heidelberg, Öko-Institut, IVE/RMCON, Berlin – Hannover - Heidelberg, July 31th 2011 [referenced 23 July 2013]. http://www.ecotransit.org/download/ecotransit_background_report.pdf

Eco TransIT World, 2013a. About, general information [referenced 8 September 2013]. http://www.ecotransit.org/about.en.html

European Commission, 2013. Transport, transport themes, European Strategies, White Paper 2011 [referenced 21 September 2013]. http://ec.europa.eu/transport/themes/strategies/2011_white_paper_en.htm

Green Logistics, 2008 [referenced 21 September 2013], Research into the sustainability of logistics systems and supply chains, http://www.greenlogistics.org/PageView.aspx?id=97

Hassi, S. 2012. Oikeus terveyteen - vai saastutukseen? *(right to health - or to pollute)* [updated 1 October 2012, referenced 7 July 2013]. http://www.satuhassi.net/2012/oikeus-terveyteen-%E2%80%93-vai-saastutukseen/

Helsingin Sanomat, 2012a. Rikkidirektiivi hyväksyttiin EU-parlamentissa *(the sulphur directive was accepted in the EU parliament)* [updated 11 September 2012, referenced 3 August 2013]. http://www.hs.fi/talous/a1305598420475

Helsingin Sanomat, 2012b. Ilmansaasteet voivat viedä jopa kaksi vuotta elämästä EU:ssa *(air pollution can cost up to two years off lifetime in the EU)* [updated 24 September 2012, referenced 7 July 2013]. http://www.hs.fi/ulkomaat/a1305601269449

Hänninen, J. 2013. Vientiteollisuudelta tiukka vaatimuslista hallitukselle *(tight demands made by the export industries on the Government)*, Helsingin

Sanomat [updated 19 August 2013, referenced 25 August 2013]. http://www.hs.fi/talous/a1376875753483

IMO, 2013. International Maritime Organisation, Introduction to IMO, [referenced 29 September 2013]. http://www.imo.org/About/Pages/Default.aspx

Logy, 2013. Vuoden Logistikko Lauri Ojala: Sopeutuminen rikkidirektiiviin kannattaa aloittaa heti *(the years' logistician Lauri Ojala: adjusting to the sulphur directive should commence immediately)* [updated 7 February 2013, referenced 3 August 2013]. http://www.logy.fi/yhdistys/arkisto.php?we_objectID=1985

Maaseudun Tulevaisuus, 2012. UPM: Rikkidirektiivi vie paperituotantoa Suomesta *(UPM: the sulphur directive moves paper production away from Finland)* [updated 7 September 2012, referenced 2 August 2013]. http://www.maaseuduntulevaisuus.fi/mets%C3%A4/upm-rikkidirektiivi-vie-paperintuotantoa-suomesta-1.23576

MapandGuide, 2013. References [referenced 8 September 2013]. http://www.mapandguide.com/en/references/

Mättö, Ville, 2012, Hangon satama hyötyy laivojen polttoainekustannusten noususta *(the port of Hanko will benefit from the increases in ships bunker fuel costs)*, YLE, Helsinki 7 September 2012 [referenced 18 July 2013], http://yle.fi/uutiset/hangon_satama_hyotyy_laivojen_polttoainekustannusten_noususta/6285547

NTM Calc, 2011. About NTM [referenced 23 July 2013]. http://www.ntmcalc.org/index.html

NTM, 2013. Why you should become a member [referenced 8 September 2013]. http://www.ntmcalc.org/index.html

Ojanperä, K. 2012. Rikkidirektiiville löytyi yksi hyötyjäkin *(the sulphur directive finds a beneficiar)* [updated 7 September 2012, referenced 2 August]. http://www.tekniikkatalous.fi/Liikenne/rikkidirektiiville+loytyi+yksi+hyotyjakin/a836386

Pohjanpalo, O. 2013. Suomalaislaivoihin asennettu vain yksi rikkipesuri *(only one Finnish vessel has been fitted with a sulphur washer)* [updated 21 February 2013, referenced 21 July 2013]. http://www.hs.fi/talous/a1361374435877

Ravantti, Hede, 2008, Routing analysis using intermodal transport chains, Case DSV Road Oy, Bachelor’s Thesis of Business Administration, Lahti University of Applied Sciences, Lahti Spring 2008

http://publications.theseus.fi/bitstream/handle/10024/11145/2008-07-31-21.pdf?sequence=1

Roueche, Len, 2012, Brussels Supports Low-Sulphur Fuel, Interferry news publication, cited 11 November 2012, http://www.interferry.com/node/2060

RBGC, 2013. Rail Baltica Growth Corridor, Final Conference, Berlin City Hall, 14.6.2013. Rail Baltic moving ahead with strong support [referenced 16 July 2013]. http://www.rbgc.eu/final_conference.html

Snap Surveys, 2013, Qualitative vs Quantitative Research [referenced 7 September 2013]. http://www.snapsurveys.com/qualitative-quantitative-research/

Taloussanomat, 2013. Yle: EU:lta jättituet Helsingin ja Tallinnan merireitin kehitykseen (*EU to grant major funding for the development of the sea service between Helsinki and Tallinn*) [updated 16 July 2013, referenced 15 September 2013]. http://www.taloussanomat.fi/liikenne/2013/07/16/yle-eulta-jattituet-helsingin-ja-tallinnan-merireitin-kehitykseen/20139900/12

Tableau, 2013. Tableau software, story, mission [referenced 8 September 2013]. http://mission.tableausoftware.com/#/mission/

Yle Uutiset, 2012. SKAL: kuljetusyrittäjistä rikkidirektiivin maksumiehiä *(SKAL: transportation entrepreneurs will pay for the sulphur directive)* [updated 20 November 2012, referenced 2 August 2013]. http://yle.fi/uutiset/skal_kuljetusyrittajista_rikkidirektiivin_maksumiehia/6384359

Oral references

Andler, B. 2012. Division Director Western Europe and Domestic, DSV Road Oy. Interview 16 November 2012.

Kohi, R. 2013. Traffic Manager Eastern Europe, DSV Road Oy. Interview 20 June 2013.

Kuosmanen, M. 2013. Traffic Manager Austria and Germany, DSV Road Oy. Interview 3 July 2013.

Naumanen, M. 2013. Traffic Manager Southern Europe, DSV Road Oy. Interview 3 July 2013.

Email

Fagerstrom, H. 2013. Re: Master's Thesis; impacts of sulphur restrictions [email message]. Recipient Hede Ravantti. Sent 27 September 2013 [referenced 28 September 2013].

Kari, K. 2013. Re: Master's Thesis; impacts of sulphur restrictions [email message]. Recipient Hede Ravantti. Sent 30 September 2013 [referenced 2 October 2013].

Kari, K. 2013. Re: Hanko 2015 report final version [email message]. Recipient Hede Ravantti. Sent 1 October 2013 [referenced 2 October 2013].

King, C. 2013. Re: Bunkerworld Information [email message]. Recipient Hede Ravantti. Sent 2 August 2013 [referenced 22 September 2013].

Lahdenranta, M. 2013. Re: Bunkerworld [email message]. Recipient Hede Ravantti. Sent 21 August 2013 [referenced 22 September].

Lyytikäinen, P. 2013. Re: Hanko 2015 report final version [email message]. Recipient Kimmo Kari. Sent 1 October 2013 [referenced 2 October 2013].

Pihlajaniemi, K. 2013. Re: Master's Thesis; impacts of sulphur restrictions [email message]. Recipient Hede Ravantti. Sent 8 October 2013 [referenced 10 October 2013].

Ravantti, H. 2013. Re: Bunkerworld [email message]. Recipient Tietokeskus PHKK and Ullamari Tuominen. Sent 5 August 2013 [referenced 22 September].

Ravantti, H. 2013. Re: Master's Thesis; impacts of sulphur restrictions [email message]. Recipient Håkan Fagerstrom. Sent 16 September 2013 [referenced 28 September 2013].

Ravantti, H. 2013. Re: Master's Thesis; impacts of sulphur restrictions [email message]. Recipient Kimmo Kari. Sent 16 September 2013 [referenced 2 October 2013].

Ravantti, H. 2013. Re: Master's Thesis; impacts of sulphur restrictions [email message]. Recipient Torkel Saarnio. Sent 16 September 2013 [referenced 5 October 2013].

Ravantti, H. 2013. Re: Master's Thesis; impacts of sulphur restrictions [email message]. Recipient Harri Tamminen. Sent 16 September 2013 [referenced 12 October 2013].

Saarnio, T. 2013. Re: Master's Thesis; impacts of sulphur restrictions [email message]. Recipient Hede Ravantti. Sent 4 October 2013 [referenced 5 October 2013].

Other references

DSV, 2012. Weekly reports, trailers. K:\Weekly Reports 2012.

EK, 2013. Merenkulun merkitys Suomen taloudelle ja kilpailukyvylle *(the meaning of seaways to the Finnish economy and competitiveness),* Logistiikkapäivä Wanha Satama, Helsinki 9.4.2013

Gröhn, J. 2010. Kansallinen logistiikkastrategia *(national logistics strategy),* EsLogC seminaari, liikenne- ja viestintäministeriö, Hyvinkää 19.10.2010.

Jaatinen, T. 2013. Metsäteollisuuden tulevaisuus Suomessa ja sen vaikutus kuljetuksiin *(the future of forest industry in Finland and its impacts on transportation services),* Helsingin XVIII Satamapäivä, Helsinki 10.9.2013

Kalli, J. 2012. Rikkipäästörajoitusten vaikutus Hangon sataman kautta tapahtuvien kuljetusten kustannuksiin (*effects of sulphur emission restrictions on transport costs via the Port of Hanko*), University of Turku 6.9.2012

Laaksonen, K-P. 2013. Logistics Service Operator: Alternatives 1.1.2015 →, Containerships Group, Logistiikkapäivä Wanha Satama, Helsinki 9.4.2013

Lehtimäki, J. 2010. Kuehne + Nagel Lead Logistics Solutions, Green Supply Chain - Costs or Savings, Lecture LUAS 24.3.2010.

Mäki, K. 2013. Port of Helsinki, Helsingin XVIII Satamapäivä, Helsinki 10.9.2013

Nietola, O. 2013. Rikkidirektiivi, metsäteollisuuden näkökulma *(Sulphur directive, a forest industry view),* Logistiikkapäivä Wanha Satama, Helsinki 9.4.2013

Pursiainen, H. 2013. Suomen kilpailukyky ja satamat *(Finland's competitiveness and the ports),* Helsingin XVIII Satamapäivä, Helsinki 10.9.2013

Routa, T. & Kämäräinen, J. 2011. IMO 2015, EU Rikkidirektiivi (IMO 2015, EU Sulphur Directive) Vienti ja tuontilogistiikan haasteet 13.10.2011, Trafi.

Saranen, J. 2012. Towards Sustainable Transportation? - Sulphur Reductions in Baltic Sea Region, Logistiikkastrategiat 26.9.2012, Lecture LUAS

Tools

NTM Calc 3.0, 2011a. Basic Freight Calculator [referenced for CO2e calculations]. http://www.ntmcalc.org/index.html

PVT M&G Internet 2.2.14086, 2013a. Route planning, Traffic nformation, Vehicle management [referenced for worksheet and database information, including CO2e calculations]. http://mginter.mapandguide.com/frontend/app.html?language=en&user=DSVFIN.12#sunrise:start

Eco TransIT World, 2013a. Calculation Parameters [referenced for Co2e calculations]. http://www.ecotransit.org/calculation.en.html

Images

[1] Map of SECA, http://www.shortsea.nl/resources/userfiles/image/SECA%20kaart_1.jpg

[2] Map of Europe, http://www.worldatlas.com/webimage/countrys/europe/euoutleu.jpg

[3] Map of Rail Baltica, http://baltic-review.com/wp-content/uploads/2010/11/RailBaltica.jpg

[4] Map of Rail Baltica Growth Corridor, http://www.baltictransportjournal.com/useruploads/images/rail_baltica_growth_corridor_m.jpg

[5] PEST-Analysis Template, http://stunningpresentations.com/wp-content/uploads/2011/09/PEST-Analysis-1.png

[6] Map of Baltic-Adrianic Corridor, http://www.baltic-adriatic.eu/images/map.png

LIST OF APPENDICES

APPENDICES

APPENDIX 1 – Expert Interview

1. Q. According to a publication of the Ministry of Transport and Communications Finland, 2009, the 0.1% max. SO_2 contents in ships bunker fuel will reflect as a 35-41% increase in transportation costs (lorry) in comparison with the current levels. Based on the knowledge and information available to you, would you, at present, consider it an adequate indicator?
   A. *It is as adequate as the rest of the indicators out there. Bunker World*[1] *supplies the price difference between the fuel qualities at present, allowing for the increased contribution to be calculated in relation to the current fuel surcharge levels. However, the availability of max.*SO_2 *0.1% contents fuel, amongst other factors, will have an impact on the price levels. All in all, 35-50% increase is an adequate indicator.*
2. Q. At the same time, an EMSA assessment study concludes that existing shipping routes which are competitive whilst using 1.5% HFO will remain so even after the 0.1% limit is applicable in 2015. How likely would you see a modal shift taking place?
   A. *A modal shift is likely, strongly influenced by geographic positioning of the Shipper in Finland and Consignee in Europe, the close-to-border markets are most likely to shift in routing. In order for Finnish export industries to sustain competitiveness on the European market the price-cost relation must be kept at an optimal level. This holds a key emphasis on transportation costs and subsequently on the transport service provider's ability to compete on the market.*
3. Q. What are the most likely futures shifts in routing and briefly why?
   A. *There are only two possibilities; via Sweden or via Baltic, which is most likely is dependent on the geographic locations in Finland and mainland Europe. The infrastructure is in place both ways, however, Sweden benefits from a railway connection for inland transport whilst going via the Baltic States indicates a backshift. On the other hand, going via Sweden means two sea crossings whilst via the Baltic is one sea crossing away. Rail Baltica is under development tackling the backshift, nevertheless without certainty.*
4. Q. Modal backshift runs counter to EU policy; would you see it risky in respect to future enforcement / control?
   A. *Indeed there is a risk and likelihood for future control, however, impossible to predict in which form.*
5. Q. What criteria do you consider critical whilst looking at alternative routing via mentioned future shifts?

A. *Naturally it is important to consider various criteria including green logistics and awareness of environmental impacts. Nevertheless, the cost efficiency is of utmost importance in this case. The cost structure must be kept at bay in order support the Finnish export industries ability to remain competitive. The types of goods exported from Finland, in general, cannot survive a rate increase in transportation costs. ‘’The goods-flows always find their ways’’, as an example, the removal of a vessel between Sweden and Finland did not stop the cost efficient goods-flows of forest industry products.*

6. Q. In September it was reported that the port of Hanko is going to benefit from the increased fuel costs from Finland’s perspective as it is situated the shortest sea journey away from mainland Europe (Mättö, 2012). Do you see a possible futures shift towards an increased use of the Hanko port?
   A. *If reflecting upon the current pricing of the Hanko-, Turku-, Helsinki-Travemünde lanes, the answer is no. There needs to be a substantial difference is the pricing mechanism in order to make Hanko a competitive routing after the* SO_2 *max 0.1% contents in ships bunker fuel.*
7. Q. The new IMO regulation may negatively influence the competitive positioning of some of the industries in Finland (Ministry of Transport and Communications, 2009), at the same time the volumes of scale benefits from seafreight and bulk cargoes may be jeopardized (Gröhn, 2010). Would you consider it farfetched that road transportation may benefit from the developments?
   A. *It may be the case that a small increased volume seeks trailer transportation. It depends on the lanes and geographic positioning, for example the transportation of sawn mill products from Finland to Denmark are near enough on the same price level for bulk and trailer transportation at current. The bottom line in any case is the share of the freight costs in the bulk products nett* m^3 *price.*
8. Q. Would you consider some risk in the initial objective of this measurement to protect the air quality and reduced health risks within EU, as the decrease in SO_2 may lead to increased CO_2 emissions?
   A. *It is the case that reduced sulphur emissions may lead to increased* CO_2 *levels. It is important to keep in mind the railway connections and that the use of rail is less environmentally burdening than that of road.*
9. Q. Would you consider it possible that modal shift is not considered a substantial risk due to current lack of capacity on alternative routing? ie vessel space between Finland and the Baltics vv. and Finland and Sweden vv.?
   A. *It is important to investigate the possibilities and know in advance what the impacts of 2015 are. Although the current capacity is in line*

with current requirements, if demand increases, the supply will follow. If we look at the current development of the German market it is stable, whereas for example the Eastern markets are growing and current flows to Tallinn is bigger than those to Sweden. One vessel operator alone has six daily departures from Helsinki to Tallinn and there is plenty room for more.

10. Q. Would you see that the maintenance and impact on infrastructure and equipment, if modal backshift is to take place, is underestimated in current available studies?
    A. It is probable that there will be a greater split of volumes over the possible routings. Alternative connections will accommodate certain flows whereas some are going to benefit most from the current direct connections. The shift will be gradual and the potential areas will be developed over time. It is likely that eg road tolls will be applied in areas prone to extra flows.

APPENDIX 2 - Expert Interview

1a. Q. In what proportion is heavy fuel and distilled fuel grades used in the vessels

> *A. We use mainly HFO of 380 cSt. We use only MGO in ship aux engines if the ship stays in port more than 2 h. In a ship where 180 cSt HFO is needed, a 380 cSt HFO can be mixed with appr. 15% MGO.*

1b. Q. Does mixing the fuel grades lead to increased engine problems (poorer quality fuel)

> *A. Yes, most likely the low viscosity of MGO might be a problem if you here mean a switch from HFO to MGO.*

1c. Q. Is the 2015 requirement technically possible with mixing fuel grades

> *A. Yes, switching from HFO to MGO is possible. But you have to overhaul all fuel pumps which perhaps are worn out after a longer residual fuel use. You have also to install a fuel cooler on all engines and eventually you need to change all exhaust valves to other material.*

2. Q. How has the changes in the price of fuel 2006-2013 affected the relative cost structure

> *A. Since 2007 the HFO price has varied much, from USD 400,-/ton up to USD 800,-/ton. This has increased ship owners operational costs.*

3a. Q. Can the current scheduled routes become slower in an effort to minimize the monetary impacts ie. is it possible to achieve adequate compensation and what would the reduction of speed be

> *A. Yes, slow steaming is for someone possible. But we must optimize our time schedules according to our customer's needs; we can't prolong the time schedule too much. In this kind of traffic the optimal speed reduction can't be implemented, the focus will be on the time schedule.*

3b. Q. Will the use of sulphur scrubbers increase accommodating the use of current fuel grades

> *A. No, because with scrubbers a HFO with 2,5-3,0% S will be used. Now we use a HFO with 0,5-1,0% S which will perhaps not be available on the market after 2015..*

3c. Q. Are the ports prepared to receive the sulphur scrubber waste from ships

> *A. No, unfortunately they aren't. The solid sulphuric waste can perhaps be handled by subcontractors. But the effluent from the scrubbers is containing too much sulphate and heavy metals (Cu and Ni) are on a too high level so the effluent can't be pumped into the port sewage systems.*

4. Q. In light of the upcoming changes on fuel requirements and a switch to the use of gas oil and diesel oil, what are the estimates on the availability of the low-sulphur fuels?

> *A. As you perhaps know aspahalt and HFO aren't profitable products for a refinery. For instance it's forecasted that major Russian producers will decrease their production of HFO from 75 Mton/year down to 10-12 Mton/year until 2020. Russian and all major refineries in the Baltic Sea region will focus on distillates instead. We don't see any problem in the availability, there will be enough MGO on the market.*

5a. Q. What are the biggest challenges in the investment and installation of sulphur scrubbers in existing vessels eg. cleaning efficiency vs units' size> impact on ships' earning potential

> *A. The scrubber itself is functioning properly; this technique has been used in shore based industry for several years. The challenges are in weight of the scrubber which results in loss of cargo space. But we see serious challenges instead in effluent treatment which the EGS manufacturers haven't been able to solve. The shortage or availability of a low sulphur 0,5-1,0% S HFO in 2015 will definitely be a problem when we know that the scrubber needs such fuel in order to function together with NOx abatement equipment such as SCR and DWI.*

5b. Q. Will the Government's environmental grant of 30 million euros for vessel investments in 2013- 2014 enhance the development in the area with the maximum potential of covering 50% of the scrubber cost.

> *A. Unfortunately not, because many ship owners doubt that the scrubbers will function properly. The scrubber technology isn't fully developed to meet the need from the shipping industry. Another reason is that the government environmental aid came too late. The time schedule is too tight if the scrubber must be designed, manufactured, installed and class approved before end of 2014. There are not perhaps enough yard capacity in the Baltic Sea region either.*

APPENDIX 3 - Questionnaire, vessel operators

2009: HFO/IFO 95% , MDO/MGO 5% (fuel containing less than 1,5% sulphur, SECA).
Current sulphur contents: 1%
1 January 2015: 0.1%

Q1. a) in what proportion is heavy fuel and distilled fuel grades used in the vessels
b) does mixing fuel grades lead to increased engine problems (poorer quality fuel)
c) is the 2015 requirement technically possible with mixing fuel grades

Vessels entering Finnish ports, fuel costs account for the largest share of vessel costs (2006: ro-ro vessels 36%, car and passenger ferries 30%).

Q2. how has the changes in the price of fuel 2006-2013 affected the relative cost structure

Rising fuel costs are incorporated in their entirety in sea freight costs.
The speed of a vessel affects consumption with a direct implication on fuel costs.

Q3. a) can the current scheduled routes become slower in an effort to minimize the monetary impacts
ie. is it possible to achieve adequate compensation and what would the reduction of speed be
b) will the use of sulphur scrubbers increase accommodating the use of current fuel grades
c) are the ports prepared to receive the sulphur scrubber waste from ships

A Finnish study (2009 Ministry of Transport and Communications) suggests that large car and passenger ferries on the Baltic Sea have been using heavy fuel oil (sulphur content no more than 0,5%) for quite some time now, however have been facing challenges with its availability. It was estimated that the situation may continue to escalate.

Q4. In light of the upcoming changes on fuel requirements and a switch to the use of gas oil and diesel oil, what are the estimates on the availability of the low-sulphur fuels?

Wärtsilä indicates that they have sold aprx 40 sulphur scrubbers, but only one of them is on a vessel under a Finnish flag (Containerships, Containerships VII), prior to that some testing was conducted onboard Neste's Suula vessel. Wärtsilä as a leading manufacturer of sulphur scrubbers is baffled with the slow response of Finnish vessel operators' investments, giving a price indicator of 1 - 5 million euros with a potential ROI of 1 - 2 years

Q5. a) what are the biggest challenges in the investment and installation of sulphur scrubbers in existing vessels
eg. cleaning efficiency vs units' size> impact on ships' earning potential
b) will the Government's environmental grant of 30 million euros for vessel investments in 2013- 2014 enhance the development in the area with the maximum potential of covering 50% of the scrubber cost

APPENDIX 4 - Answers, vessel operators

Q1. a)

Operator A: MGO/HGO some 9% (in t)
Operator B: Varies from traffic area to traffic area and vessel to vessel – unfortunately we do not have an average rate
Operator C: We are using 0.5% at sea and MGO in port

b)

Operator A: Nobody recommends mixing, mainly due to unstable result and thus resulting problems
Operator B: It can yes
Operator C: We have not seen any major challenges due to the sustainable supplier chain

c)

Operator A: 0,1% S is not possible to solve by mixing
Operator B: No, as far as we understand you have to use either heavy oil with scrubber or MGO/MDO with low sulphur
Operator C: The low sulphur (0.1% max) product cannot be diluted until the process must be handled via refinery

Q2.

Operator A: ---
Operator B: Sorry – confidential information
Operator C: ---

Q3. a)

Operator A: ---
Operator B: Yes. Speed is the critical factor what it comes to the fuel consumption – answer is yes. But what the speed will be depends on traffic area and frequency demand.
Operator C: This item is ship and route specific item and cannot be considered as a common rule

b)

Operator A: Scrubbers for traffic in the Baltic Sea (North Sea) SECA are typically designed for up to some 2,8% S due to nonavailability of up to 3,5% S fuel.
Operator B: ---

Operator C: In Baltic region, there will be a limited type of fuels available, whereas in Europe you can select from LSHFO to normal HFO

c)

Operator A: Yes, ports or other business partners. There may be problems with zero discharge as the sewage (piping) may not tolerate the wash water
Operator B: I would recommend that you ask directly from the ports
Operator C: Sludge will be sent to Ekokem or equal treatment plants, but the treated water (clean effluent) will be discharged overboard

Q4.

Operator A: Most vessels will not have scrubbers and will thus run on MGO that has 0,1% S. In principle there is no market for other grades but MGO and high sulphur HFO (vessels with scrubbers)
Operator B: Sorry, no idea today..Hopefully end 2014 we know more
Operator C: ---

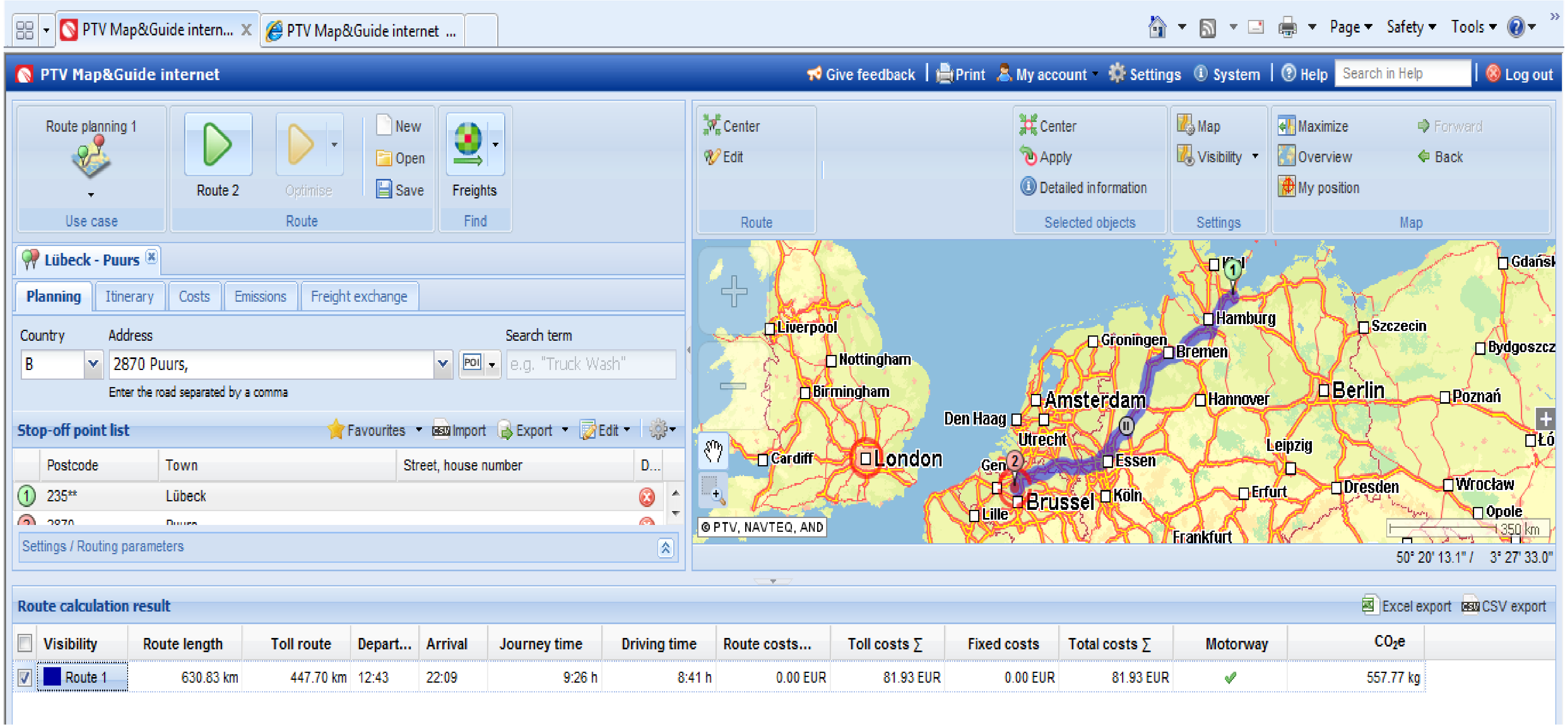
Q5. **a)**

Operator A: loss of cargo capacity to some extent (vessel specific), high investment, increased running costs compared to present status
Operator B: Still confidential – let you know end 2014 ☺
Operator C: The weight, space, integration of such a large system in compact size of machinery space, functionality of the cleaning system (proper treatment of cleaning water) and unknown return of investments period (ROI)

b)

Operator A: No, the model for calculating the economics is such that it will trigger hardly any scrubber investments
Operator B: Only for the vessels under Finnish flag
Operator C: Topic discussed in more detail over the phone 8.10.; alternatives are being further evaluated and cooperation continued with partners to develop future decisions

APPENDIX 5 - PTV Map & Guide internet, example



Lübeck - Puurs

Country: B

Address: 2870 Puurs,

Search term: e.g. "Truck Wash"

Enter the road separated by a comma

Stop-off point list

	Postcode	Town	Street, house number	D...
①	235**	Lübeck		
②	2870	Puurs		

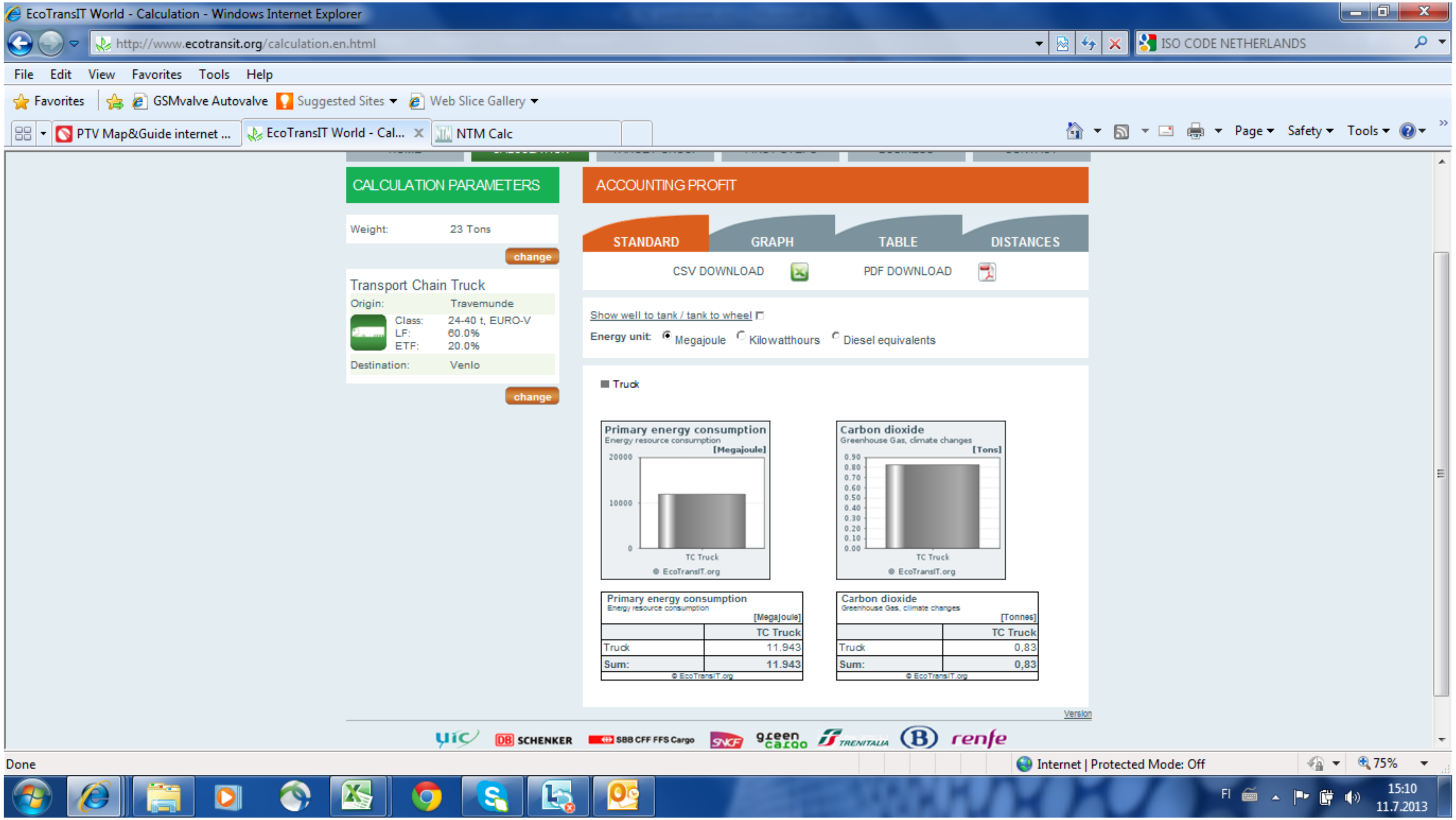
50° 20' 13.1" / 3° 27' 33.0"

Route calculation result

☐ Visibility	Route length	Toll route	Depart...	Arrival	Journey time	Driving time	Route costs...	Toll costs ∑	Fixed costs	Total costs ∑	Motorway	CO_2e
☑ Route 1	630.83 km	447.70 km	12:43	22:09	9:26 h	8:41 h	0.00 EUR	81.93 EUR	0.00 EUR	81.93 EUR	✓	557.77 kg

Route planning tool

APPENDIX 6 - Eco TransIT World, example



CALCULATION PARAMETERS

Weight: 23 Tons

change

Transport Chain Truck

Origin: Travemunde

Class: 24-40 t, EURO-V
LF: 60.0%
ETF: 20.0%

Destination: Venlo

change

ACCOUNTING PROFIT

STANDARD | GRAPH | TABLE | DISTANCES

CSV DOWNLOAD PDF DOWNLOAD

Show well to tank / tank to wheel ☐

Energy unit: ● Megajoule ○ Kilowatthours ○ Diesel equivalents

▪ Truck

Primary energy consumption
Energy resource consumption
[Megajoule]

	TC Truck
Truck	11.943
Sum:	11.943

© EcoTransIT.org

Carbon dioxide
Greenhouse Gas, climate changes
[Tonnes]

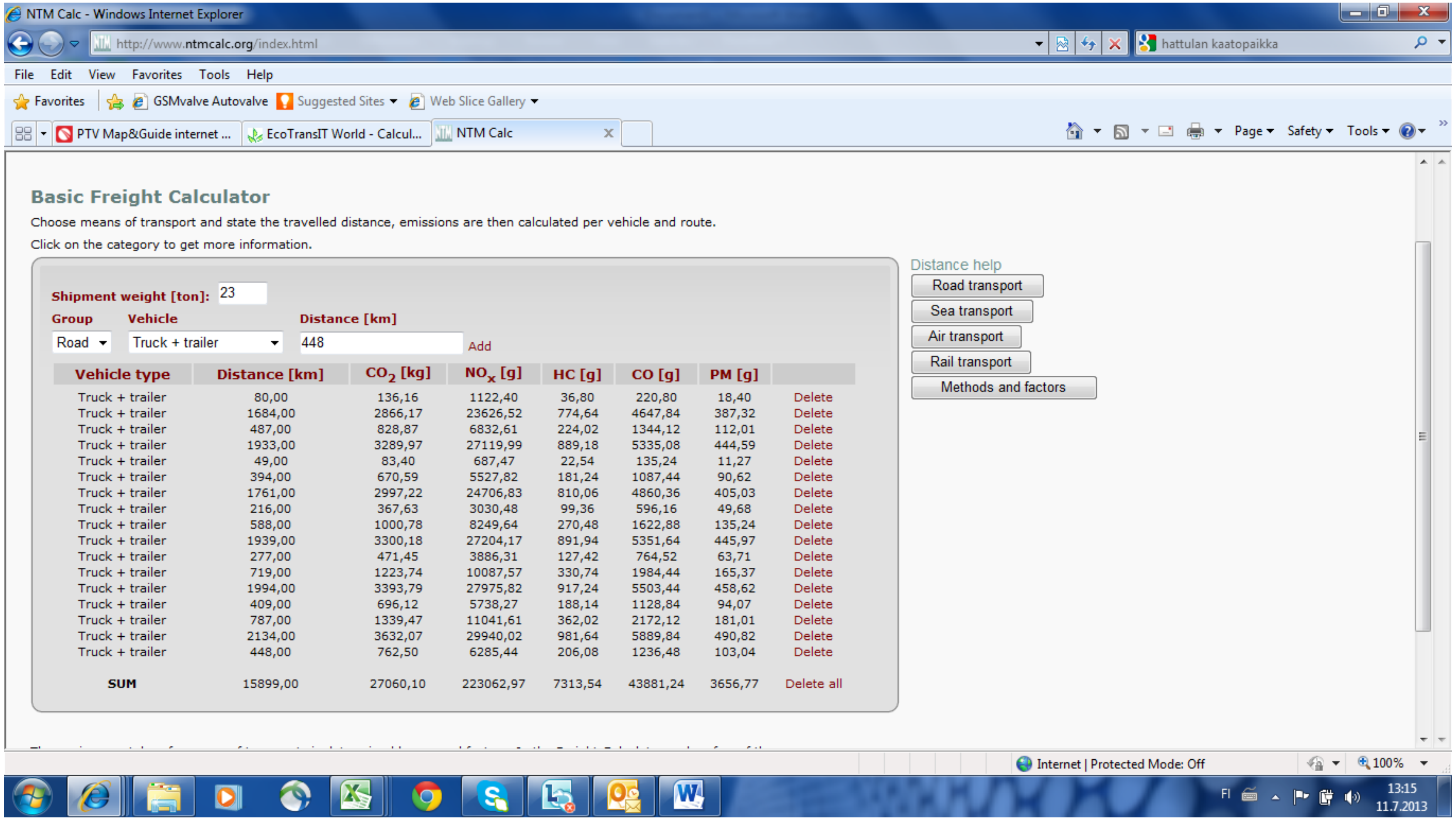
	TC Truck
Truck	0,83
Sum:	0,83

© EcoTransIT.org

Version

Emissions calculation tool

APPENDIX 7 - NTM Calc, example



Basic Freight Calculator

Choose means of transport and state the travelled distance, emissions are then calculated per vehicle and route.

Click on the category to get more information.

Shipment weight [ton]: 23

Group: Road
Vehicle: Truck + trailer
Distance [km]: 448
Add

Vehicle type	Distance [km]	CO_2 [kg]	NO_x [g]	HC [g]	CO [g]	PM [g]	
Truck + trailer	80,00	136,16	1122,40	36,80	220,80	18,40	Delete
Truck + trailer	1684,00	2866,17	23626,52	774,64	4647,84	387,32	Delete
Truck + trailer	487,00	828,87	6832,61	224,02	1344,12	112,01	Delete
Truck + trailer	1933,00	3289,97	27119,99	889,18	5335,08	444,59	Delete
Truck + trailer	49,00	83,40	687,47	22,54	135,24	11,27	Delete
Truck + trailer	394,00	670,59	5527,82	181,24	1087,44	90,62	Delete
Truck + trailer	1761,00	2997,22	24706,83	810,06	4860,36	405,03	Delete
Truck + trailer	216,00	367,63	3030,48	99,36	596,16	49,68	Delete
Truck + trailer	588,00	1000,78	8249,64	270,48	1622,88	135,24	Delete
Truck + trailer	1939,00	3300,18	27204,17	891,94	5351,64	445,97	Delete
Truck + trailer	277,00	471,45	3886,31	127,42	764,52	63,71	Delete
Truck + trailer	719,00	1223,74	10087,57	330,74	1984,44	165,37	Delete
Truck + trailer	1994,00	3393,79	27975,82	917,24	5503,44	458,62	Delete
Truck + trailer	409,00	696,12	5738,27	188,14	1128,84	94,07	Delete
Truck + trailer	787,00	1339,47	11041,61	362,02	2172,12	181,01	Delete
Truck + trailer	2134,00	3632,07	29940,02	981,64	5889,84	490,82	Delete
Truck + trailer	448,00	762,50	6285,44	206,08	1236,48	103,04	Delete
SUM	15899,00	27060,10	223062,97	7313,54	43881,24	3656,77	Delete all

Emissions calculation tool

APPENDIX 8 - CO_2 emissions comparison

ISO country code	**postcode**	**depot**	**Route 1 (km)**	**CO2 kg 1**	**CO2 kg 2**	**CO2 kg 3**	**Route 2 (km)**	**CO2 kg 1**	**CO2 kg 2**	**CO2 kg 3**	**Route 3 (km)**	**CO2 kg 1**	**CO2 kg 2**	**CO2 kg 3**
SVK	SK-903 01	SENEC	881,73	887,81	1490,00	1501,16	1607,19	1653,20	2690,00	2735,11	0	0	0	0
SVN	SI-4000	KRANJ	1327,76	1336,74	2010,00	2260,26	2053,21	2102,13	3400,00	3494,21	0	0	0	0
HUN	HU-2040	BUDAÖRS	1109,61	1061,90	1660,00	1889,22	1835,07	1827,29	2820,00	3123,17	0	0	0	0
POL	PL-80-298	GDANSK	22,00	30,46	39,00	37,44	871,00	898,66	1440,00	1482,44	0	0	0	0
CZE	CZ-742 51	MOSNOV	659,12	656,47	1160,00	1121,62	1384,58	1421,86	2360,00	2357,27	0	0	0	0
CZE	CZ-252 19	RUDNÁ U PRAHY	858,38	891,10	1260,00	1460,32	1727,78	1744,93	2670,00	2941,06	0	0	0	0
AUT	AT-4975	SUBEN	1110,03	1128,64	1670,00	1889,22	1912,85	1933,73	3100,00	3255,93	0	0	0	0
AUT	AT-1235	WIEN	938,76	942,69	1420,00	1598,18	1662,65	1705,95	2810,00	2830,43	0	0	0	0
DEU	D-22113	HAMBURG	79,55	76,76	160	136,16	1683,85	1645,43	2610	2866,17	0	0	0	0
DEU	D-41468	NEUSS	487,09	460,16	800	828,87	1932,98	1913,94	3180	3289,97	49,24	44,67	53	83,4
DEU	D-34225	BAUNATAL	393,53	380,2	670	670,59	1760,78	1747,72	2900	2997,22	215,61	226,37	350	367,63
DEU	D-63741	ASCHAFFENBURG	587,86	588,61	980	1000,78	1939,15	1929,2	3100	3300,18	276,53	291,02	460	471,45
DEU	D-71701	SCHWIEBERDINGEN	719,24	773,9	1200	1223,74	1993,84	1974,99	3250	3393,79	409,17	423,3	650	696,12
DEU	D-76933	LAHR	787	751,4	1310	1339,47	2133,59	2085,97	3470	3632,07	447,9	435,42	720	762,5
BEL	BE-2870	PUURS	647,7	574,01	1070	1102,9	2117,32	2048,26	3470	3603,13	198,67	170,19	320	338,7
NLD	NL-5928 LC	VENLO	496,18	445,03	830	844,19	1965,54	1920,15	3220	3346,13	46,88	42,08	77	79,99
CHE	CH-4133	PRATTELN	896,55	846,29	1480	1526,69	2243,14	2180,86	3630	3817,59	9,51	11,71	14	17,02
ITA	IT-20096	LIMITO DI PIOLTELLO	1208,63	1239,78	2000	2057,72	2431,97	2418,77	3960	4139,26	70,69	66,85	110	120,84
ITA	IT-41100	MODENA	1371,41	1362,44	2100	2333,44	2477,58	2432,45	4050	4217,56	106,77	96,8	160	182,11
ITA	IT-37137	VERONA	1278,5	1283,8	1950	2176,86	2384,67	2353,8	3890	4059,27	4,13	6,15	5,3	6,81
ITA	IT-59100	PRATO	1488,53	1509,09	2290	2534,28	2480,19	2548,62	4150	4220,96	228,52	246,18	360	389,76
FRA	FR-92631	GENNEVILLIERS CEDEX	965,26	867,5	1580	1642,43	2421,95	2366,61	3970	4122,24	514,22	462,29	830	874,83
FRA	FR-59812	LESQUIN CEDEX	768,5	678,44	1250	1308,84	2237,43	2151,73	3650	3807,37	317,19	272,34	500	539,53
FRA	FR-38070	ST. QUENTIN FALLAVIER	1257,27	1181	2240	2139,41	2604,22	2515,77	4650	4432,01	375,75	379,76	1910	639,95
ESP	ES-08191	RUBÍ	1887,51	1770,66	3030	3213,38	3234,88	3107,25	5220	5505,97	168,83	172,03	280	287,64
ESP	ES-20180	OIARTZUN	1775	1596,48	2910	3021,05	3232,11	3097,42	5310	5500,86	559,92	523,05	910	953,12
ESP	ES-28823	COSLADA	2229,72	2121,05	3670	3795,46	3686,83	3621,99	6070	6275,27	754,69	774,04	1260	1285,01
ESP	ES-46469	BENIPARREL	2242,08	2088,93	3610	3815,88	3589,45	3425,52	5800	6108,48	523,41	490,3	860	890,15

Route 1	current production
Route 2	via Baltica
Route 3	current production including use of train

	Methodology	Emissions Tool	Vehicle type	source
CO2 kg 1	HBEFA 3.1, INFRAS AG, Bern	PTV Map&Guide Internet	EURO4	http://mginter.mapandguide.com/frontend/?language=en
CO2 kg 2	INFRAS Bern and IVE mbH Hannover	ECO TransIT World - Calculation	EURO5 (default)	http://www.ecotransit.org/calculation.en.html
CO2 kg 3	common and accepted method for calculation of emissions	NTM Calc	Truck + Trailer	http://www.ntmcalc.org/index.html

emmissions calculations based on 23ton freight weight*

emmissions calculations include ONLY driven km performance on mainland Europe*

Latest update 11.7.2013

APPENDIX 9 - Benelux, worksheet

BELGIUM (BE)	BEL								
DSV ROAD N.V.		km Travemünde	kg CO2	€	Driving time (h)	km Tallinn	kg CO2	€	Driving time (h)
Schoonmansveld 40	train DUISBURG								
BE-2870 PUURS	BE-2870 PUURS	647,7	574,01	777	8,56	2117,32	2048,26	2011,45	36,37
Route length	Toll route	Journey time	Driving time	Toll costs ∑	Motorway	CO2e	CO2e tonnes	CO2e kg	
647.70 km	466.30 km	20:40 h	8:56 h	85.32 EUR	Yes	574.01 kg	1,07	1102,90	
Route length	Toll route	Journey time	Driving time	Toll costs ∑	Motorway	CO2e			
2117.32 km	837.41 km	83:37 h	36:37 h	143.92 EUR	Yes	2048.26 kg	3,47	3603,13	
Route length	Toll route	Journey time	Driving time	Toll costs ∑	Motorway	CO2e			
198.67 km	38.70 km	2:51 h	2:51 h	7.09 EUR	Yes	170.19 kg	0,32	338,70	
THE NETHERLANDS (NL)	NLD								
DSV ROAD B.V.		km Travemünde	kg CO2	€	Driving time (h)	km Tallinn	kg CO2	€	Driving time (h)
Tasmanweg 2	train DUISBURG								
NL-5928 LC VENLO	NL-5928 LC VENLO	496,18	445,03	595	6,43	1965,54	1920,15	1867,26	34,25
Route length	Toll route	Journey time	Driving time	Toll costs ∑	Motorway	CO2e	CO2e tonnes	CO2e kg	
496.18 km	465.90 km	17:44 h	6:43 h	85.25 EUR	Yes	445.03 kg	0,83	844,19	
Route length	Toll route	Journey time	Driving time	Toll costs ∑	Motorway	CO2e			
1965.54 km	837.41 km	81:25 h	34:25 h	143.92 EUR	Yes	1920.15 kg	3,22	3346,13	
Route length	Toll route	Journey time	Driving time	Toll costs ∑	Motorway	CO2e			
46.88 km	38.70 km	0:40 h	0:40 h	7.09 EUR	Yes	42.08 kg	0,077	79,99	
Sources:									
PTV Map&Guide internet 2013									
Eco TransIT World 2013									
NTM Calc 2013									
* Kuosmanen, Naumanen, Ravantti 2013									
latest update 19.7.2013									

APPENDIX 10 - Germany, worksheet

GERMANY (DE)	DEU	**km Travemünde**	**kg CO2**	**€**	**Driving time (h)**	**km Tallinn**	**kg CO2**	**€**	**Driving time (h)**
DSV ROAD GMBH									
Pinkertweg 12 a									
D-22113 HAMBURG	**D-22113 HAMBURG**	**79,55**	**76,76**	**95,46**	**1,17**	**1683,85**	**1645,43**	**1599,6575**	**30,47**
Route length	Toll route		Driving time	Toll costs ∑	Motorway	CO2e	CO2e tonnes	CO2e kg	
79.55 km	76.50 km		1:17 h	13.98 EUR	Yes	76.76 kg	0,16	136,16	
Route length	Toll route	Journey time	Driving time	Toll costs ∑	Motorway	CO2e			
1683.85 km	561.81 km	66:02 h	30:47 h	94.13 EUR	Yes	1645.43 kg	2,61	2866,17	
DSV ROAD GMBH		**km Travemünde**	**kg CO2**	**€**	**Driving time (h)**	**km Tallinn**	**kg CO2**	**€**	**Driving time (h)**
Am Fuchsberg 3	train DUISBURG								
D-41468 NEUSS	**D-41468 NEUSS**	**487,09**	**460,16**	**584,51**	**6,4**	**1932,98**	**1913,94**	**1836,33**	**34,03**
Route length	Toll route		Driving time	Toll costs ∑	Motorway	CO2e	CO2e tonnes	CO2e kg	
487.09 km	484.30 km		6:40 h	88.60 EUR	Yes	460.16 kg	0,8	828,87	
Route length	Toll route	Journey time	Driving time	Toll costs ∑	Motorway	CO2e			
1932.98 km	810.81 km	70:03 h	34:03 h	139.70 EUR	Yes	1913.94 kg	3,18	3289,97	
Route length	Toll route	Journey time	Driving time	Toll costs ∑	Motorway	CO2e			
49.24 km	44.80 km	0:45 h	0:45 h	8.20 EUR	Yes	44.67 kg	0,053	83,4	
DSV ROAD GMBH		**km Travemünde**	**kg CO2**	**€**	**Driving time (h)**	**km Tallinn**	**kg CO2**	**€**	**Driving time (h)**
Fehrenberger Strasse 2	train DUISBURG								
D-34225 BAUNATAL	**D-34225 BAUNATAL**	**393,53**	**380,2**	**472,24**	**5,3**	**1760,78**	**1747,72**	**1672,74**	**31,48**
Route length	Toll route		Driving time	Toll costs ∑	Motorway	CO2e	CO2e tonnes	CO2e kg	
393.53 km	392.10 km		5:30 h	71.74 EUR	Yes	380.20 kg	0,67	670,59	
Route length	Toll route	Journey time	Driving time	Toll costs ∑	Motorway	CO2e			
1760.78 km	639.91 km	67:48 h	31:48 h	108.43 EUR	Yes	1747.72 kg	2,9	2997,22	
Route length	Toll route	Journey time	Driving time	Toll costs ∑	Motorway	CO2e			
215.61 km	204.20 km	3:08 h	3:08 h	37.38 EUR	Yes	226.37 kg	0,35	367,63	
DSV ROAD GMBH		**km Travemünde**	**kg CO2**	**€**	**Driving time (h)**	**km Tallinn**	**kg CO2**	**€**	**Driving time (h)**
Römerstrasse 22	train DUISBURG								
D-63741 ASCHAFFENBURG	**D-63741 ASCHAFFENBURG**	**587,86**	**588,61**	**705,43**	**8,11**	**1939,15**	**1929,2**	**1842,19**	**34,16**
Route length	Toll route	Journey time	Driving time	Toll costs ∑	Motorway	CO2e	CO2e tonnes	CO2e kg	
587.86 km	574.10 km	8,52	8:11 h	105.05 EUR	Yes	588.61 kg	0,98	1000,78	
Route length	Toll route	Journey time	Driving time	Toll costs ∑	Motorway	CO2e			
1939.15 km	798,06	70:16 h	34:16 h	138.83 EUR	Yes	1929.20 kg	3,1	3300,18	
Route length	Toll route	Journey time	Driving time	Toll costs ∑	Motorway	CO2e			
276.53 km	268.10 km	3:50 h	3:50 h	49.02 EUR	Yes	291.02 kg	0,46	471,45	
DSV STUTTGART GMBH & CO		**km Travemünde**	**kg CO2**	**€**	**Driving time (h)**	**km Tallinn**	**kg CO2**	**€**	**Driving time (h)**
Marktgröninger Strasse 50	train DUISBURG								
D-71701 SCHWIEBERDINGEN	**D-71701 SCHWIEBERDINGEN**	**719,24**	**773,9**	**863,09**	**10,01**	**1993,84**	**1974,99**	**1894,15**	**34,53**
Route length	Toll route		Driving time	Toll costs ∑	Motorway	CO2e	CO2e tonnes	CO2e kg	
719.24 km	706.40 km	21,44	10:01 h	129.28 EUR	Yes	773.90 kg	1,2	1223,74	
Route length	Toll route	Journey time	Driving time	Toll costs ∑	Motorway	CO2e			
1993.84 km	867.91 km	70:53 h	34:53 h	150.15 EUR	Yes	1974.99 kg	3,25	3393,79	
Route length	Toll route	Journey time	Driving time	Toll costs ∑	Motorway	CO2e			
409.17 km	400.40 km	6:25 h	5:40 h	73.23 EUR	Yes	423.30 kg	0,65	696,12	
DSV ROAD GMBH		**km Travemünde**	**kg CO2**	**€**	**Driving time (h)**	**km Tallinn**	**kg CO2**	**€**	**Driving time (h)**
Einsteinallee 12	train DUISBURG								
D-76933 LAHR	**D-76933 LAHR**	**787**	**751,4**	**944,4**	**10,42**	**2133,59**	**2085,97**	**2026,91**	**36,41**
Route length	Toll route		Driving time	Toll costs ∑	Motorway	CO2e	CO2e tonnes	CO2e kg	
787.00 km	784.60 km	22,32	10:42 h	143.58 EUR	Yes	751.40 kg	1,31	1339,47	
Route length	Toll route	Journey time	Driving time	Toll costs ∑	Motorway	CO2e			
2133.59 km	1011.91 km	83:41 h	36:41 h	176.48 EUR	Yes	2085.97 kg	3,47	3632,07	
Route length	Toll route	Journey time	Driving time	Toll costs ∑	Motorway	CO2e			
447.90 km	437.30 km	6:52 h	6:07 h	79.99 EUR	Yes	435.42 kg	0,72	762,5	
Sources:									
PTV Map&Guide internet 2013									
Eco TransIT World 2013									
NTM Calc 2013									
* Kuosmanen, Naumanen, Ravantti 2013									
latest update 19.7.2013									

APPENDIX 11 - South, worksheet

ITALY (IT)	ITA	km Travemünde	kg CO2	€	Driving time (h)	km Tallinn		€	Driving time (h)
SAIMA AVANDERO S.p.A.									
Via Dante, 134	train Novara (Milan)								
IT-20096 LIMITO DI PIOLTELLO	IT-20096 LIMITO DI PIOLTELLO	1208,63	1239,78	1450,4	17,11	2431,97		2310,3715	41,32
Route length	Toll route	Journey time	Driving time	Toll costs ∑	Motorway	CO2e	CO2e kg	CO2e kg	
1208.63 km	1151.47 km	29:41 h	17:11 h	347.48 EUR	Yes	1239,78	2000	2057,72	2
Route length	Toll route	Journey time	Driving time	Toll costs ∑	Motorway	CO2e	0		
2431.97 km	1255.08 km	89:17 h	41:32 h	357.42 EUR	Yes	2418,77	3960	4139,26	3,96
Route length	Toll route	Journey time	Driving time	Toll costs ∑	Motorway	CO2e	0		
70.69 km	35.78 km	1:16 h	1:16 h	6.07 EUR	Yes	66,85	110	120,84	0,11
SAIMA AVANDERO S.p.A.		km Travemünde	kg CO2	€	Driving time (h)	km Tallinn		€	Driving time (h)
Via V. Brigatti, 25/A	train Verona								
IT-41100 MODENA	IT-41100 MODENA	1371,41	1362,44	1645,69	18,52	2477,58		2353,701	41,39
Route length	Toll route	Journey time	Driving time	Toll costs ∑	Motorway	CO2e	CO2e kg	CO2e kg	
1371.41 km	1360.78 km	42:22 h	18:52 h	309.75 EUR	Yes	1362,44	2100	2333,44	2,1
Route length	Toll route	Journey time	Driving time	Toll costs ∑	Motorway	CO2e	0		
2477.58 km	1346.79 km	89:25 h	41:39 h	298.19 EUR	Yes	2432,45	4050	4217,56	4,05
Route length	Toll route	Journey time	Driving time	Toll costs ∑	Motorway	CO2e	0		
106.77 km	90.79 km	1:52 h	1:52 h	15.39 EUR	Yes	96,8	160	182,11	0,16
SAIMA AVANDERO S.p.A.		km Travemünde	kg CO2	€	Driving time (h)	km Tallinn		€	Driving time (h)
Via Sommacampagna, 22/A	train Verona								
IT-37137 VERONA	IT-37137 VERONA	1278,5	1283,8	1534,2	17,26	2384,67		2265,4365	40,14
Route length	Toll route	Journey time	Driving time	Toll costs ∑	Motorway	CO2e	CO2e kg	CO2e kg	
1278.50 km	1273.90 km	29:56 h	17:26 h	295.01 EUR	Yes	1283,8	1950	2176,86	1,95
Route length	Toll route	Journey time	Driving time	Toll costs ∑	Motorway	CO2e	0		
2384.67 km	1259.91 km	87:14 h	40:14 h	283.45 EUR	Yes	2353,8	3890	4059,27	3,89
Route length	Toll route	Journey time	Driving time	Toll costs ∑	Motorway	CO2e	0		
4.13 km	0.00 km	0:08 h	0:08 h	0.00 EUR	No	6,15	5,3	6,81	0,0053
SAIMA AVANDERO S.p.A.		km Travemünde	kg CO2	€	Driving time (h)	km Tallinn		€	Driving time (h)
Interporto della Toscana Centrale									
Via di Gonfienti, 4/36	train Verona								
IT-59100 PRATO	IT-59100 PRATO	1488,53	1509,09	1786,236	20,29	2480,19		2356,1805	43,28
Route length	Toll route	Journey time	Driving time	Toll costs ∑	Motorway	CO2e	CO2e kg	CO2e kg	
1488.53 km	1483.35 km	43:59 h	20:29 h	330.53 EUR	Yes	1509,09	2290	2534,28	2,29
Route length	Toll route	Journey time	Driving time	Toll costs ∑	Motorway	CO2e	0		
2480.19 km	1171.64 km	91:13 h	43:28 h	283.67 EUR	Yes	2548,62	4150	4220,96	4,15
Route length	Toll route	Journey time	Driving time	Toll costs ∑	Motorway	CO2e	0		
228.52 km	220.02 km	3:29 h	3:29 h	37.31 EUR	Yes	246,18	360	389,76	0,36

continued

SWITZERLAND (CH)	CHE	km Travemünde	kg CO2	€	Driving time (h)	km Tallinn	kg CO2	€	Driving time (h)
DSV LOGISTICS SA									
Salinenstrasse 61	train Weil am Rhein (Basel)								
CH-4133 PRATTELN	CH-4133 PRATTELN	896,55	846,29	1075,86	12,11	2243,14	2180,86	2130,983	38,11
Route length	Toll route	Journey time	Driving time	Toll costs ∑	Motorway	CO2e kg	CO2e kg	CO2e kg	1000
896.55 km	867.50 km	23:56 h	12:11 h	165.38 EUR	Yes	846,29	1480	1526,69	1,48
Route length	Toll route	Journey time	Driving time	Toll costs ∑	Motorway	CO2e	0		
2243.14 km	1094.70 km	85:11 h	38:11 h	197.93 EUR	Yes	2180,86	3630	3817,59	3,63
Route length	Toll route	Journey time	Driving time	Toll costs ∑	Motorway	CO2e	0		
9.51 km	9.50 km	0:13 h	0:13 h	6.98 EUR	Yes	11,71	14	17,02	0,014
RANSKA (FR)	FRA	km Travemünde	kg CO2	€	Driving time (h)	km Tallinn		€	Driving time (h)
DSV S.A. (Paris)									
C.E. no 116 – Route du Bassin no 1	train Duisburg								
FR-92631 GENNEVILLIERS CEDEX	FR-92631 GENNEVILLIERS CEDEX	965,26	867,5	1061,79	13,18	2421,95		2300,8525	40,45
Route length	Toll route	Journey time	Driving time	Toll costs ∑	Motorway	CO2e	CO2e kg	CO2e kg	
965.26 km	630.21 km	25:03 h	13:18 h	117.27 EUR	Yes	867,5	1580	1642,43	1,58
Route length	Toll route	Journey time	Driving time	Toll costs ∑	Motorway	CO2e	0		
2421.95 km	1055.02 km	88:30 h	40:45 h	186.06 EUR	Yes	2366,61	3970	4122,24	3,97
Route length	Toll route	Journey time	Driving time	Toll costs ∑	Motorway	CO2e	0		
514.22 km	202.61 km	7:57 h	7:12 h	41.54 EUR	Yes	462,29	830	874,83	0,83
DSV S.A. (Lille)									
Parc d’activité du Mélantois		km Travemünde	kg CO2	€	Driving time (h)	km Tallinn		€	Driving time (h)
Rue des Séquoias									
BP 335	train Duisburg								
FR-59812 LESQUIN CEDEX	FR-59812 LESQUIN CEDEX	768,5	678,44	845,35	10,34	2237,43		2125,5585	38,13
Route length	Toll route	Journey time	Driving time	Toll costs ∑	Motorway	CO2e	CO2e kg	CO2e kg	
768.50 km	466.30 km	22:19 h	10:34 h	85.32 EUR	Yes	678,44	1250	1308,84	1,25
Route length	Toll route	Journey time	Driving time	Toll costs ∑	Motorway	CO2e	0		
2237.43 km	837.41 km	85:13 h	38:13 h	144.28 EUR	Yes	2151,73	3650	3807,37	3,65
Route length	Toll route	Journey time	Driving time	Toll costs ∑	Motorway	CO2e	0		
317.19 km	38.70 km	4:27 h	4:27 h	7.09 EUR	Yes	272,34	500	539,53	0,5
DSV S.A. (Lyon)		km Travemünde	kg CO2	€	Driving time (h)	km Tallinn		€	Driving time (h)
104, rue Santoyon									
Parc d’activités de Chesnes – Chesnes Le Loup	train Novara (Milan)								
FR-38070 ST. QUENTIN FALLAVIER	FR-38070 ST. QUENTIN FALLAVIER	1257,27	1181	1383,00	16,59	2604,22		2474,009	43
Route length	Toll route	Journey time	Driving time	Toll costs ∑	Motorway	CO2e	CO2e kg	CO2e kg	
1257.27 km	1184.56 km	29:29 h	16:59 h	242.09 EUR	Yes	1181	2240	2139,41	2,24
Route length	Toll route	Journey time	Driving time	Toll costs ∑	Motorway	CO2e	0		
2604.22 km	1411.77 km	90:45 h	43:00 h	274.64 EUR	Yes	2515,77	4650	4432,01	4,65
Route length	Toll route	Journey time	Driving time	Toll costs ∑	Motorway	CO2e	0		
375.75 km	296.90 km	6:27 h	5:42 h	329.93 EUR	Yes	379,76	1910	639,95	1,91

continued

ESPANJA (ES)	ESP	km Travemünde	kg CO2	€	Driving time (h)	km Tallinn		€	Driving time (h)
DSV Road Spain, S.A.U. (Barcelona)									
Polígono Industrial Molí de la Bastida									
Sector W, c/Pagesía, s/n	train FR-66160 Le Boulou								
E-08191 RUBÍ	ES-08191 RUBÍ	1887,51	1770,66	2076	25,25	3234,88		3073,136	51,29
Route length	Toll route	Journey time	Driving time	Toll costs ∑	Motorway	CO2e	CO2e kg	CO2e kg	
1887.51 km	1740.94 km	49:40 h	25:25 h	358.43 EUR	Yes	1770,66	3030	3213,38	3,03
Route length	Toll route	Journey time	Driving time	Toll costs ∑	Motorway	CO2e	0		
3234.88 km	1968.55 km	121:59 h	51:29 h	390.69 EUR	Yes	3107,25	5220	5505,97	5,22
Route length	Toll route	Journey time	Driving time	Toll costs ∑	Motorway	CO2e	0		
168.83 km	142.12 km	2:27 h	2:27 h	20.25 EUR	Yes	172,03	280	287,64	0,28
DSV Road Spain, S.A.U. (Irun)		km Travemünde	kg CO2	€	Driving time (h)	km Tallinn		€	Driving time (h)
Parque Logistico Lanbarren									
Apdo no 77	train FR-66160 Le Boulou								
ES-20180 OIARTZUN	ES-20180 OIARTZUN	1775	1596,48	1952,5	24,33	3232,11		3070,5045	52,03
Route length	Toll route	Journey time	Driving time	Toll costs ∑	Motorway	CO2e	CO2e kg	CO2e kg	
1775.00 km	1251.76 km	49:09 h	24:33 h	299.57 EUR	Yes	1596,48	2910	3021,05	2,91
Route length	Toll route	Journey time	Driving time	Toll costs ∑	Motorway	CO2e	0		
3232.11 km	1676.97 km	111:33 h	52:03 h	368.07 EUR	Yes	3097,42	5310	5500,86	5,31
Route length	Toll route	Journey time	Driving time	Toll costs ∑	Motorway	CO2e	0		
559.92 km	450.58 km	8:25 h	7:40 h	106.20 EUR	Yes	523,05	910	953,12	0,91
DSV Road Spain, S.A.U. (Madrid)		km Travemünde	kg CO2	€	Driving time (h)	km Tallinn		€	Driving time (h)
Avenida de la Cañada 64-66									
Nave 1A y 1B	train FR-66160 Le Boulou								
ES-28823 COSLADA	ES-28823 COSLADA	2229,72	2121,05	2453	30,51	3686,83		3502,4885	58,21
Route length	Toll route	Journey time	Driving time	Toll costs ∑	Motorway	CO2e	CO2e kg	CO2e kg	
2229.72 km	1449.53 km	66:07 h	30:51 h	327.02 EUR	Yes	2121,05	3670	3795,46	3,67
Route length	Toll route	Journey time	Driving time	Toll costs ∑	Motorway	CO2e	0		
3686.83 km	1874.73 km	139:51 h	58:21 h	395.51 EUR	Yes	3621,99	6070	6275,27	6,07
Route length	Toll route	Journey time	Driving time	Toll costs ∑	Motorway	CO2e	0		
754.69 km	406.16 km	22:16 h	10:31 h	56.90 EUR	Yes	774,04	1260	1285,01	1,26
DSV Road Spain, S.A.U. (Valencia)		km Travemünde	kg CO2	€	Driving time (h)	km Tallinn		€	Driving time (h)
Camí Vell d'Albal no 53	train FR-66160 Le Boulou								
ES-46469 BENIPARREL	ES-46469 BENIPARREL	2242,08	2099,93	2466,288	30,21	3589,45		3409,9775	56,25
Route length	Toll route	Journey time	Driving time	Toll costs ∑	Motorway	CO2e	CO2e kg	CO2e kg	
2242.08 km	2048.50 km	66:27 h	30:21 h	401.12 EUR	Yes	2088,93	3610	3815,88	3,61
Route length	Toll route	Journey time	Driving time	Toll costs ∑	Motorway	CO2e	0		
3589.45 km	2276.11 km	127:40 h	56:25 h	433.38 EUR	Yes	3425,52	5800	6108,48	5,8
Route length	Toll route	Journey time	Driving time	Toll costs ∑	Motorway	CO2e	0		
523.41 km	449.68 km	8:09 h	7:24 h	62.94 EUR	Yes	490,3	860	890,15	0,86
Sources:									
PTV Map&Guide internet 2013									
Eco TransIT World 2013									
NTM Calc 2013									
* Naumanen, Ravantti 2013									
latest update 16.7.2013									

APPENDIX 12 - Travemünde route, worksheet [confidential, total 3 pages]

APPENDIX 13 - Travemünde route 2015, worksheet [confidential, total 2 pages]

APPENDIX 14 - Travemünde route 2013 & 2015, database [confidential, total 3 pages]

APPENDIX 15 - East, worksheet

	ISO COUNTRY CODE										
SLOVAKIA (SK)	SVK	**km Gdynia**	**kg CO2**	**€**	**Driving time (h)**	**Journey time (h)**	**km Tallinn**	**kg CO2**	**€**	**Driving time (h)**	**Journey time (h)**
DSV ROAD s.r.o.											
Dialnicna 6											
SK-903 01 SENEC	**SK-903 01 SENEC**	**881,73**	**887,81**	**661**	**15,28**	**27,58**	**1607,19**	**1653,2**	**1044,6735**	**31,43**	**67,43**
Route length	Toll route	Journey time	Driving time	Toll costs ∑	Motorway		CO2e kg	CO2e tonnes	CO2e kg		
881.73 km	368.06 km	27:58 h	15:28 h	50.90 EUR	Yes		887.81 kg	1,49	1501,16		
Route length	Toll route	Journey time	Driving time	Toll costs ∑	Motorway		CO2e				
1607.19 km	332.40 km	67:43 h	31:43 h	47.51 EUR	Yes		1653.20 kg	2,69	2735,11		
SLOVENIA (SI)	SVN	**km Gdynia**	**kg CO2**	**€**	**Driving time (h)**	**Journey time (h)**	**km Tallinn**	**kg CO2**	**€**	**Driving time (h)**	**Journey time (h)**
DSV Road d.o.o.											
Struzevo 90											
SI-4000 KRANJ	**SI-4000 KRANJ**	**1327,76**	**1336,74**	**996**	**21,06**	**55,36**	**2053,21**	**2102,13**	**1334,5865**	**37,2**	**84,2**
Route length	Toll route	Journey time	Driving time	Toll costs ∑	Motorway		CO2e	CO2e tonnes	CO2e kg		
1327.76 km	794.36 km	55:36 h	21:06 h	195.52 EUR	Yes		1336.74 kg	2,01	2260,26		
Route length	Toll route	Journey time	Driving time	Toll costs ∑	Motorway		CO2e				
2053.21 km	758.71 km	84:20 h	37:20 h	192.12 EUR	Yes		2102.13 kg	3,4	3494,21		
HUNGARY (HU)	HUN	**km Gdynia**	**kg CO2**	**€**	**Driving time (h)**	**Journey time (h)**	**km Tallinn**	**kg CO2**	**€**	**Driving time (h)**	**Journey time (h)**
DSV ROAD KFT (Budapest)											
Vasút Utca 11											
H-2040 BUDAÖRS	**HU-2040 BUDAÖRS**	**1109,61**	**1061,9**	**832**	**17,35**	**41,05**	**1835,07**	**1827,29**	**1192,7955**	**33,49**	**80,49**
Route length	Toll route	Journey time	Driving time	Toll costs ∑	Motorway		CO2e	CO2e tonnes	CO2e kg		
1109.61 km	604.08 km	41:05 h	17:35 h	82.98 EUR	Yes		1061.90 kg	1,66	1889,22		
Route length	Toll route	Journey time	Driving time	Toll costs ∑	Motorway		CO2e				
1835.07 km	568.43 km	80:49 h	33:49 h	79.58 EUR	Yes		1827.29 kg	2,82	3123,17		
POLAND (PL)	POL	**km Gdynia**	**kg CO2**	**€**	**Driving time (h)**	**Journey time (h)**	**km Tallinn**	**kg CO2**	**€**	**Driving time (h)**	**Journey time (h)**
DSV ROAD Sp. z o.o.											
Ul. Bysewska 18											
PL-80-298 GDANSK	**PL-80-298 GDANSK**	**21,83**	**30,46**	**16,3725**	**0,4**	**0,4**	**871,04**	**898,66**	**566,176**	**18,11**	**41,41**
Route length	Toll route	Journey time	Driving time	Total costs ∑	Motorway		CO2e	CO2e tonnes	CO2e kg		
21.83 km	0.00 km	0:40 h	0:40 h	0.00 EUR	No		30.46 kg	0,039	37,44		
Route length	Toll route	Journey time	Driving time	Total costs ∑	Motorway		CO2e				
871.04 km	51.71 km	41:41 h	18:11 h	4.41 EUR	Yes		898.66 kg	1,44	1482,44		

continued

Czech Republic (CZ)	CZE	**km Gdynia**	**kg CO2**	**€**	**Driving time (h)**	**Journey time (h)**	**km Tallinn**	**kg CO2**	**€**	**Driving time (h)**	**Journey time (h)**
DSV ROAD A.S.											
Obchodne podnikatelsky areal 327/22											
CZ-742 51 MOSNOV	**CZ-742 51 MOSNOV**	**659,12**	**656,47**	**494,34**	**11,37**	**23,22**	**1384,58**	**1421,86**	**899,977**	**27,51**	**63,06**
Route length	Toll route	Journey time	Driving time	Total costs ∑	Motorway		CO2e	CO2e tonnes	CO2e kg		
659.12 km	162.35 km	23:22 h	11:37 h	16.86 EUR	Yes		656.47 kg	1,16	1121,62		
Route length	Toll route	Journey time	Driving time	Total costs ∑	Motorway		CO2e				
1384.58 km	126.70 km	63:06 h	27:51 h	13.54 EUR	Yes		1421.86 kg	2,36	2357,27		
DSV ROAD A.S. (Only a terminal)	CZE	**km Gdynia**	**kg CO2**	**€**	**Driving time (h)**	**Journey time (h)**	**km Tallinn**	**kg CO2**	**€**	**Driving time (h)**	**Journey time (h)**
K Vypichu 1119											
CZ-252 19 RUDNÁ U PRAHY	**CZ-252 19 RUDNÁ U PRAHY**	**858,38**	**891,1**	**643,785**	**14,46**	**27,16**	**1727,78**	**1744,93**	**1123,057**	**31,5**	**67,5**
Route length	Toll route	Journey time	Driving time	Total costs ∑	Motorway		CO2e	CO2e tonnes	CO2e kg		
858.38 km	535.82 km	27:16 h	14:46 h	97.88 EUR	Yes		891.10 kg	1,26	1460,32		
Route length	Toll route	Journey time	Driving time	Total costs ∑	Motorway		CO2e				
1727.78 km	564.51 km	67:50 h	31:50 h	99.85 EUR	Yes		1744.93 kg	2,67	2941,06		
AUSTRIA (AT)	AUT	**km Gdynia**	**kg CO2**	**€**	**Driving time (h)**	**Journey time (h)**	**km Tallinn**	**kg CO2**	**€**	**Driving time (h)**	**Journey time (h)**
DSV ÖSTERREICH SPEDITION GMBH											
Etzelshofen 14											
AT-4975 SUBEN	**AT-4975 SUBEN**	**1110,03**	**1128,64**	**833**	**18,07**	**41,37**	**1912,85**	**1933,73**	**1243,4**	**35,19**	**71,19**
Route length	Toll route	Journey time	Driving time	Toll costs ∑	Motorway		CO2e	CO2e tonnes	CO2e kg		
1110.03 km	803.25 km	41:37 h	18:07 h	140.79 EUR	Yes		1128.64 kg	1,67	1889,22		
Route length	Toll route	Journey time	Driving time	Toll costs ∑	Motorway		CO2e				
1912.85 km	626.28 km	71:19 h	35:19 h	168.80 EUR	Yes		1933.73 kg	3,1	3255,93		
	AUT	**km Gdynia**	**kg CO2**	**€**	**Driving time (h)**	**Journey time (h)**	**km Tallinn**	**kg CO2**	**€**	**Driving time (h)**	**Journey time (h)**
DSV ÖSTERREICH SPEDITION GMBH											
Siebenhirtenstrasse 11											
AT-1235 WIEN	**AT-1235 WIEN**	**938,76**	**942,69**	**704**	**15,51**	**28,21**	**1662,65**	**1705,95**	**1080,7225**	**32,03**	**68,03**
Route length	Toll route	Journey time	Driving time	Toll costs ∑	Motorway		CO2e	CO2e tonnes	CO2e kg		
938.76 km	408.60 km	28:21 h	15:51 h	81.64 EUR	Yes		942.69 kg	1,42	1598,18		
Route length	Toll route	Journey time	Driving time	Toll costs ∑	Motorway		CO2e				
1662.65 km	372.95 km	68:03 h	32:03 h	78.32 EUR	Yes		1705.95 kg	2,81	2830,43		
Sources:											
PTV Map&Guide internet 2013											
Eco TransIT World 2013											
NTM Calc 2013											
* Kohi 2013											
latest update 15.7.2013											

APPENDIX 16 - Gdynia route, worksheet [confidential, total 2 pages]

APPENDIX 17 - Gdynia route 2015, worksheet [confidential, total 2 pages]

APPENDIX 18 - Gdynia route 2013 & 2015, database [confidential, total 2 pages]

APPENDIX 19 - Gdynia, Travemünde 2013 & 2015, database [confidential, total 2 pages]

APPENDIX 20 - Rail calculations [confidential, total 1 page]

APPENDIX 21 - Rail Baltica, worksheet [confidential, total 1 page]

APPENDIX 22 - Rail Baltica, database [confidential, total 1 page]

APPENDIX 23 - BRF Key [confidential, total 1 page]

APPENDIX 24 - Recommendation, further study, Gdynia route - worksheet [confidential, total 2 pages]