Juha Saranen (Editor)

INTERMODAL TRANSPORTATION IN EMERGENCY SITUATIONS IN THE GULF OF FINLAND

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FACULTY OF TECHNOLOGY MANAGEMENT
DEPARTMENT OF INDUSTRIAL MANAGEMENT

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Department of Industrial Engineering and Management
Kouvola Research Unit
Research Report 223

Intermodal transportation in emergency situations in the Gulf of Finland

Juha Saranen (Editor)

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Foreword

This report was written as a part of STOCA project (STOCA = Study of cargo flows in the Gulf of Finland in emergency situations). As the economic crisis at the end of year 2008 had already hit Europe as STOCA started in spring 2009, it was evident that research focusing on transportation risks, rather than seeking extra capacity from existing transportation routes, would be relevant. However, we have been reminded of the timeliness of our research subject several times during the project. It is well known that Finland is like an island in term of logistics, as our trade is heavily dependent on seaborne transportation. Firstly, the ice conditions in the Gulf of Finland during winter 2009 - 2010 were giving hard time for the ice breakers. Secondly, in March 2010 Finnish sea ports were closed due to a labor strikes for 16 days. In Norway, also in March, sixteen rail wagons rolled eight kilometers uncontrolled towards Oslo harbor. Some of the wagons crashed finally into a terminal, killing three people and causing problems in airplane fuel delivery. The vulnerability of air traffic was demonstrated in April 2010, when most of European flights were canceled for roughly a week, because a volcano erupting in Iceland. During late April 2010 world faced yet another large-scale oil spill, this time in the Gulf of Mexico (accident, which is still not in full control). It is unknown, what kind of direct and indirect effects this terrible accident will have on nature and economy; what is known for sure is that total price of this unwanted situation will exceed billion USD. These mentioned cases give motivation for our research work – new solutions and more robust systems in general are needed in transportation logistics in order to cope with increased uncertainty. For example, railway tunnel between Tallinn and Helsinki is said to be unprofitable with current level of knowledge, but uncertainty and opportunity costs could change it as viable investment in the future.

We would like to thank the partners who have provided the financial means to concentrate our research effort on this interesting and timely research topic: the Central Baltic INTERREG IV A program 2007-2013 of the European Union, European Regional Development Fund, Regional Council of Southwest Finland, Estonian Maritime Academy and National Emergency Supply Agency. Completing this report would not have been possible without the helpfulness and hospitality of the numerous hosts we have been able to visit both in Estonia as well as in Finland. A special thank you goes to the Estonian Maritime Academy for enabling the excursions in Estonia. We would also like to thank the researchers who have been involved in the process of writing the report (in alphabetical order): Jouko Karttunen, Milla Laisi, Lauri Lättilä and Bulcsu Szekely.

During June 2010 in Kouvola,

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Abstract:

During the last decade globalization has resulted in larger volumes of foreign trade. As a result maritime transportation and containerization have increased. In Finland over 75 percent of trade volumes flow through sea ports. Thus, the functionality of the ports and supporting infrastructure plays an important role in the national economy and security of supply.

Although, sea is the main mode of transportation in the Gulf of Finland region, there does not exist studies on how the maritime volumes could be handled, if the operational environment changes unexpectedly. The objective of this report is to identify possible risks in transportation routes that use sea ports in the Gulf of Finland and to evaluate the functionality of the transportation system under selected risk scenarios by using system dynamics simulation.

According to the literature review conducted, the functionality of a maritime transportation system is affected by the form co-operation and information exchange between the parties involved in the system. Previous research has mainly concentrated on providing sufficient infrastructure for the expected growth in international transportation flows. Special risks identified for international ports include foreign containers and recreational vessels.

Based on our case studies in the Gulf of Finland region different ports and railway yards have differing risk profiles depending on the infrastructure and cargo handled. Special kind of risk is connected to spillage of railway wagons, as a large amount of Russian oil and liquid bulk is transported via Finland and Estonia. The case studies also highlight the significance of logistics operator characteristics in emergency situations: Multinational firms can change their transportation flows in case of disruptions, while local operators might be forced to close their business down for malfunctioning period.

According to our evaluation of a railway tunnel between Tallinn and Helsinki. the tunnel seems unprofitable, because of the high construction cost. Sensitivity analysis (Monte Carlo simulations) shows that in very rare circumstances profitability could also be achieved. However, operating it would be economically feasible. Furthermore, a calculation which includes the effect of decreasing the nationwide financial losses due to labor strikes (or other equivalent unwanted situation, like large-scale oil spill) supports building of the tunnel.

Based on our analysis Finnish privatization and deregulation of freight transportation has proceeded in line with EU legislation. This affects the government’s ability to react in emergency situations as rail remains the only transport mode which it has direct control of.

Our simulation results stress the impact of hinterland on the performance of the transportation system. In the short term the capacity of alternative transportation routes is determined by the handling capacity in the sea port. As storage space is used the sea port capacity is determined by the hinterland capacity. In container traffic concentration of handling capacity increases vulnerability of the transportation system. This also decreases the flexibility in rerouting containers. Container traffic needed to maintain security of supply can be handled given that a sufficient amount of platforms are available. Based on the simulation experiments, a long time is needed to return to normal situation in the chain after the local crisis, e.g. in the sea port is over. Westbound transit through Finland and Estonia uses mainly rail. In transporting bulk, such as oil, disruptions can prepared for by inventories located in sea port. In other types of cargo disruptions have immediate effects. Based on our findings, the functionality of sea ports should not be analyzed in isolation, but merely as a part of a wider transportation chain.

Keywords: Supply chain management**,** intermodal transportation, sea ports, efficiency, containerization, system dynamics, simulation

Tiivistelmä:

Viimeisimmän vuosikymmenen aikana globalisaatio on johtanut kansainvälisen kaupan kasvuun. Tämän seurauksena merikuljetusten määrä ja konttien käyttö on lisääntynyt. Suomen ulkomaan kaupan volyymista yli 75 prosenttia kulkee satamien kautta. Näin ollen satamien ja niitä tukevien järjestelmien toimivuus on merkittävää kansantalouden ja huoltovarmuuden kannalta.

Vaikka meri on yleisin kuljetusmuoto Suomenlahden alueella, aiemmin ei ole tutkittu, kuinka merikuljetuksen volyymit voitaisiin käsitellä, jos toiminnallinen ympäristö yllättäen muuttuu. Tämän raportin tavoitteena on tunnistaa Suomenlahden alueella merikuljetusta käyttävien kuljetusketjujen riskejä sekä arvioida näiden riskien vaikutusta kuljetusketjujen toiminnallisuuteen systeemidynamiikkaa käyttäen.

Kirjallisuustutkimuksen perusteella kuljetusketjuun osallistuvien jäsenten yhteistyö ja tiedonvaihto vaikuttavat kuljetusjärjestelmän toimivuuteen. Aiempi tutkimus on pääosin keskittynyt varmistamaan puitteet oletetuille kasvaville kansainvälisille tavaravirroille. Erityisiksi riskeiksi kansainvälisissä satamissa on identifioitu ulkomailta saapuvat kontit ja huviveneet.

Suomenlahden alueella tekemiemme case-tutkimusten perusteella eri satamien ja rautatiepihojen riskit riippuvat infrastruktuurista ja käsitellystä rahdista. Erityinen riski liittyy säiliövaunujen vuotamiseen, sillä Suomen ja Viron rautateillä kuljetetaan merkittäviä määriä venäläistä öljyä ja muita nesteitä. Tapaustutkimusten perusteella myöskin logistiikkaoperaattorien ominaisuudet merkitsevät poikkeusoloissa. Monikansalliset yritykset voivat muuttaa tavaravirtojaan häiriötilanteissa, paikallisten operaattoreiden on mahdollisesti keskeytettävä toimintansa.

Tekemämme Tallinnan ja Helsingin välisen rautatietunnelin taloudellisen analyysin perusteella tunneli vaikuttaa kannattamattomalta korkeiden rakennuskustannusten vuoksi. Monte Carlo simuloinnilla suoritettujen herkkyystarkastelujen perusteella investoinnin kannattavuus voitaisiin saavuttaa joissain harvoissa tapauksissa. Kuitenkin tunnelin operointi olisi taloudellisesti järkevää. Lisäksi, jos laskelmassa huomioidaan lakkoilusta koituvien kansallisten taloudellisten menetysten väheneminen (tai suuremman öljyvuoden aiheuttamat taloudelliset menetykset), se tukee tunnelin rakentamista.

Tutkimuksemme mukaan kuljetussektorin yksityistäminen ja sääntelyn purkaminen Suomessa on edennyt Euroopan unionin lainsäädännön edellyttämällä tavalla. Tämä vaikuttaa viranomaisten kykyyn reagoida hätätilanteisiin, koska rautatie on ainut kuljetusmuoto, joka on suoraan valtiovallan hallinnassa.

Simulointituloksemme korostavat satamien takamaan merkitystä kuljetusjärjestelmän toimivuudelle. Lyhyellä aikavälillä vaihtoehtoisten kuljetusreittien kapasiteetin määrittää laivojen käsittelykapasiteetti satamassa. Varastotilan täytyttyä sataman kapasiteetin määrittää takamaan kapasiteetti. Konttiliikenteessä käsittelykapasiteetin keskittäminen lisää kuljetusjärjestelmän haavoittuvuutta. Tämä vähentää konttivirtojen uudelleenreitittämisen mahdollisuutta. Huoltovarmuuden turvaavaa konttiliikennettä voidaan kuitenkin pitää yllä, mikäli kuljetusalustoja on riittävästi saatavilla. Simulointien perusteella normaalitilanteeseen palautuminen kestää vielä pitkään sen jälkeen, kun paikallinen onnettomuus esimerkiksi satamassa on ohi. Suomen ja Viron kautta länteen suuntautuva transitoliikenne hoidetaan pääosin rautateitse. Öljynkuljetuksissa keskeytyksiin rautatieliikenteessä voidaan varautua satamassa sijaitsevilla varastoilla, kappaletavaroissa vaikutukset ovat välittömät. Havaintojemme perusteella satamien toiminnallisuutta ei tule tutkia erillisenä, vaan pikemminkin osana laajempaa kuljetusketjua.

Avainsanat: toimitusketjun hallinta**,** intermodaalikuljetukset, merisatamat, tehokkuus, kontittuminen, systeemidynamiikka, simulointi

Authors of this report are listed in below by chapter:

Juha Saranen

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Definitions of Key Concepts

AGV	Automatic Guided Vehicle
ARIMA	Auto Regressive Integrated Moving Average
Bilateral international transport	Transport between two countries performed by a vehicle that is registered in either the country of loading or the country of unloading.
BCR	Benefit-Cost Ratio
BSR	Baltic Sea Region
BVAR	Bayesian Vector Autoregressive
Cabotage	Cabotage is national road transport by non-resident hauliers: Transport between a place of loading and a place of unloading that are located in the same country performed by a vehicle that is registered in another country.
CIP	Critical Infrastructure Protection
GDP	Gross Domestic Product
CMP	Copenhagen Malmö Port
CSI	Container Security Initiative
GOF	Gulf of Finland
GPS	Global Positioning Systems
ECMT	Ministers of European Conference of Ministers of Transport
EEC	European Economic Community
Efficiency	Is used here in relation to economic efficiency of a system: a) More output cannot be obtained without increasing the amount of inputs b) Production of products and services proceeds at the lowest possible per-unit cost.
EU	European Union

EU-27 This refers to all the 27 current Member States of the EU: Austria, Belgium, Bulgaria, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxemburg, Malta, the Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden and the United Kingdom.

Heuristics In computer science heuristic solution of a problem embraces a rule or a set of rules (algorithms) that is able to produce an acceptable solution to a problem in many practical scenarios, but for which there is no formal proof of its correctness

ISAC Information Sharing and Analysis Center

Intermodal transport The movement of goods in one and the same loading unit or road vehicle, which uses successively two or more modes of transport without handling the goods themselves in changing modes.

International transport Transport between a place of loading and a place of unloading that are located in two different countries.

IMO International Maritime Organisation

ISO 9001 International Organization of Standardization. ISO 9001 standard includes quality management systems and requirements

ISO 14001 International Organization of Standardization. ISO 14001 standard include environmental management systems and requirements with guidance for use.

ISPS International Ships and Port Facility Security Code. The purpose of code is to increase maritime safety. The Code is a two-part document describing minimum requirements for security of ships and ports. Part A provides mandatory requirements. Part B provides guidance for implementation. It came to force in 2004. It prescribes responsibilities to governments, shipping companies, shipboard personnel, and port/facility personnel to detect security threats and take preventative measures against security incidents affecting ships or port facilities used in international trade.

LIB Index Rail Liberalization Index

MARSEC Maritime Security Services

National Transport Transport between a place of loading and a place of unloading that are located in the same country, performed by a vehicle that is registered in that country.

NPV Net Present Value

NSHS National Strategy of Homeland Security

OHSAS 18001 OHSAS 18000: Standard include occupational health and safety information, guidance and resources to support this standard.

PCCIP Presidents' Commission on Critical Infrastructure Protection

PDD Presidential Decision Directive

Productivity Productivity refers to metrics and measures of output from production or service processes, per unit of input.

Port authority A company, government body or organization that owns or controls the land and activities at a sea port.

PPP Public-Private Partnership

Risk In general it can be seen as probability or threat of a damage, injury, liability, loss, or other negative occurrence, caused by external or internal vulnerabilities, and which may be neutralized through pre-mediated action. In decision theory and statistic it can be seen as a state of uncertainty, where some possible outcomes have an undesired effect or significant loss.

RFID Radio Frequency Identification

RMSRR Regional Maritime Security Risk Rating

Simulation Computer based modeling of a real-world process or system in a dynamic manner – over time. There are two forms of simulation: in the case of discrete – event simulation the state of variables are allowed to change over time only at a countable manner. In continuous simulation in turn these variables change continuously over time.

SD System Dynamics

SST Smart and Secure Trade

STOCA	Study of cargo flows in the Gulf of Finland in emergency situations. A research consortium led by the Kotka Maritime Research Centre (University of Turku)
System Dynamics	**"**a methodology for studying and managing complex feedback systems, such as one finds in business and other social systems. In fact it has been used to address practically every sort of feedback system. While the word system has been applied to all sorts of situations, feedback is the differentiating descriptor here. Feedback refers to the situation of X affecting Y and Y in turn affecting X perhaps through a chain of causes and effects. One cannot study the link between X and Y and, independently, the link between Y and X and predict how the system will behave. Only the study of the whole system as a feedback system will lead to correct results." (System Dynamics Society, 2009)
STS	Satellite Tracking System
TEN	Trans-European Network
TEU	Twenty foot Equivalent Unit, a unit of measure of capacity in container transport
THC	Terminal Handling Charge
Uncertainty	A risk that cannot be quantified. In decision theory and statistics it can be referred as state of having limited knowledge, where it is impossible to exactly describe existing state or future outcome, more than one possible outcome.
Quality	In general terms it can be seen as a measure of excellence or state of being free from defects, deficiencies, and significant variations. In manufacturing products or providing services it is referred to as a strict and consistent adherence to measurable and verifiable standards to achieve uniformity of output that satisfies specific customer or user requirements.
VAT	Value Added Tax
VECM	Vector Error Correction Model

1 Introduction

Sea ports play an important part in the Finnish foreign trade flows; in 2009 over 77 percent of tons imported and 88 percent of tons exported traveled through sea ports (National Board of Customs, 2010). On a global scale the amount of trade through sea is enormous and trade using containers has increased to 142.9 million TEU per year (Drewry Shipping Consultants, 2009). Although the economic crisis at the end of year 2008 has decreased international trade dramatically in medium term, the growth is expected to continue already in 2010, as the world becomes even more connected through globalization (United Nations, 2009).

Sea ports also play an important part in the competitiveness of the national infrastructure and thus have an indirect impact on the competitiveness of companies. Sea ports should be able to offer quick service for the ships in order to remain competitive. In addition to competitiveness of a nation, sea ports play an important part in the overall wellbeing of a nation as most countries are heavily dependent on trade. For instance, in Finland the amount of exports and imports are 45.5 percent and 40.8 percent, respectively, from Gross Domestic Product (Statistics Finland, 2010).

According to the Ministry of Transport and Communications Finland (2009) Finnish ports handled 37.4 million tons of dangerous goods in 2007, petroleum and oil products counting for two thirds of the volume. The largest ports in terms of dangerous goods transported were Kilpilahti, Naantali, Hamina, Pori and Helsinki. The same year transportation of dangerous goods on road and rail network totalled 9.5 and 5.6 million tons respectively, flammable liquids being the largest transportation group.

To the Baltic Sea Region (BSR) commodities are imported from the biggest container ports of the world, which are located in Asia, America and Europe. Figure 1 presents direct routes of container ships from Estonian and Finnish harbors. The thickness of each line presents the number of connections on the respective route. As can be noted, the harbors on both sides of the Gulf of Finland are connected well; in addition to other European ports each of the Estonian harbors is connected directly at least to one Finnish port. Along with own import and export the ports of Gulf of Finland handle a great deal of Russian transit. In transit Finnish ports have mainly concentrated on container and consumer commodities import to Russia, whereas Estonian ports carry a great share of the oil export from Russia (Hilmola et al,. 2007a; Terk et al., 2007). The Finnish route constituted about one third of transit value of Russian import in 2008 (Märkälä and Jumpponen, 2009). Russia has also own ports on the shores of the Baltic sea, in the St. Petersburg region and Kaliningrad. In Russia, e.g. in Ust-Luga, additional port facilities are under construction, which will probably have a major structural impact on transit routes in the BSR. The Russian government has announced in 2005 its transportation strategy, according to which Russia aims at gaining self sufficiency in logistics by building up own sea ports and other logistics infrastructure. (Transportation Ministry of the Russian Federation, 2005).

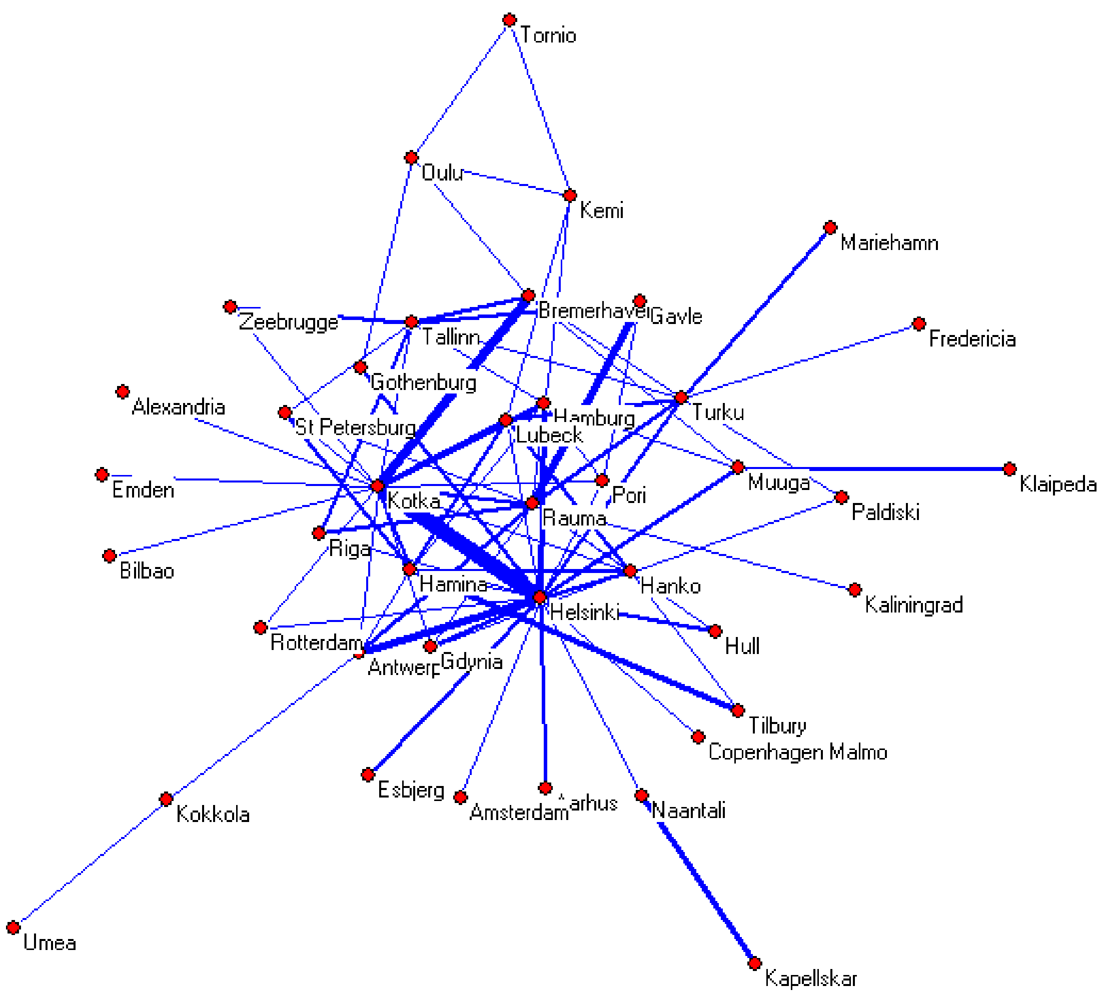

Figure 1. Container ship routes of Finnish and Estonian harbors. (Containerisation International Yearbook, 2009)

Although sea is the main mode of transportation in the region, there is no study on how the maritime volumes could be handled, if the operational environment changes unexpectedly. This is the main focus of the STOCA project (Study of cargo flows in the Gulf of Finland in emergency situations), a research consortium led by the Kotka Maritime Research Centre, University of Turku. STOCA aims at improved sustainable accessibility and movement of cargo within the Gulf of Finland, with a special focus on the movement of cargo in emergency situations. The aim is to facilitate business actors and authorities in both Finland and Estonia with improved knowledge to renew their strategies and operations to meet the future requirements, and to enhance the competitiveness of the region.

This research report has been completed as a part of the STOCA project and concentrates on identifying and evaluating risks of seaborne freight transportation routes in the region of Gulf of Finland. The specific research questions in the report are: (1) what kind of risks are related to transportation routes that use sea ports in the Gulf of Finland and (2) if realized, how do selected risks affect the functionality of the transportation system. In this report the evaluation of the functionality is done by using system dynamics simulation.

Data gathering is based on multiple sources in order to increase the reliability of the research. A literature review on the security of supply and efficiency of transportation systems including sea ports is conducted to reveal major risks. Risks are studied also through case interviews conducted in selected major transportation nodes, i.e. sea ports and supporting railway yards in the Gulf of Finland, as well as different stake holders in the supply chain. For exploring the functionality of the transportation system under selected scenarios, we use system dynamics simulation. Naylor et al. (1966) define simulation as the process of designing a mathematical or logical model of a real system and then conducting computer-based experiments with the model to describe, explain, and predict the behavior of the real system. Recently, for example Engelen et al. (2006) have used system dynamics for analyzing sea transportation by constructing a strategic and tactical decision making model for ship owners in the dry bulk sector.

The case study interviews were conducted using a semi-structured questionnaire concentrating on the logistics infrastructure and functional risks of the transportation facility in question. The duration of the interviews varied between one and three hours. Additional information on the facilities was gathered using publicly available sources such as company Internet pages. The simulation studies enable us to explore the functional effects of different risk scenarios. From simulation experiments we acquire quantitative estimates on e.g. throughput and recovery time of the transportation system.

This research report is structured as follows: In the second section a literature review of factors affecting the efficiency and risk related to port operations is presented. The majority of the studies assumed, that international trade will grow in the future. Based on this assumption, research effort mostly concentrated on evaluating different procedures to ensure sufficient transportation capacity to fulfill this growth. Based on the literature review the functionality of a maritime transportation system is affected by the form cooperation and information exchange between the parties involved in the system. Risks are context dependent; special risks identified for international ports included foreign containers and recreational vessels. The third section presents case study analyses of perceived risks in selected sea ports, railway yards and stake holders in the logistic chain. In line with the findings of the literature study the risk of different stake holders in the supply chain face different risks. The ports are depending on information and energy systems whereas major railway yards are depending on transport equipment and railway infrastructure such as tracks, switches and brakes. However, a spillage is a common perceived source of risk in intermodal transportation in Gulf of Finland. The section includes a feasibility study of a hypothetical railway tunnel connecting Tallinn and Helsinki. The tunnel could provide an additional freight route for Finnish trade, and thereby increase the security of supply as it is not affected by catastrophes at sea, volcano eruptions or labor strikes in harbors. As the ability to react to emergency situations is affected by the ownership of transportation infrastructure and transportation fleet, Section four covers the legal background and current status of transportation deregulation in different transportation modes. According to the analysis, in Finland privatization and deregulation of freight transportation has proceeded in line with EU legislation. The state plays a major role only in railway freight through the state owned operator VR-Group Ltd., which is the only railway operator on Finnish rail network (situation in June 2010).

Section five is devoted for presenting system dynamics simulation, the quantitative modeling method used. The simulation studies, which were constructed based on the case study interviews, are presented in section six. The results show that the functionality of sea ports should not be evaluated in isolation, but merely as parts of a wider intermodal supply chain. Based on the simulations conducted it was possible to notice that hinterland capacity plays a vital role in crisis situations. As long as there is adequate storage for containers, the sea port can handle a large amount of vessels. When all of the storages are full, the handling capacity drops dramatically. Even when the crisis is over it takes a long time to return to normal situation. If hinterland is diminished due to a disaster, the sea ports have to pay a high price in lost revenues, if there is inadequate capacity to store all of the railway wagons arriving. The whole network is interdependent and the whole system reacts to a malfunction. The final section contains both discussion about the simulation models and concludes this research report. We also provide further research avenues in this section.

2 Literature Review: Functionality of Multimodal Freight Transport Systems

2.1 The Book: Container Transport Management – Chapters 1 and 2

Authors: Y.H. Venus Lun, K.H. Lai and T.C.E. Cheng

Despite the extreme growth of volumes in international containerized trade, the container shipping market has remained in the form of an oligopoly. The characteristics of this market can be outlined as having high fixed costs and little difference between the services provided by different shipping service operators. Concentration is becoming even higher and in the future an even smaller group of businesses will hold the majority of the total shipping supply. It is pointed out that according to the theory of industrial organization paradigm container shipping market depends not only on the demand for and supply of container shipping services, but also on market structure. Structural setting of the market is relevant especially in the sense that it affects the number and size of service providers, the extent of concentration among these actors and the degree of homogeneity of the offerings available.

This study's main intention was to discover the factors that influence the supply of container shipping services by gathering empirical evidence from the market and test the causal relationships of these factors when determining the fleet size. The principal hypothesis for the research was: "The demand for container shipping services influences freight rate, which adjusts the supply of world fleets." Related literature review was carried out in order to be able to identify the factors affecting fleet size. In the constructed theoretical model the fleet size of container shipping is a function of the demand for container shipping service, container freight rate, and supply of container shipping service. Regression analysis was employed to validate the proposed model. In addition the relative strength of each factor was calculated by factor analysis to determine the one with highest importance with regard to fleet size.

Literature review supports the findings that the supply of container services is determined by seaborne trade, freight rate, ordering of new ships, delivering of new ships, and scrapping of old ones. The test results indicate that fleet size is affected by seaborne trade, freight rate, new orders of ships, delivery of new ships and withdrawal of ships. According to the results, seaborne trade volume has the single most important role in the decision of ship carriers to adjust fleet size. The study was limited to examining container shipping and the data sources were mainly secondary.

A literature review was carried out to specify the interrelationships between these elements. In particular the facets of localizing regional competitiveness integrated with the theory of national competitive advantage were scrutinized to reveal the evolution of intermodal transport service system effectiveness needed for developing Hong Kong as an international hub centre.

The study is explanatory in nature aiming at a conceptual framework for international intermodal system development. In a regional setting a sea port is to have an ability to offer system based intermodal services that give more value for clients, while using its resources better in comparison to rivals. Porter has defined the elements of system competition: inputs of production, home demand, related and supporting industries, strategies of firms, industry structure and rivalry. These elements are interrelated and their convergence creates demand for specialized tools for regional shipping and container services. In the end a sea port is to render itself into a centre of a dynamic cluster.

In the context of intermodal transport there are five different clusters. The first group of actors consists of organizations physically owning the cargo to transport, for example global traders, small domestic exporters, etc. The second arrays of operators are parties that own the transportation resource fleet and facilities to be able to offer logistics and transport services. The third group of businesses is a set of parties offering value added services directly to shippers, e.g. customs brokers' etc. Fourth party users are entities that control the third party logistics service providers for meeting customer requirements. Fifth party users are agencies undertaking research studies and offering consultation to facilitate growth in the region.

The intermodal framework includes the constructional elements of an international port centre: infrastructure, new technology, transport corridor, transport operators, external business environment, regional location, management of containers, operations of container terminals, deregulation policies and a pool of logistics services. Important infrastructure facilities cover adequate deep water, wide channels, long berths for feeder vessels, reasonably high productivity with well priced labor supply, and a functional rail and road connections to hinterland. From the broad set of novel technologies available, Radio Frequency Identification (RFID), On-board Trucker Information System, and Global Positioning Systems (GPS) are the most relevant ones. There has to be seamless cooperation between various actors (ocean carriers, truckers, feeder service providers and terminal operators) in an intermodal transport hub in order to cut costs and improve values of their connected transport. The external business environment is a territory of government and regional officials having an aim at ensuring the availability of financial and commercial support as well as any other data services needed for. Regional location can be set out as the continental area of origin and destination traffic flow throughout a port. Regional location can be used as a cradle for emerging new business sectors and clusters. Management of containers helps collaborating firms to cut out the negative network externalities of containerization so that they could generate revenue with a smaller resource base. Efficient container terminal operations include high level of utilization of terminal management systems to facilitate flexible adaptation to changes in demand through capacity enlargement/cut-offs. In the face of increasing globalization of integrated transport systems, regulation needs to be loosened to some degree to induce collaboration initiatives between actors of private and public sector. In this way the availability of sufficient pool of logistics services can be ensured. The scope of these services is going to grow to cover procurement, call centre and production assembly services. The inspection of containers is of primary importance these days making it for shippers to trust the in-port scanning services.

2.2 Dissertation 1: An Integrated Modeling Framework for Intermodal Freight Operations in Hub Cities

Author: Duan, M. A

The aim of this study was to develop an integrated framework by combining large-scale simulation and optimization tools in effort to search for efficiency enhancement possibilities over the intermodal transport operation system of a hub city. In particular the objective was to cut out empty truck trips and shorten the time needed for accomplishing delivery of items by coordinated transportation. This is achieved through examining three interrelated questions: (1) "*How trucks react to requests and how they are routed and scheduled to serve the requests?*", (2) "*How these trucks impact on traffic congestion and routing of other vehicles?*" and (3) "*How truck dispatching interacts with terminal and train operations?*" In addressing answers for these problems three simulation models were developed and then combined.

In the framework system model, the simulation of a terminal is the most important element, since it helps to find with sensitivity analysis the first bottleneck of the system and then with scenarios it addresses the most effective way of reducing costs. By elaborating an integrated framework that is consisting of combination of the three sub models, each actor can evaluate and quantify the impact of its decision to the rest of the system to eliminate traffic and terminal congestion through calculated aggregate or disaggregate requests (see Figure 2 below).

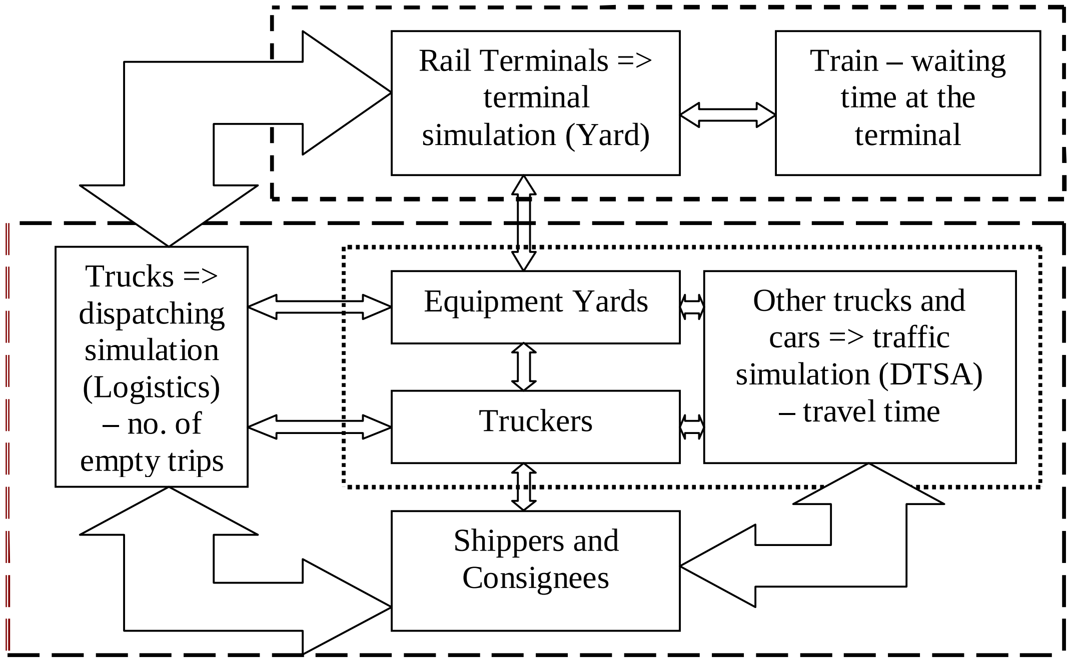

Figure 2. The relations among three components of the intermodal transport system. Arrows indicate requests. (Adapted from the dissertation)

The simulation model was built with the objective of constructing "what-if" scenarios, so the costs and benefits for both the terminal and the trucks could be assessed. Measures of effectiveness provided by the framework model include empty truck trips and truck route durations in the logistics model, total network travel time and delay in the Multi-class Dynamic Traffic Assignment (DTSA) model, and truck waiting time and terminal performance in the Yard model, are interrelated in a specific manner (see Table 1 below).

Table 1. The contents of interaction between component models within the system. (Adapted from the dissertation)

Data/Models	LOGISTICS	DTSA	YARD
Input data	Truck request Travel time Waiting/service time	Dynamic demand Other network data	Dynamic demand Other network data
Output data	Dynamic demand	Travel time	Waiting/service time
Measures (data) of effectiveness produced	Number of empty trips Fleet size Scheduled time	Total travel time Delay	Truck waiting time Terminal resource utilization

The primary results indicate that a simple insertion of a local search heuristics to dispatch trucks can eliminate largely both traffic congestion caused by vehicles and terminal congestion by reducing the number of trips of trucks in line with the dissertation results of Newmann (1998). Secondly, increasing the flexibility of train departure does not lead to significant elimination of traffic congestion, but it changes the pattern of truck arrivals at terminals. Thirdly, the results show that sufficiently large buffer areas are meaningful in aiming at reducing local traffic congestion.

The thesis provides evidence, why trucks are preferred by companies as flexible elements in cutting costs. This signifies the need of developing railway wagon solutions that could be seen as “capable” as trucks by being at a similar level in delivery reliability (see Vihavainen, 2009). The author himself notifies that there are many limitations and artificial assumptions held when arriving at the final outcomes. However, the research points out as well that negotiation efforts are one of the keys in reaching compromises on system optimal solutions between the parties of an intermodal transport system.

2.3 Dissertation 2: Optimizing Intermodal Rail Operations

Author: Newmann, G

The purpose of this thesis is to create a mathematical solution to minimize intermodal rail operation costs. The developed tool is an integer programming formulation, more specifically a "piecewise – concave- cost multi-commodity flow integer program" that is able to deal with configurations containing thousands of variables and constraints for practical problem instances of moderate size. The network problem is illustrated by employing two different instances of commodity network – a single commodity network and a multi-commodity network, where a commodity is defined by its origin, destination, arrival date at the origin, and the due date at the destination. The network is set out as consisting of two origins, one hub, two destinations, two time periods, and two levels of service (see Figure 3 below). Specifically the research problem can be depicted in the following manner:

"..how to schedule trains and allocate containers to the trains to meet due dates while minimizing the sum of fixed costs for running the trains and per unit costs for transporting containers and holding them in inventory." The settings cover both direct (origin to destination), indirect (via a hub) trains and dynamic arrivals of containers in relation to a multi-period planning horizon.

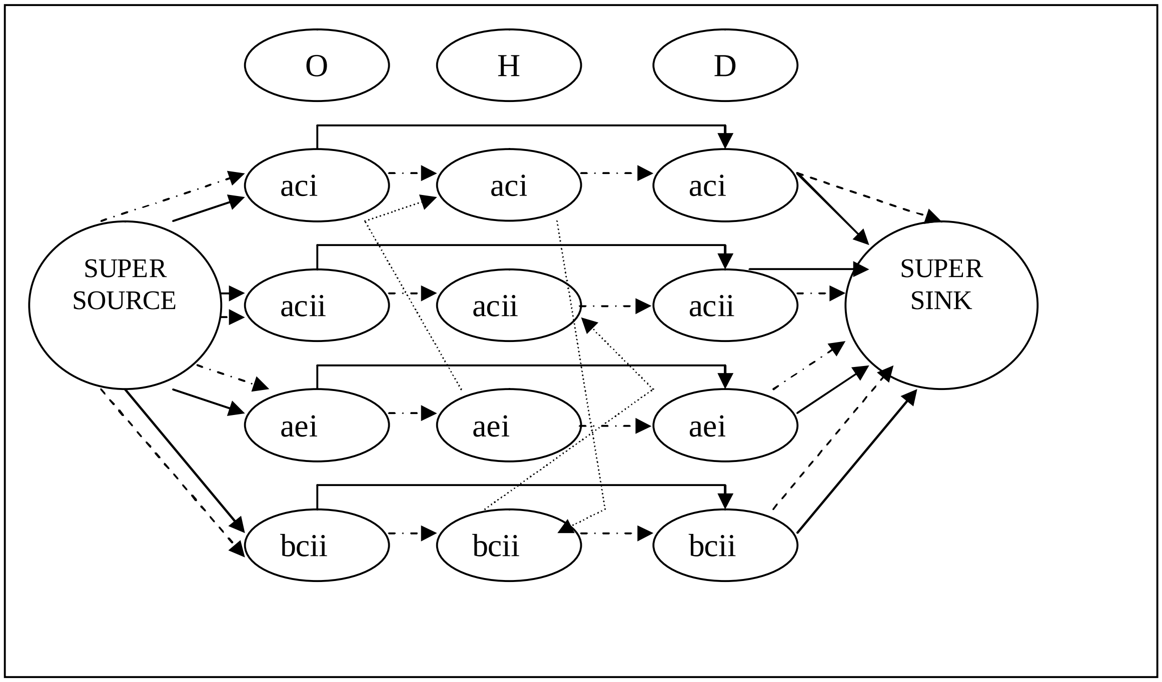

Figure 3. The representation of a single commodity network. Denotation: O = origin: a, b; H = hub, D = destination, c, e, i, ii = service level. Continuous line = direct shipment, dashed line = indirect shipment, dotted line = inventory. (Adapted from the dissertation)

The results confirm that significant cost savings can be achieved by applying two proposed heuristics based operational procedures. Both operational plans utilize much more direct train connections than it can be seen in practice, and there is no allowance for the delivery to be late. In essence the first solution plan suggests delivering all containers not requiring expediting to go with origin-destination direct trains with order of urgent cases first. All remaining cargo can be delivered with indirect train. Indirect trains are used as well to ship containers from the hub to destinations. Containers need different treatment at the hub based only on information whether they require extra service or not and if they may be placed on trains in any order. The second operational plan differs from the first one by using direct train connections regardless of the possibility of involving indirect connections. This scenario assumes that there is a volume high enough of container traffic between each origin destination pairs. The estimate of this quantity is based on managerial considerations on the relative values of fixed and variable costs generated at the origin, and at the hub and typical traffic patterns.

In addition it was recognized that as such this mathematical integer model cannot be applied to real life situations and only near-by optimal solutions can be produced. The model does not take into account capacity constraints of the hub or limitations deriving from limited amount of locomotive capacity. The calculation process ignores also the feasibility of early container arrival at the destination. The tool is applicable only situations with one hub. It derives from the thesis that direct trains are cost savers and the simpler the heuristics for operation, the better chances to decrease costs (Grisone, 2008). This course of development would lead to shorter timeframe of transport within the intermodal network; according to the author, this would be already enough for many shippers to switch onto rail since transit time would decrease well enough.

2.4 Dissertation 3: Rail Network Analysis for Coal Transportation in China

Author: Tehara, G.

This study aims to investigate the concept of efficiency from an interdisciplinary point of view. Specifically it scrutinizes to measure efficiency through the relationships between the coal industry transportation planning management and the institutional platform from a historical policy viewpoint and connects these settings to quantitative contribution of network models in the country context of China.

The first part of the dissertation is targeting the history of political economy and planning management of the railway transportation. The conclusion is that in the past efficiency as a measure of enhancing profitability of railway transportation was ignored and the system was managed by setting numbers for physical terms for tons and ton-kilometers specified by the governmental bodies.

Rail capacities around city of Datong are exhausted, which is due to extremely cheap freight rates of coal by rail. The most critical rail lines connect Beijing with Datong and Tianjin. A non-linear calculation model is developed to investigate the congestion effect on the network. It concludes that coal might well be in practice transported via longer distance to suppress delivery time – this outcome contradicts with the results to some extent obtained by Newmann (1998). A linear network model is adopted to reveal the content of relationships between the coal price gap existing among regions in China and coal flow pattern on the rail network. Specifically the research question is as follows: *"…if cheaper coal is produced in the southwestern region, can the coal flow be dispersed more evenly over the entire network?"* In addition answers are given to questions such as how much external subsidy would be needed and is the increase of coal tariffs a good move for being able to develop southwestern coal mine industry of China.

The results indicate that by decreacing the tariff level a larger customer base could be attracted. Each coal mine in this area should focus on internal efforts to reduce production costs. Increase of coal tariff in this context is possible and might lead to attract more customers. Regional adaptation of tariff level is an important measure to outset the trade imbalance between regions. In overall, it is estimated that even if the current price gap is completely eliminated, there is no chance to double output of coal production as a consequence of low production capabilities of mines in southwestern region. These arguments strongly support the need for specific investments into links between rail transport and production facilities (Limbourg and Jourquin, 2009). It is assumed by the author that in China rail freight market will be governed by market economy principles, where the price of coal must reflect costs incurred and that distribution system will be laid out by the demand side of markets. It is argued that rail will remain an important transportation mode for coal.

2.5 Dissertation 4: A Multivariable Technique for Analyzing U.S. Regional Maritime Risk

Author: Direnzo III, J.

This work was to respond the growing threat of global terrorism on maritime industry in the United States. The view was justified with the continuing dominance of international trade by sea transport, while the terrorists' aim is at leveraging psychological shock by creating unpredictability of the implementation of their plans. The purpose of the research is: *"When one examines nine U.S. maritime regions, which is at most risk of terrorist exploitation when analyzed using a standardized technique comprising multiple variables, based on terrorist exploitation that goes beyond critical infrastructure?"* The main hypothesis was formulated to assign "St. Lawrence Seaway and Great Lakes" region as the one that would be most risky target for a terrorist attack. The methodology was a quantitative one, where the concepts of "impact" and "attackability" were linked to variables. First the key terms for the topic were introduced and defined. In the second phase "CARVER – method" (a risk assessment tool measuring vulnerability) was adopted to determine total component weighting with values of 1, 3 and 5. The components of this method are:

- *Criticality*: measure of public health and economic impacts of an attack
- *Accessibility*: ability to physically access and egress from target
- *Recuperability*: ability of system to recover from an attack
- *Vulnerability*: ease of accomplishing attack
- *Effect*: amount of direct loss from an attack as measured by loss in production
- *Recognizability*: ease of identifying target
- *Shock:* combined measure of health, economic and psychological impacts of an attack

Finally *Regional Maritime Security Risk Rating* (RMSRR) was formulated based on total scores for each variable in a region. A statistical variance test called "ANOVA" was adapted to measure whether the differences between the means of groups of samples were significant. The most significant limitations of the study were lack of access to classified secret material and a group of essential concepts that were excluded from the study as it was not known how to quantify them.

As a starting point the core terms were defined as follows: “*consequence, critical infrastructure, homeland, maritime, maritime domain awareness, maritime terrorism, risk, threat, vulnerability and weapons for mass destruction*”. Risk was outlined as *”threat × vulnerability × consequence”*. Using extensive literature review a novel index-tool was constructed embracing eight variables that are related to eight dimensions of measuring national security in the United States:

1) The length and distance of the maritime region
2) The total amount of selected dangerous cargoes
3) The total number of Maritime Transportation Security Act–required facility security plans in place
4) The total annual number of foreign – flagged commercial vessel ships (over 10 000 gross tons) that enter each region’s maritime border
5) The total annual number of loaded foreign shipping containers that entered each region’s maritime borders from outside the U.S.
6) The total annual estimated amount of liquefied natural gas/liquid petroleum gas shipments that transited each region’s maritime borders
7) The total annual estimated amount of crude petroleum and gasoline shipments that transited each region’s maritime borders
8) The total number of recreational boats registered within a region

The process of forming RMSRR and the final results provided by the novel index are illustrated in the tables below. From Table 2 can be seen that each one of the eight variables receives a value between 1 and 25. After summarizing the subtotals each region is assigned a value describing its vulnerability.

Table 2. Summary on RMSRR. (Adapted from the dissertation)

Variable	**Units**	**Impact**	**Attack**	**TCW**
Values		1,3,5	1,3,5	Impact × attack
Coastline	Miles	Population in coastal countries per region	Estimated AIS. Surveillance coverage out to 200 miles	Impact × attack
Selected CDSSI chemical fertilizer/ explosives	Thousand sort tons	Average wind speed/ direction	Number of energy generating facilities required to have an MTSA FSP	Impact × attack
Facility Security Plans	Number	Population density per coastal counsel per region	Number of energy generating facilities to have an required MTSA FSP	Impact × attack
Foreign-flagged vessels	Number	Number of foreign flagged vessels arrivals	Number of estimated total radiation detectors per region	Impact × attack
Containers	Number	Number of foreign loaded containers entering each region	Number of estimated total radiation detectors per region	Impact × attack
LNG/LPG	Thousand sort tons	Tonnage of LNG/LPG entering per region	Number of LNG/LPG ship transits per region	Impact × attack
Crude petroleum gasoline	Thousand sort tons	Total tonnage entering per region	Total number of crude petroleum/ gasoline carrier movements per region	Impact × attack
Recreational vessels	Number	Total number of recreational vessels per region	Percentage of vessels per region that are classified as	Of vessels per region that are classified as “power” boats

Table 3 shows the final order between regions in terms of vulnerability for being attacked. It can be noticed that the original hypothesis is found invalid: Northeast and Southeast part of the US are perceived to be the most vulnerable areas to terrorist attack, while the region of Rio Grande was perceived to be the safest area of the US. However, the risk of being attacked changes all the time and risk is dynamic in nature; therefore, it can be suggested that in the future scenario based models that could reduce risks have to include some further dynamic parameters such as traffic congestion peak time, impact of domino effect, lean concept or cost volatility (Drewry Shipping Consultants, 2009; Merrick et al., 2001; Rytkönen, 2007). Classification of risks into process, market and asset related, organizational, and macro economical risks could also provide deeper insight how to allocate resources between target locations (Drewry Shipping Consultant, 2009).

Table 3. The list of regions indicating their vulnerability to be attacked. (Adapted from the dissertation)

Region/ TCW	Total population	Wind	Population density	Foreign-flagged vessels	Foreign loads of shipping containers	LNG/ LPG tons	Crude Petroleum / gasoline	Recreational vessels
Northeast	15	15	25	15	15	25	25	5
Southeast	15	15	25	25	5	15	15	25
Gulf, east	3	1	1	9	15	1	3	15
Gulf, west	15	15	1	25	15	15	25	15
Rio Grande	5	3	1	1	5	1	1	1
Pacific, southwest	15	15	1	9	25	3	15	15
Pacific, northwest	9	15	1	9	25	1	5	15
Great Lakes	9	3	15	3	3	3	3	25
Alaska	5	5	3	3	25	3	3	3
Total	91	87	73	99	123	67	95	119

Table 3 reveals the most relevant combined factors for indicating vulnerability of attacks: According to the findings, the containers that are loaded into ships outside the USA are the most decisive indicator when assessing exposure of attack. Registered vessels that can be modified to be able to accomplish new missions are also an important factor for assessing the possibility of being attacked.

2.6 Dissertation 5: Systems Engineering Approach to Model and Analyze the Performance of Containerized Shipping and its Interdependencies with the United States Critical Infrastructure

Author: Vandiver, Susan G.

The objective of this dissertation was to define the causes and effects of interruptions in container handling and those effects to the operation in the port of Houston and extensively to the U.S. critical infrastructure. The study also defined the most important commodities to the U.S. critical infrastructure. The critical infrastructure of the United States is an ever-evolving system of systems with complex interdependencies. In this research work systems engineering principles and practices are used as the fundamental methodology. Systems engineering is applied to the analysis of containerized shipping and its interdependencies with the U.S. critical infrastructure. The empirical data was collected by interviewing the stake holders: personnel of ports and security authorities. Many of the stake holders' viewpoints have been previously documented in press releases or legislation. The data were analyzed under normal and abnormal conditions with several scenarios using the developed models. Containerized shipping is depended on the supply of products of the critical infrastructure such as electric power, oil, gas, telecom and other transportation systems. The performance of containerized shipping is affected by external sources including weather, security events, labor availability, stake holder decisions, technology and accidents. Simulations were made in several scenarios to estimate U.S. critical infrastructure and its interdependencies.

Because U.S. critical infrastructure depends on the commodities provided by containerized shipping, a trade-off table was made to evaluate the relative criticality of 16 commodities based upon the number of infrastructure sector they supply, the dollar value of imports, and predicted increase in import of the specific commodity. On the other hand, container shipping is a subsystem of this critical infrastructure (Rinaldi et al., 2001).

Containerized shipping was researched in the port of Houston between 2001 and 2004. Houston is the biggest container port in the U.S. and it is located in the Gulf of Mexico. During the research period the port was shut down three times: due to fog and hurricanes for two days, during a MARSEC III and due to a labor strike for a week.

The United States Critical Infrastructure is defined in several laws: 1) Presidential Decision Directive, PDD, (1998), 2) Public Law 107-56, Patriot act, (2001), 3) National Strategy of Homeland Security, NSHS, (2002), and 4) National Plan for Research and Development in Support of Critical Infrastructure Protection, (2004). The critical infrastructure identified in each of the laws is presented in Table 4.

Table 4. U.S. Critical infrastructure identification. (Adapted from the dissertation)

PDD	Patriot act	National Strategy for Homeland Security	National Plan for Research and Development in Support of Critical Infrastructure Protection
Telecommunication Banking and Finance Transportation Energy Water Systems Emergency Services	Telecommunications Financial Services Transportation Sectors Energy Water	Information and Telecommunications Banking and Finance Transportation Energy Water Public Health Chemical Industry Food Agriculture Postal and Shipping Government Defense Industrial Base Emergency Services	Telecommunications Banking and Finance Transportation Systems Energy Water Public Health and Healthcare Chemical Agriculture and Food Postal and Shipping Defense Industrial Base Information technology Emergency Services
		Key assets: Historic Attractions National Monuments Icons Events	**Key resources:** National monuments/Icons Dams Government Facilities Nuclear Reactors Materials and Waste

Containerized shipping developed from a need to transport cargo small lot sizes more efficiently as well as the need to move high-value and delicate cargo (Reichert, 2003). During recent years use of containers has increased substantially and nowadays it is a common way to move several types of products.

Better awareness of terrorism has redefined port security and increased attention to risks in containerized shipping. In a simulation of a terrorist attack every sea port of the U.S. were shut down and the losses in revenue to the U.S. economy were 59 billion USD (General Accounting Office, 2003). Afterwards the port security strategy has been based on U.S. cooperation with its trade partners, in order to increase security in the ports all over the world. Security experts in U.S. assumed that one or some of its allies could be the victim of a terrorist attack (Willis and Ortiz, 2004). U.S. ports grant funding and other social and private organizations improve the port security systems by increasing the amount of container controls, pre-screening containers before their arrival in U.S. and developing technologies to track in-transit containers. After September 11, 2001 the access control systems have become commonplace in majority of ports worldwide. Also the International Maritime Organization works in close partnership with the Custom and Border Protection (CBP, 2004) and updates the International Ships and Port Facility Security (ISPS) code to require port, carrier and vessel security plan and personnel security plans. The main objective is: 1) securing personnel, 2) capital of ports, and 3) maritime transportation system (Maritime Transportation Security Act, 2002). The Maritime Transportation Security Act requires all U.S. port facilities to conduct a vulnerability assessment and develop a plan for security of all vessels and facilities (automatic international identification with security card). Container Security Initiative (CSI) (CBP, 2004) is set to tight bilateral security cooperation in international commerce:

1. Cargo originating, transiting, exiting or trans shipping country analysis
2. Non-intrusive inspectional (NII) and radiation equipment must be available
3. The ports must establish a risk management system to identify potential containers
4. The ports must share critical data, intelligence and risk management information
5. The ports must resolve vulnerabilities (ports own and maritime transportation)
6. The ports must have integrity programs to prevent lapses of employees

At the lowest level port security technologies (see Table 5) include lightning, fencing and patrol boats. With advanced software techniques Smart and Secure Trade (SST) lanes are designed, which can be combined with the automatic identification technologies (codes, sensors, mechanical and electronic seals), which can digitally lock the containers and transmit real time alerts about tampering and other events over radio frequency identification (RFID) and satellite tracking systems (STS).

Table 5. The list of port security technologies. (Adapted from the dissertation)

Fencing	Cargo tracking
Lighting	Radar
Cameras	Radiation screening
Assess Control	Ballast water management
High tech patrol boats	Explosive materials determining
Sonar	Thermal imaging
Biometrics	Data integrity
RFID	Command center
Chemical & Biological weapons screening	Tie in to federal/local law enforcement
Anti-tampering	Security processes
SST	Security plan/ management

System engineering was used in developing a mathematical model to describe containerized shipping and its independencies with U.S. critical infrastructure. The model is divided into two parts.

Model 1 describes the time of container to transfer from arrival at the port domain to departure from the container port under normal and abnormal conditions (see Table 6). The data was collected by statistics of the port of Houston in all five container docks and interviewing the pilots, port personnel and coast guard.

Model 2 describes the dependence of the critical infrastructure on the commodity provided by container shipping. The data was available from Census Bureau, Foreign Trade Statistics Exhibit 8, and imports of goods by end-use category and commodity.

Table 6. Parameters of Model 1: Mean values based on historical data. (Adapted from the dissertation)

Container ship arrivals per day	2.25 ships
Container ship moving time from sea to dock	3.70 hours
Container ship waiting time in terminal	130.40 hours (=5.4 days)
Container ship service time in dock	24.03 hours (= 1 day)
Truck time in terminal	0.86 hours
Truck arrival rate per day	731.20 trucks

For Model 2 sixteen commodities were selected, which were judged to be important to the U.S. critical infrastructure and imported in containers. The relative criticality of an imported commodity to the infrastructure is ranked by:

1. The number of infrastructure subsystems in which the commodity is used
2. The monthly dollar value of the imported commodity
3. The estimated increase per year in dollar value

Table 7 presents the results of the criticality assessment. According to the sensitivity analysis conducted relative ranking of the two most critical commodities depends on parameter values chosen. However, larger changes are required to move them out of top two.

Table 7. The most critical commodities in U.S. critical infrastructure. (Adapted from the dissertation)

Commodity	Scaled value of criticality
1. Computers	0.78
2. Telecom equipment	0.76
3. Pharmaceutical preparations	0.49
4. Industrial Supplies	0.46
5. Medical equipment	0.34
6. Iron and steel mill product	0.33
7. Bauxite and aluminum	0.27
8. Railway transportation equipment	0.25
9. Generators, accessories	0.21
10. Chemicals	0.16
11. Fertilizer	0.16
12. Agricultural machinery equipment	0.14
13. Meat products	0.10
14. Nuclear fuel materials	0.09
15. Food oils, oil seeds	0.06
16. Green coffee	0.06

In this research simulations are used to estimate the performance of the container shipping port and thus the delivery of commodities to the infrastructure under various scenarios.

Simulation alternatives:

1. Monte Carlo simulation to determine distribution and parameters of total time for container from arrival until departure from the port under normal conditions.
2. Scenario simulation of port channel closure for 30 days resulting from a local MARSEC III terrorist event, or an accident that creates a blockage due to a ship wreck or oil spillage.
3. Scenario simulation of the port with a reduction in the number of unloading gantries available due to a labor shortage, power shortage or hurricane damage.
4. Scenario simulation of the port with a reduction in the number of truck loading rubber wheeled gantries due to a labor shortage, power shortage, or hurricane damage.
5. Scenario simulation of the port with the highway system disturbed due a terrorist bomb, highway accident or severe weather accident.

Results of simulation:

1. Monte Carlo simulation of total time in harbor: Ship transfer, container waiting time and truck time (T=T1+T2+T3). Result T=151.8 hour.
2. Scenario of the port channel closure 30 days for MARSEC III.
   Result: After a 30 days channel closure, it is estimated that 60-70 container ships will be waiting at sea.
3. Scenario of waiting: Labor or power shortage, hurricane.
   Result: If only one gantry is operating in each dock, after a 30 days period 21 container ships will be waiting in terminal.
4. Scenario of waiting: Container is waiting for a truck.
   Result: After 5 days closure 18 container ships will be waiting in terminal.
5. Scenario of waiting: Highway accident, terrorist attack or weather conditions.
   Result: Under normal conditions container ship will be waiting for truck 5.4 days in terminal.

The dissertation builds more knowledge about vulnerabilities and risks of containerized shipping and maritime transportation system. Additionally, the study reveals what these vulnerabilities or risks can cause to containerized shipping or society. The most important U.S. organizations in respect of security of supply and emergency are Presidential Decision Directive (PDD), Patriot act, National Strategy of Homeland Security (NSHS) and National Plan for Research and Development in Support of Critical Infrastructure Protection. These organizations set the rules and give recommendations, how to protect or reduce influence of breakdowns and other faults in container shipping (and in the whole maritime transportation). The main results of the research are:

- The critical infrastructure of the United States is an ever-evolving system of systems with complex interdependencies.
- The critical infrastructure of the United States is dependent on the supplies imported in containers, and containerized shipping is dependent on the availability of the critical infrastructure.

- The shipping channel in the port of Houston is an element of the transportation infrastructure and is vulnerable to an event such as terrorism, weather, or accidents that will cause its closure.
- Recovering from a shipping channel closure of thirty days would take weeks.
- Between 2001-2004 the port of Houston was shut down due to fogs or hurricanes (two days), due to labor (a week) and during a MARSEC III.
- The U.S. critical infrastructure depends on the commodities provided (imported) by containerized shipping.
- The most important imported commodities to the U.S. critical infrastructure were computer and telecommunication equipment as well as pharmaceutical preparations and industrial supplies.

2.7 Dissertation 6: Essays on Hong Kong's Container Handling Industry

Author: Fun Kin Fai

A substantial part of literature in transportation planning and operation research on port operations has been aiming to determine the efficient, optimal capacity or optimal number of berths from the operational view (Adler, 1971; Kozan 1990; Noritake and Kimura, 1990; Plumlee, 1996; Zagrofois and Martiner, 1990). In this research a simple oligopoly model was made and afterwards a structural vector error correction model (VECM) was used to identify the structural parameters of the proposed model. Bayesian vector autoregressive model (BVAR) and an unvaried auto regressive integrated moving average model (ARIMA) was used for purposes of checking VECM results and forecasting. Projection of Hong Kong's future container throughput volume was made for timing the construction of new terminals. In the research was estimated that the socially optimal number of operators depended on the capacity and cost of container handling services. The objective of the research was to estimate the demand for Hong Kong's container handling services and to provide policy makers with alternative forecasts.

In the end of the 20th century Hong Kong's entrepot included eight container terminals and five operators with annual capacity of 11 million TEU. It serves inter-Asia, cross-Pacific and cross-

Atlantic trade and transportation. However, container shipping is not essential to the growth of economy in Hong Kong.

Hong Kong's container ports are owned by the private sector with "trigger point mechanism" (TPM), which means that the government designs capacity and service levels. In this research the need for container handling services, terminal handling charges (THC), and impacts to Hong Kong economic welfare are forecasted. The forecasts of the future development of container handling in Hong Kong define timetables and scale of investments to new container terminal capacity. However, the rise of South China ports will have large impacts on the development of the port of Hong Kong. THC, which includes container handling costs in the terminal from or to the ship, has increased annually 10 percent in the port of Hong Kong. Therefore, it is a controversial issue whether new terminals should be built in Hong Kong. Furthermore, new investments to the container terminals' infrastructure are huge and irreversible.

The official Hong Kong Port Cargo Forecast is published bi-annually by the Hong Kong's Port Development Board (PDB). The PDB forecast errors have been quite substantial at the end of twentieth century (1990-1995). The lack in the previous forecast was a systematic treatment of the interaction between other major ports in neighboring region; ports of South China, Singapore, Taiwan and South Korea. The port of Singapore is subsidized and partially managed by government, but operated by the private sector. Its container tariffs are set by the Port Authority of Singapore and these are 40 percent lower than the port of Hong Kong (De Borger et al., 2008).

"Midstream operation" means the loading and unloading at sea without going through terminals (the charge is carried to the shore by barge). It is a cheap, inefficient and unreliable alternative to handle containers; however 33 percent of total throughput of Hong Kong in 1996 was handled by this way. "Midstream operation" is usual in the waterways of Hong Kong; in Pearl River Delta, Guangdong and Guangxi.

The data (from 1986:1 to 1997:3) for the models (VECM and BVAR) consisted of total container throughput (TEU), value of foreign trade, tariffs and example ports at the research area in the ports of Hong Kong, Singapore and in "midstream". The vector error correction model (VECM) represents long-run relationships or equilibrium constraints imposed by the economic system on the movement of variables. In this research it is suggested that there may be some interactions between the throughput of the ports of Hong Kong and Singapore and there may be some dependence between their equilibrium market shares.

The Bayesian VAR (BVAR) is an alternative time series forecasting approach to traditional ARIMA and VAR approach (Litterman, 1984). The plans of construction of new terminal capacity were derived from the forecast growth path of the future demand. VECM and BVAR model gives only slightly different results on the timing of these construction investments than PDB has planned. Generally VECM recommends earlier timing than the BVAR model (Table 8).

Table 8. Comparison of the timetable for the new terminal requirement. Berth Requirement Date (year: quarter). (Adapted from the dissertation)

	HKVOL1 (VECM)	HKVOL2 (VECM)	HKVOL3 (VECM)	HKVOL1 (BVAR)	HKVOL2 (BVAR)	KHVOL3 (BVAR)	PDP
CT9							
1.Berth	1999:2	1999:3	2000:1	2000:4	2000:4	2000:1	2000:2
2.Berth	1999:3	1999:3	2000:2	2000:4	2001:1	2001:2	2001:1
3.Berth	1999:4	1999:4	2000:3	2001:1	2001:2	2002:1	2001:3
4.Berth	1999:4	2000:1	2000:4	2001:2	2001:3	2002:1	2001:4
5.Berth	2000:1	2000:4	2001:2	2001:3	2002:1	2002:2	2002:2
6.Berth	2000:3	2001:2	2001:4	2002:1	2002:4	2003:1	2003:1
CT10							
1.Berth	2000:4	2001:3	2002:1	2002:2	2003:1	2003:1	2003:2
2.Berth	2001:1	2001:4	2002:2	2002:4	2003:2	2003:3	2003:4
3.Berth	2001:2	2002:2	2002:4	2003:1	2003:3	2004:1	2004:2
4.Berth	2001:4	2002:4	2003:2	2003:2	2003:2	2004:3	2005:2
CT11							
1.Berth	2002:1	2003:1	2003:3	2003:3	2004:3	2004:4	2005:3
2.Berth	2002:3	2003:3	2004:1	2003:4	2005:1	2005:2	2006:1
3.Berth	2002:4	2003:4	2004:2	2004:1	2005:3	2005:4	2006:3
4.Berth	2003:1	2004:2	2004:3	2004:2	2005:4	2006:1	2007:1

Terminal Handling Charge (THC) was firstly introduced by Far Eastern Freight Conference (FEFC) in 1990. THC contains fees charged by shipping lines and paid by shipper for moving containers between shore and the ships. By separating shore-side charges from freight rates it was intended to provide a greater degree of transparency in shipping rates to shippers. By making THC a separate cost item it was used as a recovering tool and to prevent irrational price cutting among sales representatives. THC has been raised quickly during years from 1991 to 1997: from 0.6 dollar to 2.0 dollar per TEU in the port of Hong Kong. The average THC was remarkably lower on that period at the other ports in the world. Unfortunately it was difficult for Hong Kong shippers to pass the high THC to their customers, because the competition in the other ports in Southeast Asia and widely in the whole world. The shippers claimed that the shipping lines utilized their monopoly in setting THC without discussing with them before making THC adjustments; shipping lines can increase their profits by raising the THC, while the freight rates are falling as a result of over-capacity in container ships. That problem was researched by a hypothesis: there was a structural change in the profitability of shipping lines in 1990 and profits of shipping lines increased to the level of THC. According to the results, there has been a structural change in the period of 1989-1990, but the findings did not support the hypothesis. Therefore, the increase of profitability of shipping lines has resulted from a general increase in the shipping lines' market power.

The effects of THC on the costs of Hong Kong exporters and overseas importers varied largely between raw materials and final products. THC expenditure is about 1.3-1.8 percent of raw materials costs, but only 0.2-0.5 percent of total costs of the final products (textiles). Effects of THC at the port of Hong Kong have increased at the end of the research period; a few ports in South China were growing, e.g. a deepwater port of Yantian has increased quickly, because it has 60 percent lower THC tariffs than the port of Hong Kong. The optimal level of THC balances losses and gains on the margin in the following problems:

- An increase in THC reduces the total container throughput of domestic import and export of Hong Kong; increasing THC has influence to container industry, port related industry, trade and manufacturing industry.
- An increase in THC will increase profits of local terminal operators from their handling of entrepot cargoes under monopoly level.

According to the research the THC should be reduced on average to 53 percent from existing level (1997). By these changes Hong Kong's terminal's throughput would be 1,755,234 TEU and GDP 7,868.5 million dollars. A balance between costs and benefits of intense competition and low terminal tariff could be gained:

- by increasing number of independent terminal operators; in 1997 there were only two major players HIT (Hong Kong International Terminals Ltd.) with 52 percent and MTL (Modern Terminals Ltd.) with 24 percent of container handling markets
- by legal restraints on anti-competitive behavior as well as
- by avoiding unfair practices in the container industry with transparency.

In Hong Kong the government can set socially optimal solution of the number of operators and distribution of terminal capacity among them by using "trigger point mechanism": The next period's capacity is adjusted from the data of the last period capacity. However, an increase in sensitivity of "the trigger" combined with a higher user cost will result in a lower container terminal output and vice versa.

2.8 Summary of Literature Review

According to Lun et al. (2009) the predictability of the container shipping market is reduced by the fact that it is an oligopoly. In the current state of global economic recession, this process in turn may decrease the service capability of intermodal transport corridors (see Brooks, 2009; De Borger et al., 2008; Koskinen, 2009). While containerization improves efficiency of transportation, handling of empty containers requires additional transportation management. Although the container shipping market is concentrated, Lun et al. (2009) describe intermodal transport as a complex system having up to five levels of participants and employing several novel technologies. Below in Table 9 the core findings of the dissertations are summarized.

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Table 9. Summary on findings of the studies.

Author	Purpose	Findings
Duan (2006)	The main objective of this work was to elaborate an integrated framework for intermodal freight transport to show that by better coordination policies efficiency of the system can be increased.	The framework shows that by integrated decisions of the system players, empty container movements can be decreased and travel & waiting time inefficiencies in the transport network can be shortened.
Newmann (1998)	The objective of this work is to show that by certain operational strategies, costs related to intermodal rail operations can be cut and still meet the deadlines of delivery requests.	Decisions on scheduling and allocating containers should be made first at the origins, only after at the hubs for outbound cargo. Direct connections should be preferred.
Terahara (1999)	The main objective of this work is to shed a light on the efficiency bottlenecks of the coal transportation by rail from an economic and planning viewpoints.	From the planning perspective the bottleneck for efficiency is that costs incurred by the system do not reflect actual market conditions as a result of predefined centrally set government objective numbers. A considerable amount of coal transfers could be eliminated, if coal price gaps between regions would be settled out and some specific investment could be accomplished to ease capacity constraints.
Direnzo (2007)	The main objective of this work was to elaborate a new data-based tool to evaluate maritime risk from the point of view of homeland security indicators of vulnerability (attackability) and consequence (impact).	The created tool used risk definition of threat × vulnerability × consequence. The tool applied the CARVER method in determining the maritime risk for regions of the U.S. According to the results the region of Northwest and Northeast parts of U.S. are at most risk to be attacked.
Vandiver (2006)	The aim of this dissertation was settling U.S. Critical infrastructure and its interdependencies by studying 16 imported commodities, which are important to the U.S. critical infrastructure (these commodities are common and valuable to U.S. economy).	With system engineering model and simulation of several scenarios it was found out that minor disruptions in transportation system can cause problems if they last several days. Also the total stop in the port operations will cause an enormous economic loss. The most critical commodities were computers, telecommunication equipment and pharmaceutical preparations.
Fung (1998)	The aim of this dissertation was estimating the optimal schedule for container terminal construction in port of Hong Kong as well as the optimal value of the related Terminal Handling Charge.	VECM, BVAR and ARIMA give quite same result as PDP planned on its own plans. "Trigger point mechanism" gives the optimal number of handling operators. The optimal value of THC was 53 % from the existing level.

According to Table 9, the functionality of maritime transportation system is affected by the form cooperation and information exchange between parties involved. If information exchange is disrupted, overall efficiency of the system is reduced. Special risks identified for international ports include foreign containers and recreational vessels. Interruptions have typically been caused by labor or weather conditions. Especially delivery reliability might suffer in the face of inadequate infrastructure investments and pressures to cut costs. In order to prepare for emergency situations, scheduling activities and allocation of resources should focus on reduction of empty container moves, waiting times in ports and travel distances (times) on the network. The development of risk management tools might be beneficial to direct onto examining containers that are loaded to ships and onto recreational vessels.

The majority of the studies assumed, that international trade will grow in the future. Based on this assumption, most studies concentrated on evaluating different procedures to ensure sufficient transportation capacity to fulfill this growth. However, after the economic crisis which started in the end of year 2008, scarcity of capacity has not been a serious problem. The risk perspective of transportation systems has been scrutinized only in studies completed in recent years. The dynamic functional effects of realized risks on the transport system have been explored only by Vandiver (2006).

3 Case Studies of Selected Transportation Nodes and Logistics Operators in Gulf of Finland

Case study methodology was chosen for a number of reasons: Each port description is a case and in the end the data provided by individual cases form the “system – model” case. In this manner the emphasis is on the integration of accumulated knowledge into a new robust model, where the interaction of each entity (ports and cargo flows) can be investigated in case of “what – if” emergency situations. The case study context allows a deep understanding of transportation node, while the system model case makes it possible to compare the effects of individual components.

Furthermore, hereby it is possible to integrate the most powerful sides of quantitative and qualitative research approaches. Glaser and Strauss (1967) have detailed comparative method for developing the case theory. Yin (1994) described the design of the case study. Case study is a research strategy that involves using one or more cases to create theoretical constructs, propositions or midrange theory from case-based, empirical evidence (Eisenhardt, 1989). Case studies are rich, empirical descriptions of particular instances of a phenomenon that are typically based on variety of data sources (Yin, 1994). In case research each case serves as a distinct experiment that stands on its own as an analytic unit (Eisenhardt, 1989).

Single case studies can richly describe the existence of a phenomenon, while multiple case studies generally provide a stronger base for theory building. Multiple cases enable comparisons that clarify whether an emergent finding is simple case or consistently replicated by several cases. Multiple cases also create more robust theory, because the propositions are more deeply grounded in varied empirical evidence (Eisenhardt and Graebner, 2007). Although, multiple cases are likely to result in better theory, theoretical sampling is generally more complicated (Yin, 1994).

Case studies can accommodate a rich variety of data, including interviews, archival data, survey data, ethnographies and observations. Hargadon and Sutton (1997) combined observations of brainstorming sessions, interviews with ethnographies of two projects in their case study. Interviews are a highly efficient way to collect rich, empirical data, but it has a risk to collect only an actual data without longer perspective. The challenge of interview data is best mitigated by data collection approaches that limit bias (Eisenhardt and Graebner, 2007). The data from interviews are generally qualitative and channel research to the qualitative direction. Qualitative research, which gets data from interviews, is also descriptive, emphasizing the social construction of reality and focusing on how extant theory operates in particular examples. The result is fresh theory that bridges well from rich qualitative evidence to mainstream deductive research. At the same time quantitative data allows to reach better conclusions on qualitative research recommendations and it is even possible to concretize well some of the emergency scenarios that are closely connected to the options in the real world. For example, by employing simulation models as cases it is possible to minimize the need for subjective arguments by individuals. By integrating quantitative and qualitative research, the reliability of outcomes with regard to investment recommendations becomes higher.

The case study analyses were made by visiting selected Finnish and Estonian ports as well as other actors connected to seaborne transportation in the Gulf of Finland. The research was made by interviewing personnel who have operating, financial or security responsibility. Every interviewed case was recorded; minutes of the meetings were documented and afterwards approved by interviewed person/organization. Table 10 provides an overview of the interviews conducted.

Table 10. Overview of the interviews.

Case	Date	Contact person
1. Kouvola Railway Yard	1.6.2009	Traffic Direction Manager
2. Kotka Harbor	12.6.2009	Safety and Security Manager
3. Helsinki Harbor	24.6.2009	Director, Traffic Manager
4. Stella Corona	13.8.2009	General Manager
5. Hamina Harbor	17.8.2009	Managing Director, Security Officer
6. Kuehne+Nagel	18.8.2009	Director Road and Rail
7. Tampere Railway Yard	20.8.2009	Arrangement Master
8. Naantali Harbor	21.8.2009	Port Director
9. The National Emergency Supply Agency	4.9.2009	Chief of Preparedness
10. Estonian Harbors	14-16.9.2009	Estonian Maritime Academy
11. Kokkola Harbor	21.9.2009	Traffic Manager
12. Raahe Harbor	21.9.2009	Port Director
13. Estonian Harbors and Logistics Providers	21-22.1.2010	Estonian Maritime Academy
14. VR Cargo	30.3.2010	Safety Advisor

The case studies serve as an identification method of sources of risk for scenario building as well as a data source for simulation model infrastructure. Table 10 introduces the interviews in chronological order. In the following cases are presented starting with transportation infrastructure in Finland and Estonia followed by the two cases of logistics operators. The last, hypothetical case concerns the economic evaluation of a railway tunnel between Tallinn and Helsinki. The tunnel is presented because it would provide an additional transportation route across the Gulf and thereby increase the security of supply in both Estonia and Finland.

3.1 Case: The Port of Kotka

Municipality owned sea port of Kotka, which lies in the coast of Gulf of Finland, is the second largest Finnish container port with 31 percent of markets (year 2009) and capacity of 1 million TEU. Car transit in year 2008 was 441 940 cars, after which it has declined (Port of Kotka, 2009; 2010). In the port more than a third of freight is delivered in containers. The port of Mussalo, established in 1989, was the first container port in Finland. Kotka is also remarkable export and transit port. The port offers direct connections to Germany, Great Britain, Holland, Belgium, Estonia and other European ports. In the port of Kotka nearly 3 000 people are working daily and it has developed during the latest years towards one of the most modern, pro-environmental and safe sea ports in the region.

In the port international ships and port infrastructure safe regulations are complied. ISPS (International Ship and Port Facility Security Code) includes port security regulations to shippers and ports in all maritime infrastructures. Safe operation methods are inspected by internal and external auditing. Quality and safety systems are checked in daily operations and with extra audit. Finnish Maritime Administration has made several inspections to the port annually. Also U.S. Coast Guard and U.S. Marine and Port Organization have made informal inspections. Learning from the best practice in port operating safety and security systems is also a common way to develop security in the port.

Port security in the port of Kotka is mainly handled by access control system. Access control system is based on automatic camera identification of vehicles that are coming or leaving the entrance point of the port area. The common interest has also increased cooperation with other safety and security authorities: ISPS rehearsals have been carried out with fire and rescue department. Furthermore, port of Kotka has a new contingency plan with national defense. Besides, information is shared with other ports in the Finnish Port Associations' security group.

Infrastructure is developed in order to provide effective and safe port operation. Transformability is the building platform for developing and building new in the port, because maritime transportation and operation environment are vulnerable to quick changes. In the year 2009 a new quay (Jänskänlaituri) for gas pipes and a concrete department for the Baltic Sea gas pipes were built. Palaslahti area (150 ha) has been reserved for a new logistics area. Hietanen south area is also reserved to the port for the future use.

In order to fulfill the requirements of safe and good environment in all operating systems (planning, construction, and implementation), since the middle of 1990s port of Kotka has been utilizing the environmental ISO 14001 standard and the ISO 9001 quality standard. Additionally, in 2008 the Eco Port plan began that foresees and develops future environmental protection, energy and material saving systems in port area and largely in the Gulf of Finland. Weaknesses and anomalies, which are noted in daily operation or audit are corrected as quickly as possible to prevent accidents and interruptions in the port operation.

According to interviewee, the port of Kotka has remarkable transit traffic to Russia. Cargo includes different kind of materials: customer commodities, chemicals, combustible and explosive materials. Fireworks are transported to Russia especially during autumn and wintertime. This material is transported in containers; once a container was dropped in handling causing a risk of explosion. Also other dangerous situations have occurred. To minimize this kind of risks real time freight declarations and correctness is of primary importance when handling transit cargo. In order to minimize risk in handling orientation courses for the labor force have been arranged: The shortest orientation for stevedores takes two weeks while the duration of the longest course for a crane driver is a half year and extra test is included. In liquid bulk terminal also handling, storage and environmental risks are present. To minimize chemical risk, safety education in handling and storage has been given. Also automatic sensors with cameras to inform and alarm of exceptions have been installed. The harbor authority has arranged common drills with other authorities. Transit traffic involves increased risk of organized crime in different parts of the supply chain. To minimize these risks, international co-operation and data/knowledge sharing with local authorities is needed.

3.2 Case: The Port of Hamina

The municipality owned port of Hamina is located only 35 km from the Russian border. The port handles nearly 20 percent of the Russian transit (Port of Hamina, 2010). During year 2009 transit decreased enormously (about 39 percent) due to worldwide depression (Port of Hamina, 2010). The port of Hamina has a general responsibility of infrastructure and security while handling and warehousing is done by operators. Hamina is specialized in handling containers, liquid bulk (mostly gas) and oil. In harbor and along the road to the Russian border a large number of logistics warehouses is situated. Up to 70 000 DWT vessels can arrive to the harbor, when dredging work of shipping channel and dock to 12 meters deep is ready at the end of year 2010.

Most significant risks at the port of Hamina are a large accident in harbor, at sea, on the road or railway. Besides, leaky Russian tank wagons are a risk, although there are chemical leak indicators for over-loaded tank wagons along the railway from Russia. Furthermore, the port uses gas and does not have own power supply for emergency situations.

3.3 Case: The Port of Helsinki

The municipality owned Vuosaari cargo port of Helsinki is remarkable ro-ro and container port in Finland. Vuosaari handles about one third of the value of Finnish import and export. The terminal is planned to serve flexibly ro-ro and container shipping. There are two 750 meter container quays and 15 ro-ro berths with minimum depth of 12.5 metres. The harbor has a motorway and railway connection; there are eight tracks in the terminal area and some terminal houses can be reached by train. Vuosaari harbor is specialized in handling unitized cargo. There is a regular ferry connection to Germany, Estonia, Netherlands and UK.

In the port of Helsinki ISO 14001 (environmental system) and ISO 9001/2000 (quality system) standards are used. In emergency situations port operations are tried to be kept as effective as possible. In breakdowns all entrances are open and transportation is controlled by spot checks. Also the port operators have own quality and security systems. Risk management systems are limited to the areas owned by the city of Helsinki. In the port there is a devised risk management plan as a part of contingency plan. Vuosaari has taken decentralized port operation security model: If part of the port is closed due to breakdown, the rest of the port is operated normally. The risk management system is based on information and electric systems, ISPS system codes. Ships arrive to the port guided by a pilot. The old dock channel to Vuosaari serves as a reserve ship channel.

Information systems and electricity are the most critical systems in the port of Vuosaari. The port operations are based on electric power. Because uninterrupted electric distribution is required, the port has its own electric plant in the port area that makes all needed electric power. The port of Vuosaari is accessed through a road and railway tunnel and traffic in port is automatically directed. Reliable information systems are necessary for undisturbed port operation. The access control and automatic directing of ports' traffic are common methods in port security. Access control system in the port is based on automatic camera identification of vehicles that are coming or leaving entrance point of the port area. Security guards monitor the port 24 hours a day. All workers are chauffeured to working places by minibuses: No personal traffic is allowed in port area, which guarantees security and safety.

Safety and security work is based on good orientation: Lift drivers need to pass an aptitude test; the other workers have orientation, before they start to work alone. The workers have several qualifications and certifications to several duties and their earnings consist of basis and many extra payments. Occupational safety has improved and nowadays accidents at work are rare.

3.4 Case: The Port of Lappeenranta

Municipality owned port of Lappeenranta lies in the coast of Lake Saimaa and it has connection to the Gulf of Finland through the Saimaa Canal, which begins from Lappeenranta and ends to Gulf of Finland. The port of Mustola has an advantageous situation in Saimaa canal nearby Finnish and Russian border. It is 42.9 kilometers long canal, including eight locks and it is used annually by 2300 vessels in open water season from April to December. The maximum size of a vessel sailing in Saimaa canal is 82.5 meter long, 12.6 meter beam and 4.35 meter draught. Annually 140-200 vessels visit the port, the majority of which are freight vessels. During 2009 0.11 million tons were handled in Mustola port (Port of Lappeenranta, 2010). The area in the port of Mustola is about 15 hectares including 31 000 m^2 terminal buildings, 20 places for temperature controlled containers and 68 000 m^2 covered open storage for containers and bulk cargo. The city of Lappeenranta intends to develop the port of Mustola and therefore they have reserved 100 hectares land around the port. The logistics center has good railway, road and waterway connections to Russia and there is a free port, Lappeenranta Free Zone Ltd (owned by a Swedish company), that has 3 810 m^2 warm warehouses, 21 000 m^2 roofed storage, and 9 000 m^2 open yard space. Customs services for international connections are available in the logistics area. Because the port of Lappeenranta is accessed through the Saimaa Canal, pre-eminent risks is canal closure due to ice condition, accident or technical reasons.

3.5 Case: The Port of Naantali

Municipality owned sea port of Naantali was founded in 1943, when the state of Finland started to build its reserve stocks of oil. In 1957 Neste Ltd. built its first oil refinery to Naantali. The most important reason was port's good sheltered location and waterways. During the last decade the port has become a significant unitized cargo traffic port nationally. The port employs more than 2000 people, and it is financially significant contributor to the area, and particularly to the town of Naantali (this region holds one of the lowest municipality tax rates in Finland). The port of Naantali is specialized in ro-ro and ropax maritime traffic, but it does not handle containers: In 2009 Naantali was the second biggest truck and trailers port in Finland with 1 854 680 tons and 116 191 trucks or trailers traveling through the harbor (Finnish Port Association, 2010). Naantali has a remarkable position especially in Finland's Scandinavian freight traffic having route between Naantali and Swedish sea port of Kappelskär (Port of Naantali, 2009). The oil transportation is nowadays limited by the oil refinery capacity of Naantali. About 400 ships visit annually Naantali, and carry about 4 million tons of oil and oil products. Raw oil is transported to the refinery from Primorsk. 40 percent of oil products are transported to the customers by ships and the rest by trucks or railway.

The investments to the port infrastructure in Naantali will be large in the near future: The quays' repairing investments (a new two level ro-ro quay) will amount to 6-9 million Euros and oil shipping needed deep-waterway (15.3 meter) investment will require 4-5 million Euros. Besides that the port of Naantali is in long-term co-operation with the ports of Southern-Western Finland and Centre of Maritime Studies in education and development (University of Turku). As the operations in the port are concentrated on a relatively small area, a minor accident or spillage might cause a stop in port operations.

3.6 Case: The Port of Kokkola

The municipality owned port of Kokkola lies in the Gulf of Botnia. Kokkola is important dry bulk, single consignments, liquid chemical, oil and raw materials harbor: About 42 percent of whole exports and 54 percent of westbound transit is transported via Kokkola. (Finnish Port Association, 2010). Kokkola has the biggest European all weather terminal that enables load and unload ships in a warehouse. It has also the only freight cars tipper in harbor.

The limits of transportation routes and these capacities are the most remarkable risks to the port of Kokkola: The port of Kokkola has only one shipping line to the harbor, and an accident in it would stop transportation to the harbor. Land side transportation to the harbor is operated mainly (80 percent) by trains; the railway connection to harbor is a bottleneck. The loading capacity and especially functionality of derricks is a risk of the port of Kokkola: The port is situated in three separate areas and there are several derricks in use. Only a limited number of people have derrick driving license. In case of unexpected absence replacement for derrick drivers is hard to find, e.g. pandemia could cause problems in ship loading and unloading. Also the chemical industry near by harbor contains a possible risk, depending on wind direction. In order to avoid or reduce risks, the port of Kokkola complies with the quality, IMO and ISPS rules.

The investments to transportation capacity are the most remarkable investment in the port of Kokkola. Finnish Rail Administration has plans to build a second track and another deep quay is under building work. Also the port of Kokkola has a plan to build more capacity of open roof ware yard and warehouses.

3.7 Case: The Port of Raahe

The municipality owned port of Raahe lies in the Gulf of Botnia. Cargo consists mainly of dry bulk such as wood, steel as well as single consignments. Port of Raahe lies behind a seven kilometers long boat channel. In the end of year 2009 an investment project to deepen the channel from eight to ten meters deep was finished, which included additional risk as the port was operating at the same time. In day to day operations a malfunction in boat steering system could cause of collision between boats. The harbor has two roads and one railway connection. Avoiding or reducing risks, the port of Kokkola complies with the local rescue establishment, IMO and ISPS rules. The harbor co-operates in training emergency situations with Ruukki steel company and the local rescue establishment.

3.8 Case: Kouvola Railway Yard

Kouvola is a marshalling yard where railway traffic from the ports of Turku, Helsinki, Hanko, Hamina and Kotka is divided to the other places in Finland. Additionally, Kouvola has connection to Russia and Asia via the Rail Corridor 9. The rebuilding work at Kouvola railway yards in 2008-2010 includes replacing all surface structures in order to allow 25 ton axle weight on all tracks. Furthermore, creation of long trains used in Russian traffic will be supported as well as additional freight loading and unloading platforms will be built. In the railway yard trains are created by using an automatic downward slope. The trains that bypass Kouvola use tracks separated from the yard operations. These trains are generally freight trains from the port of Kotka to Russia.

Risks in Kouvola railway yard can be separated to environmental and occupational security. Chemical or oil tankers’ spillage is typical accident in Kouvola railway yard that has occurred annually several times. Because chemical tank wagon traffic is intensive between Finland and Russia, an automatic spillage identification point is used in Utti that measures concentration of hydrocarbon. In case of emergency, the system alarms Kouvola central railway control. In Kouvola railway yard there is a refuge pool for spillage tank wagons (Kouvolan seudun rataympäristöselvitys 2007 and 2008), because it is the most significant spillage risk soil area. Noise and vibration are the most significant risks to workers in railway yard, tracks and these neighborhoods. Noise is considered detrimental to health, if it is louder than 50 dB at night and 55 dB in daytime. Noise area at night time varies from 20 to 650 meters on both sides of track and day time from 20 to 360 meters. Noise and vibration damages to the environment can be avoided by building noise barriers and planting trees round tracks. However, noise barriers protect only in track level situated settlement. In consequence noise and vibration disadvantages can be avoided best by land use planning: by transforming the living areas near by railway yards into working places and industry grounds. In Kouvola railway yard chemical spillage can be considered a remarkable risk. In 2009 a near-by accident involving a passenger and a freight train was avoided by the alertness of the drivers. The situation was caused by the ongoing railway repairing work.

3.9 Case: Tampere Railway Yard

Tampere serves as a major marshalling yard in which railway traffic from Helsinki divides to directions of Pori, Seinäjoki and Jyväskylä. Tampere railway yard has been rebuilt during last years, in the marshalling yard around 40 trains a day consisting altogether of 700 - 800 wagons are reordered to make new trains. The cargo consists mainly of forestry products and raw materials, industrial products, chemicals and oil products to or from the Finnish ports. The railway operator, VR Cargo, has made a security plan for the railway yard with the emergency centre; a joint security exercise is run annually. A security plan is provided for disaster. Pollution of soil can be caused by derailment and spillage of wagons or locomotives. The main risk is related to handling tank wagons containing chlorine, ammonia or sulphur dioxide, as these gases can spread in large area within wind direction affecting a large population. Approximately 40 tank wagons are handled daily. However, in Tampere serious accidents have not happened.

Noise and vibration are concurred together harmful to the people and environment. As the rail yard is not located close to residential area, noise and vibration are not very harmful. Repair work of railway between Seinäjoki and Oulu will cause delays in railway traffic during years 2009-2015.

3.10 Case: Finnish Road Administration

From the beginning of year 2010 Finnish road administration has been a part of the newly formed Transport Agency. Finnish Road Administration is responsible for Finland’s highway networks. The Traffic Management Centre offers real-time traffic information to the travelers and transportation: road weather conditions, road works on public road and other and Variable Message Signs (VMS). The major goal is to promote traffic safety by improving the quality of traffic flow on the roads; for instance traffic flows can be controlled by variable speed limits. Besides that Traffic Management Centre provides information on alternative routes and public transport possibilities.

For the transit transportation Traffic Management Centre has developed real time web camera and mobile information about congestions on roads to the border and in the border region. Besides that road administration has co-operation in the Baltic Sea Region. The main goals of the cooperation with Russian neighboring areas are to improve traffic conditions, traffic infrastructure and to increase traffic safety and fluent flow of traffic.

The most remarkable risk for the services that Finnish Road Administration offers is the information system that is centralized to the Traffic Management Centre. Problems with the Internet based information system would stop the production of services. The most remarkable investments are focused in providing new information systems for the drivers and the transportation sector.

3.11 Case: The Port of Tallinn

The state-owned port of Tallinn consists of four geographically separated sea ports: The Old City harbor is specialized in passenger, ro-ro and ropax maritime transportation, the port of Muuga is specialized in oil, oil products and dry bulk, the Paldiski Southern Port has ro-ro, liquid and dry bulk, passenger and car transportation, while the smallest port of Paljassaare has an oil, coal and general cargo terminal (Port of Tallinn, 2009). Paljassaare Harbor is situated on Paljassaare Peninsula in Tallinn, approximately 6 kilometers from the centre of the city. The port of Tallinn has regular ro-ro lines to the ports of Helsinki, Hanko, Turku and Uusikaupunki (Port of Tallinn, 2010a). Many ships arriving from European ports visit both Estonian and Finnish ports on the same route. Generally the ports of Estonia have increased handling of the Russian oil during the last decade; on the other hand general cargo has decreased considerably. Also dry bulk and ro-ro transportation have increased at containers expense.

The Muuga oil and container harbor has developed as the most modern part of the port of Tallinn, due to deepest waterways, large territory areas (524 hectares) and good railway connection to Russia. Therefore, Muuga is an important export and transit harbor: Russian oil and oil products take more than 75 percent of its operation capacity and volumes of consumer commodities going to Russia are also remarkable. Currently Muuga handles nearly all containers (131,000 in 2009) going through Estonia, and its container handing capacity is estimated to reach 0.8 million TEU by year 2012 (Port of Tallinn, 2010b). However, the harbor is located very near of the City of Tallinn and nearby situated oil tanks are dangerous in case of accident, because of a possible domino effect of explosion, e.g. chemicals and other substances are held in warehouses in surrounding areas. Automatic access control, cameras and spillage indicators monitor the port 24/7 to detect interruptions and spillages. Port of Muuga has confronted few emergency situations: In 2008 six oil tank cars had spillage at the same time in the harbor, and the danger of catastrophe was obvious. The reason of spillage was heat expansion of overfilled tanks (Hunt, 2009). In addition, the main risks in Muuga are wind, tornados and ship accidents.

The Old City Harbor is a remarkable ropax and passenger ships port, which is visited by cruisers worldwide. The harbor lies near the city of Tallinn and concentrates on passenger transport. The main risk is an accident in the harbour.

The Paldiski Harbor consists of two harbors: Paldiski South Harbor that belongs to the port of Tallinn, and Paldiski North Harbor that belongs to Russian investors. Paldiski South Harbor is specialized in handling of Estonian export, import and transit transportation mainly with ro-ro ships. The future development plans in Paldiski will increase passenger car handling up to

300,000 cars annually (by year 2010). In emergency situations port operations are tried to be kept as effective as possible. In the port of Paldiski cargo handling operator Esteve has ISO 9001/2000 quality system. Most significant risks in the port of Paldiski are a large accident in the harbor, at sea, in the road or railway. The Paldiski harbor does not have own power plant, so interruptions in electricity delivery incur a considerable risk.

3.12 Case: The Port of Sillamäe

The privately owned port of Sillamäe is located 25 kilometers from the Russian border in the Gulf of Finland. With a railway connection and location close to Russia, it is specialized to handle liquid bulk: oil, oil products, methanol, acetic acid, vinyl acetate, butyl acetate, toluene, mono ethylene glycol and other petrochemicals. The port was opened in 14.10.2005, and is developing all the time: During year 2009 new quays and a car terminal were opened. New Silport Container Terminal with four quays and up to 5 million TEU handling capacity is under construction. For new investments the port has about 600 hectares reserve areas around the port (Port of Sillamäe, 2009).

Sillamäe has developed as a modern and versatile harbor also in security perspective. New techniques are employed: automatic cameras with sensors and spillage identification points. Most significant risks in the port of Sillamäe are a large accident in harbor, at sea, on the road or railway. Especially oil disaster can cause a long run stoppage in the harbor caused e.g. by leaky tankers from Russia. A considerable financial risk to the port of Sillamäe will be in long run the nearby port of Ust Luga.

3.13 Case: Logistics Operator Stella Corona

Stella Corona is a local logistics operator in the port of Kotka handling mainly customer commodities in transit transportation and a small amount in internal forwarding. Containers and new cars handling to Russia has been until now the biggest area of operations. Stella Corona provides flexible services from “door to door” solutions to being a part of the forwarding chain.

Stella Corona has all its facilities in Mussalo, Kotka, which limits its operational flexibility in terms of location. Currently Stella Corona handles the Baltic Sea gas pipes line parts of the eastern part of the pipe line.

Interruptions and breakdowns in logistics chain can be caused due to labor, customer insolvency and customs formalities. The most remarkable risks that would cause a long stoppage in logistics chain could be an accident in the port of Kotka or at sea near by the port. Minor handling accidents have occurred in terminals during loading and unloading. A risk to a local logistics operator, like Stella Corona, is caused in the long run by the new transportation routes to Russia initiated by new ports like Ust Luga in Russia and port of Sillamäe in Estonia.

3.14 Case: Logistics Operator Kuehne + Nagel

Kuehne + Nagel is a global supply chain operator that operates in all transportation modes: in sea, road, rail and air freight. Besides that it provides total logistics solutions for industry. In Finland the head office is located in Helsinki region (in Vantaa) and warehouse services are available in the port of Kotka and Hamina. In addition it operates inside customers in Pori, Vaasa, Tampere and Lahti. Because Kuehne and Nagel operates in more than 100 countries with 55,000 employees, information systems are very important: All logistics operations are saved and stored in three data centers that are situated in various places in the world. Furthermore, the operator has readiness to change its local operation from place to another easily. For emergency situations K+N have also analogical phones and faxes.

The main risks for the logistics operations are caused by labor, communication, and accidents. Also a lack of road and railway connection to Europe is considered a risk: Finland is like an island from a logistics viewpoint. Espionage and interruption in supply chain are considered risks. The risk management is focused on information systems as well as obvious supply chain risks. Alternative transportation routes are selected using routing software. In Finland, Kuehne + Nagel has the following quality standards: quality certification ISO 9001 in 1997, environmental certification ISO14001 in 2001 and certificate for occupational health and safety OHSAS 18001 in 2003.

3.15 Hypothetical Case: Economic Evaluation of a Railway Tunnel between Tallinn and Helsinki

In the world there are two long railway tunnels situated mainly under seabed: The Seikan tunnel between Isles of Hokkaido and Honshu in Japan, which total length is 53.85 km, from which 23.33 km is under seabed. The other, Eurotunnel lies (length about 50 km) in the English Channel; it consists of two railway tunnels and a service tunnel (Matthiessen, 2000). Eurotunnel is financed by investment bank consortium, while the Seikan tunnel is community owned. Neither of the railway tunnels has been economically successful. In the Seikan tunnel freight volumes have been lower than expected, because the air transportation has been very affordable in this area. In case of the Eurotunnel building costs were about 80 percent higher than expected, in total about 10 billion UK pounds. Furthermore, in the beginning of operations passenger transportation was half of expected while freight transportation was one third of expected. During the first decade, the economic problems of the Eurotunnel were enormous, until a loan arrangement was made during 2007, which made operations profitable. An 8.9 billion euro loan was released and the rest of the loan, 4.16 billion euro, was arranged through a long term loan. The remaining 4.16 billion euro loan compared to annual transport incomes 708 million euro (in year 2008) is reasonable to enable a successful future (Eurotunnel, 2009; Schueler, 2007). In addition to two tunnels presented above, under construction is a high-profile tunnel / bridge aggregate connecting Hong Kong to Macao and mainland China, city of Zhuhai. Once project is ready, it will be the world’s longest cross-sea bridge by the length of around 50 kilometers, of which approximately 35 kilometers will be built over sea. The project is estimated to cost nearly 10.7 billion USD, which will be shared by authorities in Hong Kong, Macao and mainland China. The project is expected to be finished in 2015, shortening the transport time from three hours to 30 minutes. (Chinaview, 2010; GovHK, 2010; Transport and Housing Bureau, 2010). Flyvbjerg et al. (2008) have studied capital costs incurred in building urban metro lines. According to their study in European projects the total capital cost per route-kilometre lies typically between 50 and 100 million USD (2002 prices) while American projects tend to be more costly. It must be noted, that urban metro lines include above-ground sections, where construction costs are considerably lower. Table 11 presents a comparison of the investment costs of the Eurotunnel and the Seikan tunnel.

Table 11. Cost comparison of two tunnel projects. (Bank of England, 2010; European Central Bank, 2010; Morse, 1988, Office for National Statistics, 2010; Schueler, 2007)

Project	Eurotunnel	Seikan Tunnel
Total cost (million Euros)	16 838	4 540
Tunnel length (kilometers)	50	54
Price per kilometer (million Euros)	336	84

A similar infrastructure investment is the Oresund Bridge connecting Malmö, Sweden and Copenhagen, Denmark. It had total cost of 1.3 billion USD in 2000 and was financed by States of Sweden and Denmark. The 16.4 km long connection consists of a 7.845 km long bridge, an artificial island and a tunnel which provide both car and railway connections. The bridge constructs Copenhagen-Malmö urban area, which is now Scandinavia's largest with 2.6 million people and enables good connections to the Copenhagen Airport. The bridge has been successful and transportation volumes have been higher than expected: In 2007 there were 140 trains per day, giving an annual total of 47 000 passenger trains and 8 850 freight trains. The same year about 25 million people used Oresund bridge connection: 15.2 million in cars and 9.6 million by train. Passenger volumes are expected to increase even further (Copenhagen-Malmö Port, 2008; Fenger et al., 1996).

The effects of road and railway tunnels have varied largely. In the Seikan tunnel freight transportation was largest in 1978 where after it has reduced annually. Furthermore, quick, comfortable and cheap air transportation has increased in passenger transportation between Hokkaido and Honshu. The opening of Eurotunnel stopped nearly all ferry transportation in the English Channel from East England to France, Belgium and Luxemburg. In the future the Eurotunnel has good possibilities to increase freight and passenger transportation between British Isles and Middle European metropolises. The Oresund bridge has enabled a faster connection from Sweden to Middle European metropolises: Ropax traffic has ended in this connection and especially railway sector has increased in both freight and passenger transportation. Also the

Copenhagen-Malmö Port (CMP) first confronted decline: during 2001 and 2002 freight transport decreased to 13 million tons (Copenhagen-Malmö Port, 2008), but in year 2008 volumes increased to 17 million tons (Copenhagen-Malmö Port, 2008). Passenger transportation has also recovered, because of new cruiser routes to faraway harbors. CMP has begun to build new port infrastructure to Malmö in March 2009: Providing container terminal, ro-ro terminal, combination terminal, logistics and transport company and infrastructure area with good railway connections. Also the airport of Copenhagen has benefitted from the Oresund bridge connections to Copenhagen-Malmö region.

Construction of railway tunnel

The tunnel connection consist of two 8.0 metre diameter railway tunnels 30 meters apart and between these is situated a 5.0 metre diameter service tunnel. The total length of each tunnel is about 55 kilometers. Railway tunnels have connection to the service tunnel at 400-metre spacing. Between two railway tunnels are 2.0-metre diameter air tunnels at 250-meter spacing. In tunnel connection has been also build two crossover covens and connection to the artificial island.

The amount of mined stones, presented in Table 12 were calculated using above mentioned construction of railway tunnel. Because all tunnels will be covered by concrete, the quarrying work must be done narrowly avoiding over quarrying. The amount of over quarrying is evaluated 10 percent that is 0.4 million m^3 (1.08 tons).

Table 12. Amounts of quarrying stones.

Construction	Mined stone, m^3	Mined stone, tons
Railway tunnels, 2 units	2.8 million	7.6 million
Service tunnel, 1 unit	1.1 million	3.0 million
Connection to service tunnel	0.2 million	0.5 million
Air tunnels	0.3 million	0.8 million

Calculations

The shortest tunnel connection line under seabed between Finland and Estonia would be about 55 kilometers long: In that case it would begin from Kirkkonummi, Finland and end to the northerly town of Tallinn, Estonia. The long tunnel connection needs a service connection: An artificial island should be made of the part of mined stones (about 3 million m^3) to the middle of Gulf of Finland. The rest of mined stones (about 1 million m^3) near towns of Kirkkonummi and Tallinn will be used on railway track construction. The calculation of the tunnel plan was made by using Eurotunnel as a reference plan. The construction period of the tunnel is assumed to be five years. The annual number of passenger and amount of cargo are based on sea volumes of year 2008 that are expected to shift to the tunnel (Merenkulkulaitos, 2009a; 2009b). The amount of cargo is assumed to increase by 50 percent. Price of the passenger tickets and cargo is assumed to remain on current level, and was acquired from web pages of current ferry operators as well as discussions with logistics operators. Based on the calculation, presented in Table 13, the tunnel connection between Helsinki and Tallinn seems to be unprofitable: The net present value using 30 years calculating period was -2 953 million Euros and the benefit-cost ratio (BCR) was 0.462.

Table 13. Economic evaluation of the railway tunnel Helsinki- Kirkkonummi-Tallinn.

Variable	Value
Total length of the connection	80 kilometers
Length of tunnel	55 kilometers
Passengers	6300000 persons / year
Cargo	7700000 tons / year
Pric of ticket	30 € / passenger
Price of cargo	20 € / ton
Social benefits	35 million € / year
Environmental benefits	20 million € / year
Total investment	15120 million €
EU subsidy	4536 million €
Net present value	-2953 million €
Benefit-cost-ratio	0,468

According to the sensitivity analysis reported in Figures 4 and 5, the railway tunnel seems unprofitable in most of the cases. The used distributions representing uncertainty are presented in Appendix 1. Based on Figure 6, the investment cost of the long railway tunnel is the main reason for the unprofitability of the tunnel. Also the amount of passengers and especially cargo will be far too small to turn the tunnel connection profitable. With estimated incomes and benefits the tunnel connection will be profitable, if the investment cost does not exceed 7.0 billion euro using a 30 years calculation period. On the other hand, the amount of cargo should be threefold or amount of passengers should double in order for the investment to be profitable. Although the tunnel as an investment seems unprofitable because of the high building cost, without the capital cost operating it would be economically feasible.

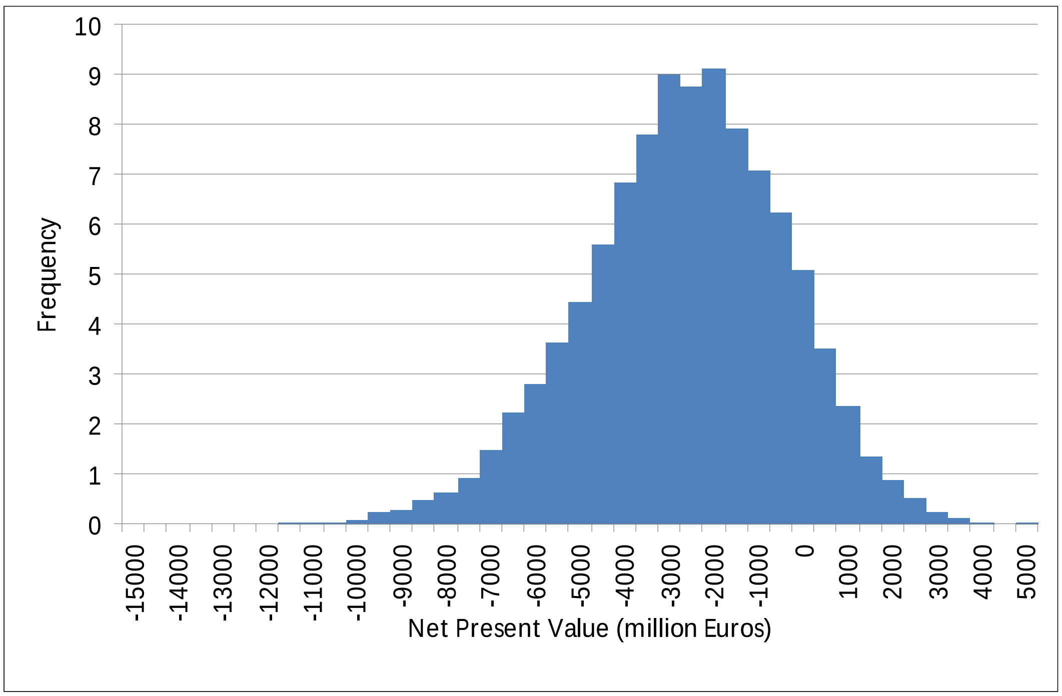

Figure 4. Variation of Net Present Value, NPV, in the Helsinki -Tallinn tunnel plan.

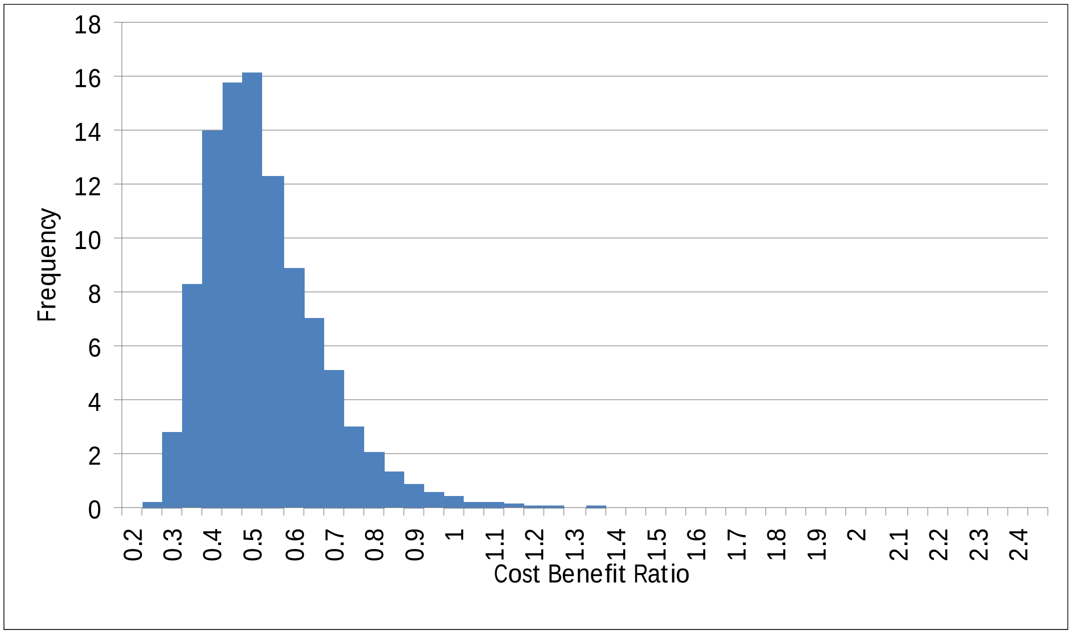

Figure 5. Variation of Cost-Benefit Ratio in the Helsinki- Tallinn tunnel plan.

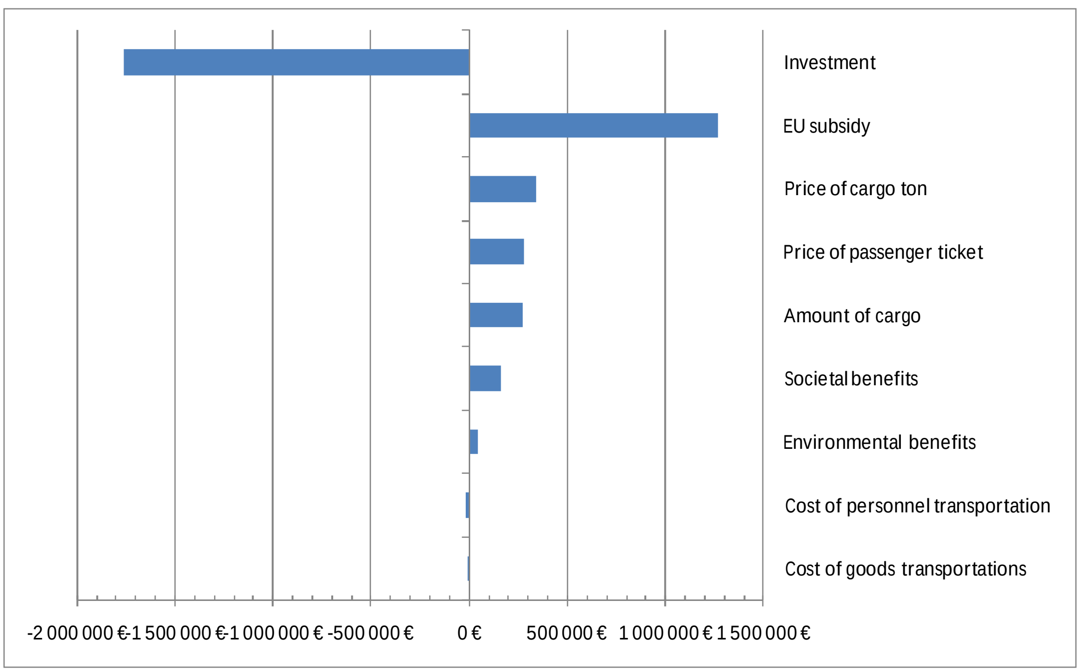

Figure 6. Regression sensitivity for Cost-Benefit Ratio.

The effects of a railway tunnel across the Gulf of Finland would be remarkable to other transportation modes: to a large degree of ro-ro, superfast passenger boats and air transportation would probably end. However, the passenger boat transportation (ropax) mainly concentrated to the summer season would probably remain. In addition to technical and economical issues, a long tunnel with only three emergency exits would be dangerous in case of an accident and therefore the service tunnel should be equipped with own transport equipment.

Evaluating the possible surplus of the mined stones

According to the above plan there are no excess stone materials from the tunnel. If the artificial island is not included in the tunnel plan a surplus of 8.1 million tons of stone will result. Furthermore, if stone material is not used for railway construction on land, the stone surplus of the tunnel will be 11.9 million tons. This material could be used for other construction purposes in Helsinki region, where the value of refined stones is assumed to vary between 10 and 20 Euros per ton. Thus, the total value of the surplus stone material varies from 119 to 238 million Euros, which equals 0.5 to 1.0 percent of railway tunnel total costs.

Including the economic effects of strikes of the tunnel calculation

According to Eurostat statistics, Finland is one of the most strike sensitive countries in Europe (EK, 2010a). Although the transport sector is not in the leading position when ranking industrial actions, every now and then situation gets difficult. In March 2010 the Finnish Transport Workers' Union AKT began a strike among stevedores. AKT demanded 12 months of severance compensation, which the employer, the Finnish Port Operators Association, considered unreasonable. The strike lasted 16 days, but the consequences were significant: strike devitalized foreign exports and imports almost totally. The financial impact in export losses was estimated to be 110 - 160 million Euros daily. Furthermore, the strike damaged Finnish companies' reputation. Strike affected directly several industries: 70 percent of paper machines were closed, and transport costs increased due to growing need for air transport. (EK, 2010b; EK, 2010c). Table 14 illustrates the strike sensitivity in Finnish ports.

Table 14. Strikes and strike threats at Finnish ports 1973-2010. (AKT, 2010)

Year	Action	Duration
1973	**Strike**	**3 weeks**
1975	Strike threat	
1976	**Strike**	**5 weeks**
1981	Strike threat	
1983	Strike threat	
1984	Strike threat	
1990	Strike threat	
1991	**Strike**	**4 weeks**
2004	**Sympathy strike**	**5 days**
2005	Strike threat	
2010	**Strike**	**16 days**

According to Eurostat figures, between 2000 and 2007 in Finland in labour disputes were lost per 1000 employees annually approximately 70 working days, which ranked Finland to fourth place, after Spain, France and Italy. For comparison, other Nordic countries generate smaller figures; Denmark around 35 and Sweden 21. Interestingly, Estonia seems to have only few labour disputes, around 5 working days were lost per 1000 employees annually between 2000 and 2007. (EK, 2010a)

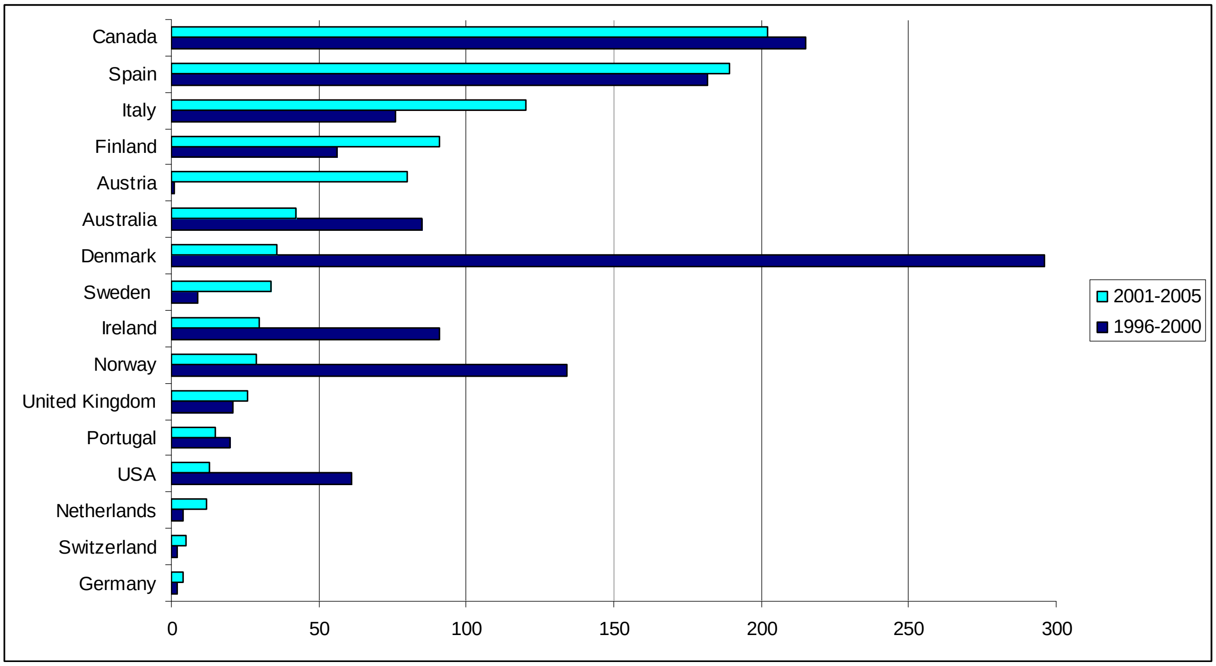

Figure 7. Labour disputes in various countries 1996 – 2005; annual average of working days lost per thousand employees. (Hale, 2007)

Figure 7 illustrates the situation worldwide. Although EU external OECD countries are taken into account, Finland still ranks rather high when comparing strike sensitivity. However, it is notable between 1996-2000 Finland ranks ninth; for example Norway, Australia, Ireland, USA and Denmark have higher figures than Finland. Therefore, it can be noted, that in 21st century strike sensitivity increased dramatically. Year 2009 was extremely volatile: number of labour disputes increased 40 percent from 2008, whereas the amount of engaged employees tripled and lost working days five folded. (EK, 2010d)

In 2009 in Finland the main reason for strike was employees' redundancy or its threat (53 percent). Additionally, supervisory tasks (15 percent) and industry's collective labour agreements (12 percent) were stated as other reasons. Although the amount of labour disputes was largest in industry (75 percent), the losses were stressed on service sector (85 percent of all working day losses). According to EK (2010e), the financial losses occurred for Confederation of Finnish Industries' member companies were approximately 400 000 Euros per industrial action. However, indirect total losses were multi folded. (EK, 2010d; EK, 2010e)

A tunnel between Helsinki and Tallinn could provide an alternative route during a strike in sea ports. This could greatly enhance the profitability of the tunnel. As the strike sensitivity has increased in the 21st century, we are going to analyze different scenarios. In the first scenario the labour union is going on strike once every 20 years, in the second scenario once every 10 years and in the last scenario once every 5 years. As the length of the strike is unknown, it is allowed to vary using a triangular distribution with a minimum value of five days, mode of 10 days and a maximum value of 20 days. Also, as the financial impacts of the strikes are unknown, it is allowed to vary using a triangular distribution with a minimum value of 100 million Euros, mode of 110 million Euros, and a maximum value of 160 million Euros per day. A thirty year analysis is conducted and the financial losses are discounted using a five percentage rate of return. The results for the scenarios with sensitivity of one strike per 10 years are shown here, while other scenarios can be found in Appendix 2. Figure 8 shows the histogram of the net present value of the discounted financial losses.

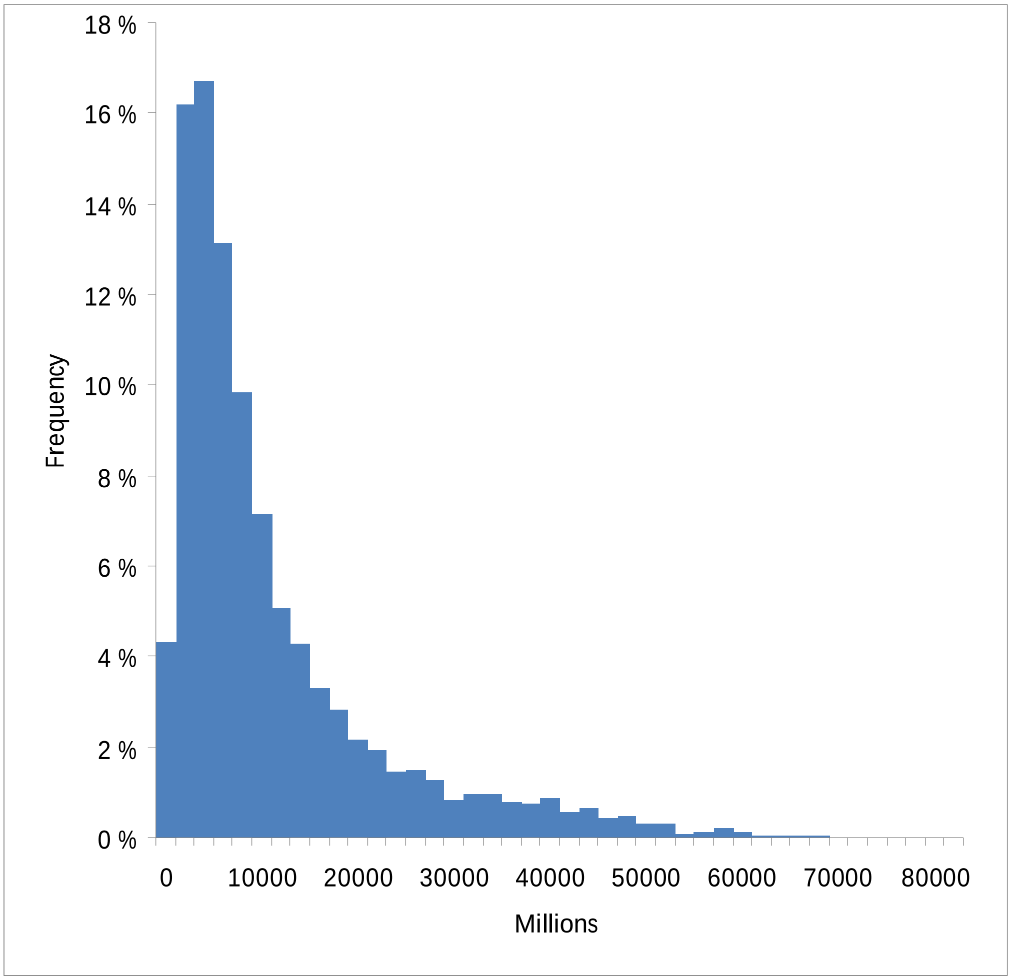

Figure 8. Histogram of the NPV of financial losses in million Euros, strike sensitivity 10 percent.

As it is possible to notice from Figure 8, the net present value is concentrated around 5 billion Euros. The mean value is over 10 billion due to a highly skewed distribution. As the tunnel will have a constrained capacity and it is not possible to transport all of the goods, Figure 9 shows the percentage of cases where the net present savings are over 2 953 million Euros, i.e. the amount that would be pivotal for the original NPV calculation presented in Table 13, with varying amount of goods being able to transport using the tunnel.

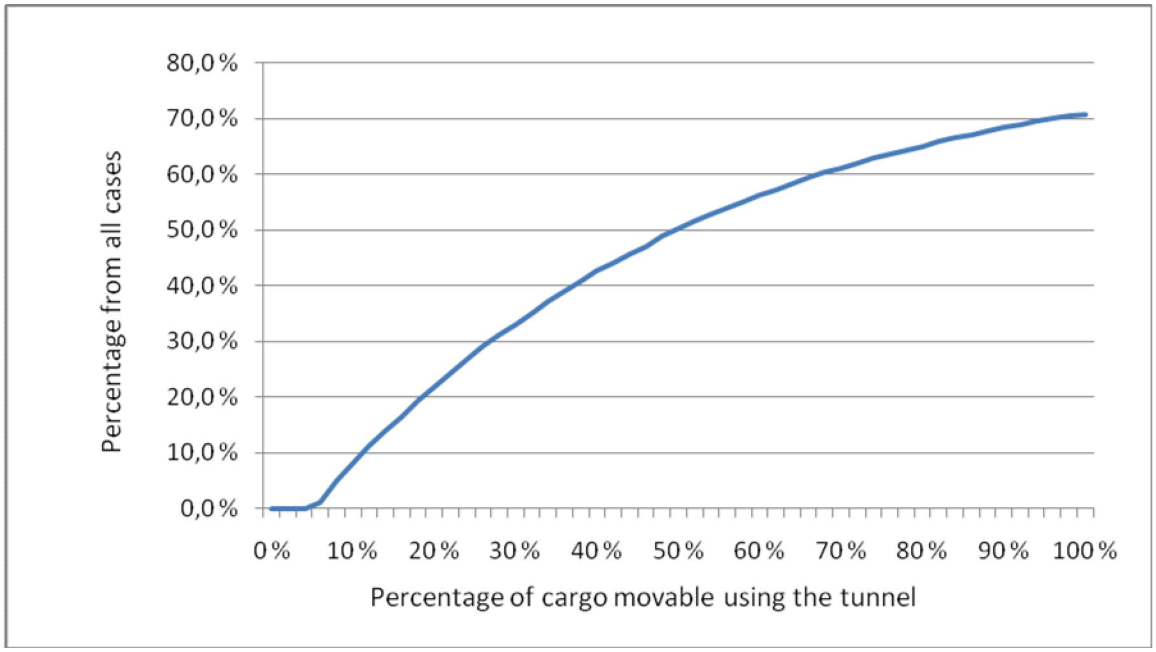

Figure 9. Percentage of cases, where NPV is over 2 953 million Euros.

The first cases start to appear, when six percent of the financial losses can be transported using the tunnel. Thereafter the trend is nonlinear ending to around 70 percent of the cases making the tunnel financially profitable. However, it should be noted that the strike sensitivity of the labour union might start to decrease as the financial impact of their actions starts to decrease. In the hindsight this might make the tunnel look financially a bad decision, althought the tunnel itself would be the reason for decreaced number of strikes.

The analysis included avoiding financial losses due to strikes, however, the economical feasibility of the tunnel would be further improved by including avoiding losses due e.g. large oil disasters. Although these disasters would actually not occur, companies currently need to prepare for them by keeping additional safefy stocks, which incurres extra cost. If the high speed rail connecting the Baltic states with Berlin, known as Rail Baltica, is actualized the tunnel would additionally provide international passenger connections also in case of ash problems in athmosphere preventing air traffic. The evaluation of this component of the benefit-cost ratio calculation is left for further studies, here we only note that the feasibility of the project is affected positively if this aspect is included.

4 Transport Market Deregulation

The history behind European Union leads back to year 1949, when few West European countries created the council of Europe. Foundation of the European Economic Community (EEC) or "common market" in 1957 increased the freedom; it enabled goods, people and services to move freely among the Member States. The final reinforcement happened in 1993, when the Single Market was completed with so called "four freedoms" (European Union, 2008): movement of goods, services, people and money. (European Union, 2008; 2010a)

In 2007, the total amount of freight transported in the EU reached 4 228 billion ton-kilometers; inland transport modes' share extended to 2 649 bill. ton-kilometers. From overall figures railway's share was 10.7 percent, while considering only inland transport modes railways share rose to 17 percent. When comparing overall transport figures from 1995 to 2007, fastest growth in freight transport was noted in road (49.6 percent), sea (37 percent) and air (five percent). However, when observing the last two years, 2006 and 2007, road (3.9 percent), railway (2.7 percent) and air (3.3 percent) grasped largest growth (see Table 15).

Table 15. Freight transport in EU-27 area (billion ton km). (European Union, 2009)

Year	**Road**	**Rail**	**Inland waterways**	**Pipelines**	**Sea**	**Air**	**Total**
1995	1289	386	122	115	1150	2.0	3064
1996	1303	392	120	119	1162	2.1	3098
1997	1352	410	128	118	1205	2.3	3215
1998	1414	393	131	125	1243	2.4	3309
1999	1470	384	129	124	1288	2.5	3397
2000	1519	404	134	127	1348	2.7	3534
2001	1556	386	133	132	1400	2.4	3610
2002	1606	384	132	128	1415	2.6	3668
2003	1625	392	124	130	1444	2.6	3718
2004	1747	416	137	132	1485	2.8	3920
2005	1800	414	139	136	1520	2.9	4012
2006	1855	440	139	135	1548	3.0	4120
2007	1927	452	141	129	1575	3.1	4228
1995-2007	49.6 %	17.1 %	15.6 %	12.1 %	37.0 %	55.0 %	38.0 %
Per year	3.4 %	1.3 %	1.2 %	1.0 %	2.7 %	3.7 %	2.7 %
2006-2007	3.9 %	2.7 %	1.9 %	-4.7 %	1.7 %	3.3 %	2.6 %

When comparing the percentage shares between different transport modes, road transport has increased its part, while railway transport has confronted decline. Other transport modes have confronted only slight changes (see Table 16).

Table 16. Freight transport share of modes in EU-27 area (percent). (European Union, 2009)

Year	**Road**	**Rail**	**Inland waterways**	**Pipelines**	**Sea**	**Air**
1995	42.1	12.6	4.0	3.8	37.5	0.1
1996	42.0	12.7	3.9	3.9	37.5	0.1
1997	42.0	12.7	4.0	3.7	37.5	0.1
1998	42.7	11.9	4.0	3.8	37.6	0.1
1999	43.3	11.3	3.8	3.7	37.9	0.1
2000	43.0	11.4	3.8	3.6	38.1	0.1
2001	43.1	10.7	3.7	3.7	38.8	0.1
2002	43.8	10.5	3.6	3.5	38.6	0.1
2003	43.7	10.5	3.3	3.5	38.8	0.1
2005	44.6	10.6	3.5	3.4	37.9	0.1
2006	44.9	10.3	3.5	3.4	37.9	0.1
2007	45.0	10.7	3.4	3.3	37.6	0.1

Figure 10 represents the development of transport in the EU from year 2000 to 2007. During the period, road freight transport increased 27 percent and sea freight transport 17 percent. However, inland waterways increased only 5 percent.

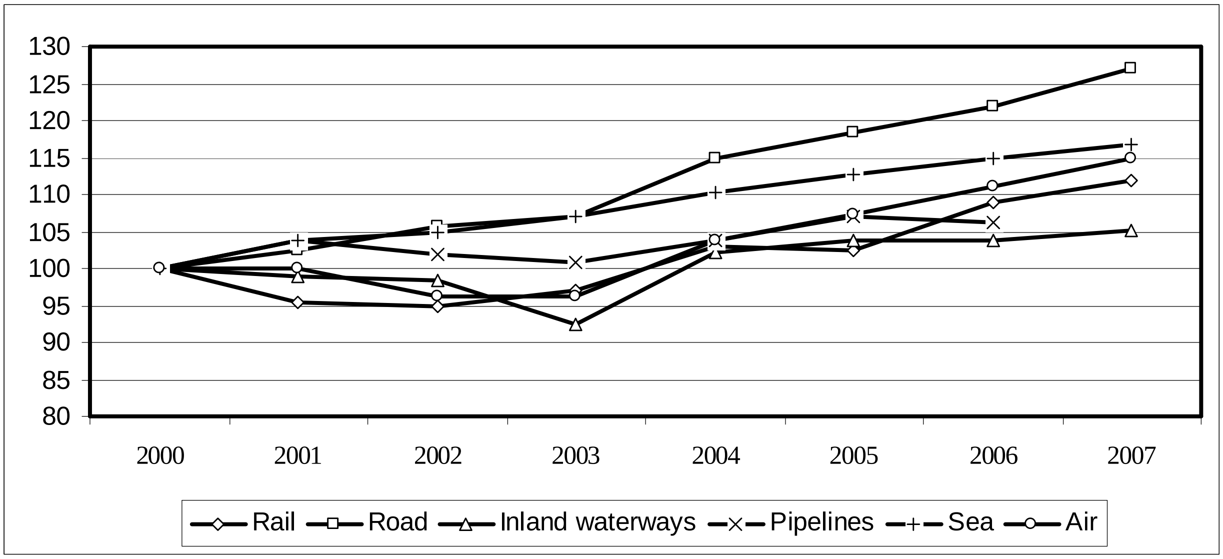

Figure 10. Development of EU-27 freight transport for all modes based on ton kilometers, (Year 2000 = 100). (European Union, 2009)

Although deregulation has had a worldwide influence on transport markets, the implementation methods have varied greatly. In the United States process started in 1980, when two major deregulation acts, the Motor Carrier Act (MCA) and Staggers Rail Act were introduced. MCA opened the road transport for competition, whereas Staggers Rail Act deregulated the American railway industry. (Jahanshahi, 1998; Lafontaine and Malaguzzi, 2005) According to various studies, deregulation has led to lower prices as well as organizational changes in transport companies (see for example Joskow and Rose, 1989; Rose, 1985; Rose, 1987; Winston et al., 1990; Ying and Keeler, 1991). Other countries have deregulated the transport markets during the last decades; in European Union, transport markets have been opened for competition concurrently with development of European Union. However, European Union has confronted problems in harmonizing the Member States' legislations. The economic deregulation has not abolished discrepancies in the conditions under which companies compete. Therefore, almost all European countries have preserved national tax and labor legislations. For example, in Eastern Europe taxes, wages and social security are lower but maximum working time longer than in old Member States. (Hilal, 2008) Thereby, logistics companies have to change operational functions in all Member States in accordance with the operational environment.

In market economy deregulation has propitious effect on service users: prices decrease, services expand and diversify and become better adapted to users' needs (Quinet and Vickerman, 2004). However, in an expansive market area (as in European Union), the deregulation effects can vary strongly, due to discrepancies in operational environment (for example infrastructure). Countries have other characteristics which impinge on situation, such as local legislation and wage level. Deregulation and liberalization does not mean total withdrawal from the state. In order to have an effectively working market, it is essential that government enforces regulations. Furthermore, it is government's responsibility to ensure that external effects are sufficiently identified, in order to ensure the benefits of deregulation are actual and attainable. (Quinet and Vickerman, 2004)

Critical infrastructure protection is noted worldwide as an essential part of national security. For example, political and administrative initiatives require better concern due to their critical nature (see for example Brunner and Suter, 2008; Dunn-Cavelty and Kristersen, 2008; Dunn-Cavelty and Suter, 2009). One challenge is confronted due to privatization and deregulation of various parts of the public sector. Since 1980s several parts of critical infrastructure have been delegated to private enterprises, which might impede the overall attention concerning the targets.

Privatization and deregulation distributes the functions to parties which have the best possibilities to take care of them. According to Banister (1990), privatization has a positive effect on economy in functional market: Public sector can utilize limited resources in an economical way. Furthermore, one of the questions is how the society can deliver basic services in emergency situations, when several important trades are operated by private sector or multinational companies.

4.1 Road Transport Deregulation

Correlation between developed and efficient transportation infrastructure and economic growth has been one of the reasons for deregulation development (Andersson and Strömquist, 1998). Regulation have been criticized for misallocating the resources. Studies from the United States discovered connection between lower productivity and regulation (Backman, 1981). According to Andersen (1992), a common solution to poorly-performing markets has been deregulation, which will achieve intensive competition by promoting new operators to markets. Because competition is presumed to lead to effective resource allocation, deregulation is often noted to decrease the prices due to effectual changes in resource distribution (Backman, 1981; Banister, 1990; Kay and Vickers, 1988)

Road transport deregulation has crabbed researchers' interest worldwide. White and Farrington (1998) studied the bus deregulation in Great Britain, whereas Marell and Westin (2002) evaluated the effects of taxicab deregulation in rural areas of Sweden. According to their studies, service level and vehicle efficiency sharpened and cost and passenger payments increased. Hilal (2008) researched the unintended social deregulation effects of road freight transport in the European Union.

Liberalization development in the European Union

After the Second World War, international transport was strongly limited by respective provisions. Haulers were permitted to provide services between two countries, only if they had bilateral authorizations and service price rates were overseen by states. One of the main objectives was the free movement of goods, which intention was to eliminate the borders between European states. Treaty of Rome was signed in March 1957 and it came into force in January 1958; its main objective was to establish common market by amalgamating the economies of Member States as far as possible by 1) a custom union with a common external tariff b) free movement of goods, persons, services, and 3) eliminating quantitative restrictions. However, it took a long time to achieve all goals. In 1980s European Economic Community (EEC) began the movement towards deregulating the heavily structured transport market (Fulmini, 2006; Hilal, 2008). The Single European Act in 1985 (enforced on 1 July 1987) acted as a specific concept of internal markets; the deadline was set on 1 January 1993 in Council Regulation (EEC) No 881/92 of 26 March 1992 (Bernadet, 2009; Coopers and Lybrand, 1996; Hilal, 2008). Most of the directives approach road transportation's harmonisation via topics such as vehicles, operations, safety, payments and taxes (European Union, 2010a). Table 17 represents essential documents concerning road transport liberalization development in the EU.

Table 17. Liberalization development of road transport in European Union.

Act	Date	Content
Council Device 2002/15/EC	20.12.2002	Working time of persons performing mobile road transport activities, with the aim of further improving road safety, preventing the distortion of competition and guaranteeing the safety and health of the mobile worker.
Directive 96/26/CE	29.4. 1996	Access to profession is basement of efficiency, safety and economy of road freight transport.
Council Regulation 3118/1993	25.10.1993	The single road cabotage market in the EU enable hauler from any EU Member State transport goods between destinations anywhere in the EU with a community license and road haulage authorization.
Council Regulation 881/1992	26.3.1992	Access to the market in the carriage of goods by road within the Community to or from the territory of a Member State or passing the territory of one or more Member States
Treaty of Rome	1958	Title V, Article 71: The Freedom to supply international inland transport services (by road, rail, inland waterway) and for the obligation to establish the conditions of access for non-resident haulers to domestics road freight haulage in a Member State, i.e. the rules that would govern cabotage.

Several articles are handling cabotage transport. According to Bergmann (2007), cabotage is *“National road transport by non-resident haulers”*. Article 1 of Council Regulations 3118/93 entitles road haulage carriers to operate services in other Member States on a temporary basis, without a registration to other countries’ officials. However, great uncertainty and divergence of practices dominate concerning what is regarded as temporary. Some countries, such as UK and Greece, are governing cabotage transport via regulations. Others, such as Austria, France and Italy, have introduced restrictions: In Austria cabotage transports are limited to maximum 30 days within a 60-day period. In France, the limit is 45 days period per year. In Finland, the time restraint follows the registration requirements, as transport vehicles may be used without local registration for max. 30 days. The European Commission prepared a new directive in fall 2009, which united the practices regarding time restrictions in cabotage transportation. Starting from spring 2010, international haulers are allowed to deliver to foreign states three cabotage operations within seven days. So called “three-in-seven” rule’s main objective was to eliminate legal uncertainty for Community haulers and adjust legislation to market needs. (Bergmann, 2007; Council of the European Union, 2009; Road Transport, 2009)

Outside EEC region European Conference of Ministers of Transport (ECMT) consummated an agreement concerning multilateral licenses in 1974. Since then, European Union (EU) and ECTM have enlarged their membership to the new EU-members and other countries in Central and Eastern Europe Countries (CEEC). Today whole EU region is deregulated, but outside EU deregulation is still rather limited (Coopers and Lybrand, 1996).

Liberalization of horizontal measures in supply chain

Liberalization of road transport has caused horizontal measures that have an influence on haulers and shippers. The most important measures for shippers and haulers are the ones related to liberalization of trade and services. On the demand side the removal of internal frontiers and elimination of trade barriers enabled shippers to take up the opportunities offered by the European Single Market. One of the targets was to reduce the relatively high capital costs compared to the transport costs. This was achieved by reducing inventory holding and lead times, reallocating the production and establishing European Distribution Centers. (Coopers and Lybrand, 1996) Therefore, shippers have started to outsource transport related activities by shifting operations from own-account towards “hire and reward transport”, which has caused even higher competition among haulers. In response to increased competition became logistics chain management and development of stable, long-term relationships with partners. One of the main factors was the willingness to outsource transport activities both in European and global scale. Therefore, liberal markets and integration development strategies increased the scope of logistics services, which meant transport operators increased transfer towards forwarding, warehousing and value added services. Liberalization had also clear advantage for international haulage: Cabotage regulations enabled haulers to operate more efficiently due to elimination of border controls. This naturally decreased the transit-time and reduced administrative costs (Coopers and Lybrand, 1996).

Harmonization

European Internal Market has produced a need to freight markets' harmonization. The main intention was to develop a fair, efficient and safe road transport market in the European Economic Community (Bernadet, 2009). Harmonization has been ongoing in various aspects: for example, technical harmonization and drivers' proficiency are noted important factors. Drivers' proficiency is based on efficiency and safety; safety is guaranteed by a certificate, which can be licensed by European Conference of Ministers of Transport (ECMT) or similar authority (Hilal, 2008). Drivers' working conditions have remarkable effect on competition between companies and operators. Transport ministers have managed to agree on the maximum working time for salaried drivers (Regulation No 561/2006 of the European Parliament and the Council of 11 March 2002), but not for self-employed persons. Due to the fact road transport sector has large amount of self-employed persons, a great group of drivers are outside the regulations. Working time and pauses are supervised by recorder which is required in professional haulers' vehicles; however, many of new Member States neglect control. Furthermore, sanctions vary greatly: for example, nine hours' continuous driving, which is five and half hours' more than regulations permit, fines 4600 Euros in Spain and 550 Euros in Netherlands (Bernadet, 2009). Additionally, in Netherlands longer working hours than in EU directive are allowed. (Bergmann, 2007)

Technical harmonization mainly deals with standards concerning the weight and size of vehicle and greenhouse emissions. The most important standards cover vehicles axle load, total weight and outside measures. However, all Member States are free to set dissimilar limit values for vehicles in domestic haulage (Bernadet, 2009). Also environmental standards are classified as technical standards: for example, in manufacturing there are certain emission standards. Furthermore, countries have certain infrastructure standards, like LKW Maut in Germany. (Bernadet, 2009)

International Transport in the European Union and to other countries

Within the EU, a community license is sufficient to authorize the holder to carry out transport between any two Member States; therefore, there exists free access to the markets. However, in practice this does not mean there is no barrier designed to protect national markets from foreign carriers (Bernadet, 2009; European Union, 2010a). Transportation routes have own effect to the road freight traffic between different EU countries. The main discrepancies originate from safety and price related matters.

Although international transport between EU Member States is fully liberalized, the cabotage regulations limit road transport, especially in the area outside of EU. Cabotage has been authorized in EU area subject to a Community license since 1 July 1998 (Hilal, 2008). Basically, cabotage means transport between a place of loading and unloading, which are located in the same country but performed by a vehicle registered in another country (European Union, 2010b). Previously cabotage rules were applied inconsistently, which caused several problems in EU Member States: some countries (for example Germany and Spain) foresaw the adoption of regulation and transposed the rule restricting cabotage to three operations within seven days in their domestic legislation (Bergmann, 2007). However, same regulation will come into effect in whole EU during spring 2010 (Council of the European Union, 2009; Road Transport, 2009). Besides, EU has limited road transportation between the new Member States (for example Slovenia and Bulgaria) within transition periods. (Bernadet, 2009; European Union, 2010b)

The decision of the gradual liberalization of road freight transport (Resolution No 22 of the ECMT in 1970) came into force on 1 January 1974. At that time transportation market expanded to cover a wider area than only European Community through multilateral licenses. Licenses cover an agreement either with two non-European Union member countries or an EU member country and non-member country. In 2009, the total number of licenses was 6090. (Bernadet, 2009; European Union, 2010b)

Although border crossing between European Union Member States has been resolved, the border crossing between European Union and non-Member States is problematic. The International Road Transport Union (IRU) reported in 2009 that waiting times including slack and peak periods were increasing; for example, in Narva (between Estonia and Russia) an average waiting time was 130 hours in period between April and September 2009. During the same period, the border crossing time between Finland and Russia was around 2 days, while the whole trip to

Moscow and back took 6 days (Bernadet, 2009). Global recession has cut transit transportation in Baltic Sea region and an average waiting time in above mentioned borders has decreased to few hours. Furthermore, Finnish and Russian border crossing has served as a pilot project of electric customs service since autumn 2009 (Finnish Customs, 2010).

Increased taxation in international haulage activities has caused new taxes to foreign vehicles. For example, Russian Federation has elaborated new taxes or levies as the import/export to/from Russia has increased. Most of these taxes have been mobilized at short notice, which has hindered road transportation to Russia (European Customs Union, 2010; Finnish Customs, 2010; FRCC, 2010). However, increased taxation could be avoided by harmonizing rules of customs and tax tariffs (Bernadet, 2009; European Union, 2010b).

4.2 Railway Transport

Free movement of goods increased the need of transportation in European Union, and the Commission perceived some actions were needed. The process started via European Directive 91/440, which noted the railway infrastructure and operations had to be separated. Actually, the directive is often noted to function as the first step towards harmonized railway freight market in the European Union. (Alexandersson and Hulten, 2005; European Union, 2009)

Liberalization Development in the European Union

The European Directive 91/440 was conjoined with several White Papers, which enlarged on railways' contribution to European Union's transport. The first White Paper was published in 1992, dealing mainly with deregulating the transport markets. The direction was continued by the second White Paper called "A Strategy for Revitalizing the Community's Railways", which was published in 1996. According to paper's first section, *"A new kind of railway is needed"* (European Union, 1996). The paper stated the railway transport should play a bigger role in the future; according to its statement, social impact of transport could be reduced by transferring traffic from road to rail. Therefore, already in 1996 were noted that increasing the usage of railway transport would solve many problems, for example pollution and congestions. The White Paper (European Union, 1996) states *"It is paradoxical that, when many of the problems that rail* *could help to solve are increasing, its share of transport markets continues to decline"*. The paper introduced the concept of "Rail Freight Freeway", which noted the existence of national railway operators is hampering the railway market's development. Therefore, this paper can be seen as the first stride towards the railway market deregulation. (Mäkitalo, 2007; European Union, 1996)

The third White Paper was submitted in 2001. It was called "*European Transport Policy for 2010: Time to Decide"* and it proceeded the idea of developing a transport system capable of changing the balance between the transport modes. The intention was to revivify the railway market, promote sea and inland waterway transportations and control the growth of air transport. One of the cornerstones was the augmentation of an integrated transport market for railway freight transportation. The paper declaimed the EU must develop socially, economically and environmentally sustainable transport system. Therefore, Commission proposed approximately 60 measures in order to develop these areas. (European Union, 2009; Mäkitalo, 2007; European Union, 2001)

The third White Paper (European Union, 2001) noted during the last decades the "stock economy" has moved towards "flow economy". Industries try to reduce production costs by relocating factories to low-cost countries, although the distance between the production unit and end-consumer might be thousands of kilometers. However, free movement of goods enables to confirm "just-in-time" and "revolving stock" production system. White Paper revealed the Commission's concern towards increasing traffic in European Union: in 2000 railway transports' market share was eight percent, while the figure in US was 40 percent. In 2001 the European Union Member States feared unless new measures were not taken by 2010, heavy goods' road transport share will increase by nearly 50 percent from the 1990s level. (European Union, 2001; Vassallo and Fagan, 2007)

The European Union railway reform continued in 2003 by introducing the Second Railway Package. In October 2003, Members of the European Parliament voted to liberalize the European railway market. The intention was to grant free access to rail networks in all EU countries by 1 January 2006. (Euractiv, 2008) The European Parliament and Council approved the Railway

Package in April 2004; it was agreed the national railway freight transport will be deregulated in member countries on 1st January 2007 (Mäkitalo, 2007).

According to Alexandersson and Hulten (2005), European Union railway policy has five main objectives:

1) create a common railway transport market,
2) achieve uniform technical and operational standards in all Member States,
3) establish a common market for rolling stock and railway material,
4) provide equal conditions for competition between different transportation modes, and
5) support a continuous development towards the transport modes that are more environmentally friendly, namely railway and sea.

In order to fulfill the objectives, European Union has introduced numerous actions in order to decentralize the transport routines. Marco Polo is a funding program, which intention is to transfer transport from road to sea, air, inland waterways and rails. Marco Polo's byword well defines the purpose (European Commission, 2009): *"Free Roads – Clean Air: it is estimated that every Euro of Marco Polo funding generates social and environmental benefits worth six Euros or more."* The current, second Marco Polo program (2007–2013) aims to deduct road transport by programs "motorways of the seas" and "traffic avoidance". (European Commission, 2009)

The market liberalization in European Union Member States

The relative market liberalization in EU countries is measured by the Rail Liberalization Index (LIB Index). In addition to EU member countries, Norway and Switzerland are included in the index. According to LIB Index, all countries are proceeding of liberalizing the railway market. However, the report observes the high entry barriers prevent having uniform access conditions. It is also noted that some countries are obeying the EU directives only on paper and grant feasibility to enter the networks only with restrictions. According to countries' performance, they are divided into three subgroups: advanced, on schedule and delayed. Figure 11 illustrates the situation in the European countries. (IBM, 2007)

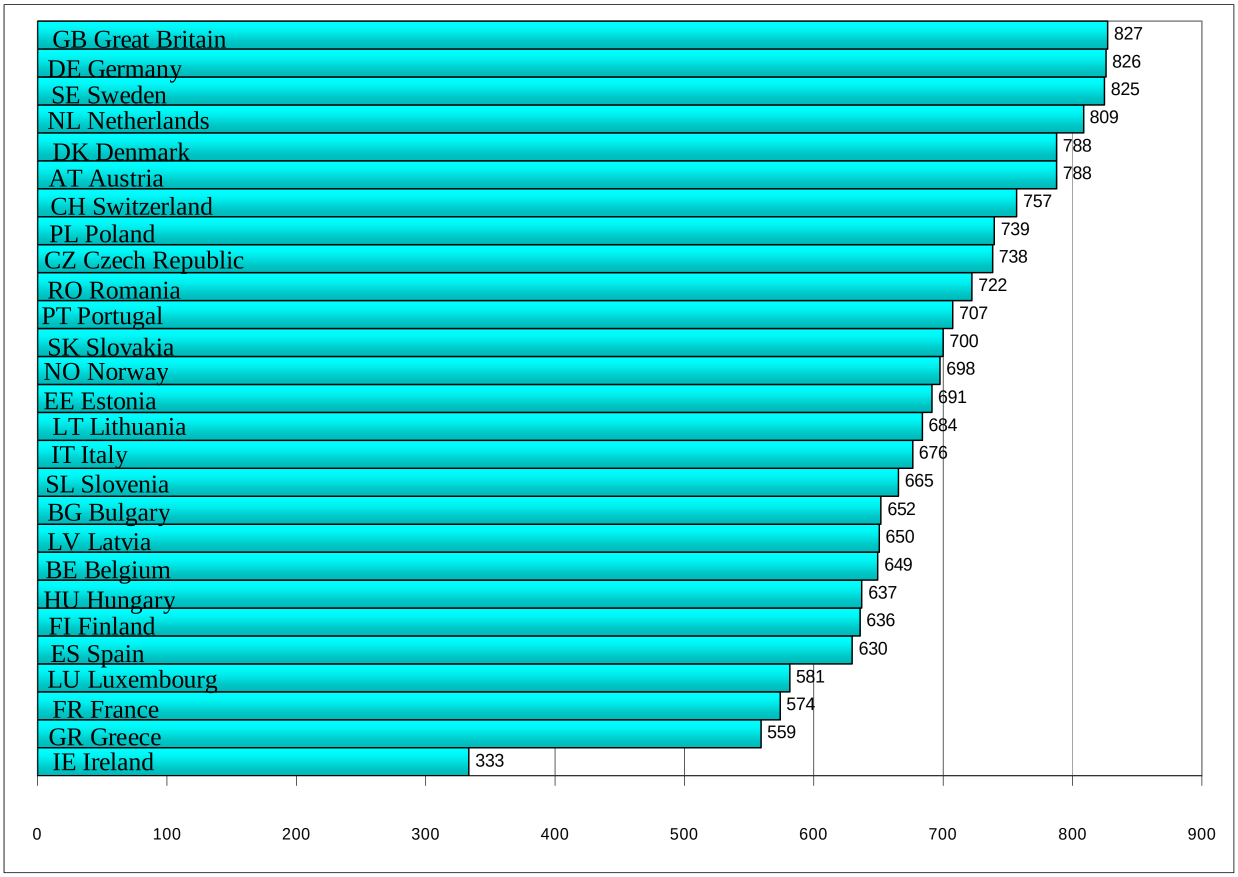

Figure 11. LIB Index 2007, country division. (Adapted from IBM, 2007)

Figure 11 presents the status of countries' liberalization process. The four first countries, Great Britain, Germany, Sweden and Netherlands belong to "advanced": These countries have made remarkable progress in the field of market opening. In the second and at the same time the biggest group, "on schedule" includes 18 European countries, including Finland and Estonia. The third group, "delayed", consists of four nations: Ireland, France, Greece and Luxembourg. These countries have the highest entry barriers.

Railways have been the first regulated markets in several countries. United States (US) was among the first ones by regulating the railroads in 1887 with the Interstate Commerce Act. Same trend continued and US was the first country to deregulate the railway market in 1980. The Staggers Rail Act opened the markets and introduced the possibility for companies to negotiate the railway contracts without interference. (Jahanshahi, 1998) OECD's research report (1997) stated railway deregulation's major benefit was the improved service level, providing more reliable and rapid services. The benefits were estimated to be worth of 5 million US dollars in 1990. At the same time employee productivity doubled during 1983 and 1992, enabling railroad transport to compete against other modes of transport, namely road, sea and air. (OECD, 1997) Market liberalization was successful in North America, because the transportation market was more competitive than traditionally was believed. The main commodities transported included bulk products and containers moving over long distances. Railway provided cost-effective transport for heavy industries like mines, electricity generating stations, refineries and manufacturing plants, which were not located by the waterway and therefore were not served via sea transport. (Gomez-Ibanez, 2004)

Some European countries decided to deregulate the railway freight market before the legislative demand of the European Union. Among the first countries were United Kingdom (UK), Germany and Sweden (Jahanshahi, 1998). In compliance with Alexandersson and Hulten (2005), the liberalization process in the European Union Member States have been guided by various types of economic, institutional and legal concerns. Alexandersson and Hulten (2005; 2008) conclude that in UK objective was towards market liberal agenda, whereas in Sweden the main force was to find new possibilities to finance railway investments. European Member States utilized four broad types of deregulation. The United Kingdom utilized rationalist approach, while Sweden relied on incremental way. Alexandersson and Hulten (2005) describe the German and Dutch approach as “wait and see” and French as a reluctant applying approach. (Alexandersson and Hulten, 2005; 2008)

In UK the privatization process started in early 1980s. In the railway freight sector a partial deregulation was introduced in 1989 by numerous privately owned terminals, wagons and locomotives. The final stage was enabled in 1992 when the British Government published a white paper called *“New Opportunities for the Railways: The Privatization of the British Rail”*. The markets were opened for free competition in 1994. (Gibb et al., 1996) Entire deregulation process was carried out during 1994 – 1997, whereby the former integrated monopoly market was separated into total privatization. Germany started the liberalization process in 1993 with the Railway Restructuring Act (Profillidis, 2004). Sweden’s process started in 1988, when Transportation Policy Act was introduced. The first new entrant started regional traffic in 1990 and first entrepreneurial feeder lines, so called short lines were established in 1991 (Jensen and Stelling, 2007).

Separation of infrastructure and operations

Requirements concerning separation of infrastructure and operations were originally included in Directive 91/440, when the principle of accounting separation was introduced. It was followed by the Directive 2001/12/EC, which noted independent organizational aggregates must be established for infrastructure management and transport operations. According to the Directive, Member States could determine whether to achieve the objective by distinct divisions within a single undertaking (the holding company model) or by establishing a separate entity. (Holvad, 2006) The models are presented in Figures 12 and 13.

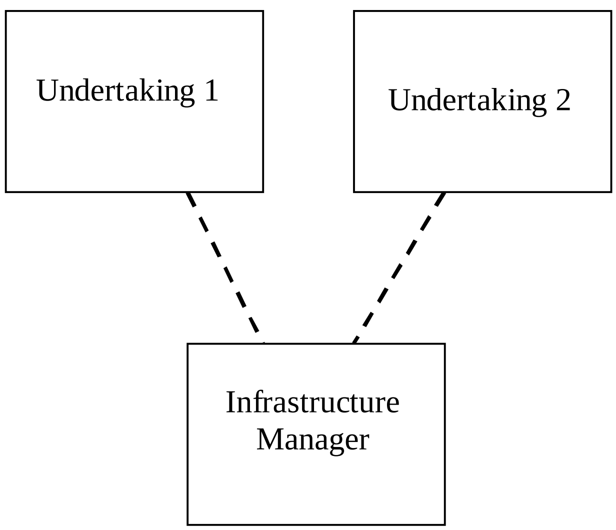

Figure 12. The separated structure. (Holvad, 2006)

Figure 12 illustrates the separated structure. The infrastructure is separated from railway undertakings, but all parties can access it under the terms of access regime. For example, in UK the process divided market into two: Railtrack became responsible for the infrastructure and operators got the responsibility of the railway services. (Alexandersson and Hulten, 2005) However, UK liberalization process is said to be a failure. The railway infrastructure company Railtrack failed to operate the market efficiently. Because of lack of investments rails were not in decent condition, passenger trains accuracy decreased significantly from 90 per cent down to 60 per cent and train accidents increased. After five years Railtrack was badly in debt and finally bankrupted in 2001. (Hilmola et al., 2007b; Szekely, 2009) In 2002 UK accepted investment plans worth of £ 34 billion to increase the safety level and reorganize the infrastructure; today the rail network is in better condition than ever. (Hilmola et al., 2007b) In order to promote the interests of the independent infrastructure managers in Europe, European Rail Infrastructure Managers (EIM) was established in 2002. Among the member countries are 10 European Union nations; Belgium, Finland, Denmark, France, Netherlands, Portugal, Spain, Sweden, UK and Norway. (EIM, 2010)

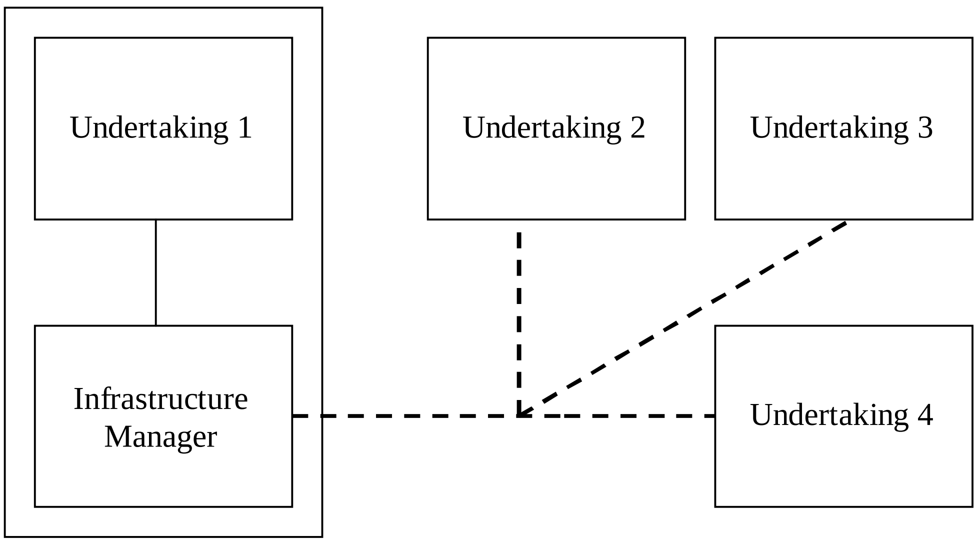

Figure 13. The integrated structure. (Adapted from Holvad, 2006)

Another model is the integrated structure, which is presented in Figure 13. The incumbent remains integrated with infrastructure management, whereas new undertakings pay for access to infrastructure. The integrated structure is utilized for example in Poland and Germany (Laisi, 2009; Simola and Szekely, 2009). Same model is also used in Russia; the national operator Russian Railways is responsible for the infrastructure. However, the Russian model is vertically integrated, due to the fact the traction services are still under RZD's monopoly. (RZD, 2010)

Railway freight markets' barriers to entry and country peculiarities

According to several studies, companies intending to enter the deregulated railway freight markets will confront various barriers. Acquiring of rolling stock, needed investments and bureaucracy have been noted as the main barriers to entry in various European Union countries. (Brewer, 1996; Laisi, 2009; Ludvigsen and Osland, 2009; Mortimer et al., 2009; Mäkitalo, 2007; Steer Davies Gleave, 2003) However, country peculiarities are also present. Brewer's study (1996) revealed the perceived level of access charges was seen a barrier in UK. In Finland (Mäkitalo, 2007) and Sweden (Steer Davies Gleave, 2003) researches estimated the difficulty of accessing the services creates a great market entry barrier. Cantos and Campos (2005) stated intermodal competition can create the market entry barrier. Mäkitalo (2007) noticed also endogenous barriers are present in Finland: The actions of the market dominating company might complicate the entry process. Identical situation is noted in Poland, where incumbent does not sell untapped rolling stock to new entrants (Laisi, 2009). The main market entry barriers in Germany are investments and interoperability; the Hungarian market confronts main problems in bureaucracy (Simola and Szekely, 2009). The similar barriers to entry are noted also in other countries: according to recent study (Laisi, 2010), the main barriers to entry in the Russian railway freight market are acquiring of rolling stock and needed capital. Capital refers to financial as well as knowhow, which is noted to be an important factor when entering the Russian market. Due to Russian railway freight market's national peculiarities, research revealed the best way to enter the market is to acquire an existing railway undertaking. (Laisi, 2010)

In addition to barriers to entry, countries' railway freight markets have several other specialties. The Polish market has severe competition; most of the railway undertakings are operating country-wide, which increases the rivalry (Laisi, 2009). The German railway freight market is one of the most liberalized in European Union, having approximately 260 railway freight undertakings operating in the market. Hungary represents younger and underdeveloped market: railway freight market was liberalized in 2003 and today market has 16-18 operators. (Simola and Szekely, 2009) Furthermore, Sweden forms an interesting example: market's 17 railway undertakings have so good cooperation and relationships, that market situation is described as "old-boy network" (Laisi, 2009). Russian market's specialties are importance of personal relations and market's close linkage with politics. Furthermore, the fact that railway market has nearly 2300 operating railway undertakings can be noted as a peculiarity (Laisi, 2010).

4.3 Sea Transport

Privatization of port management as well as ports' national reorganization has been the driving force for competition. Furthermore, the functions are noted as major factors in the shipping and port management sectors. The enticement towards privatization is due to earlier experiences; trade liberalization enabled possibilities for logistics services. Privatization has spread worldwide; China changed the port system in 2001, when national government gave all responsibility to local government, which in turn appointed particular port administration bodies. Today, national government is responsible for national port planning and policies. In Taiwan, commercial ports are managed by the state. Furthermore, four of country's six major ports are free trade zone harbors. In Japan, legislation leads back to 1950s and Port and Harbor Law. Basically, ports are governed by local public authorities, but the national government administers the ports, mainly via providing subsidies. (Ports and Harbors Bureau, 2006; Sutton, 2008) According to Stehli (1978) and Goss (1986), there exist various alternatives of port ownership and administration between purely public and private (see Table 18).

Table 18. Different port types. (Port Reform Toolkit, 2001)

Type	Infrastructure	Superstructure	Port labor	Other functions
Public service port	Public	Public	Public	Majority Public
Tool port	Public	Public	Private	Public/Private
Landlord port	Public	Private	Private	Public/Private
Private service port	Private	Private	Private	Majority Private

Within sea transport, port industries as well as shipping have become increasingly privatized. Basically, governments have stepped aside and ports and terminals are operated and managed by multinational companies via long term leases (Wang et al., 2004). Globalization and quick development of economy and industry in Asia, especially in China, has supported this trend. USA and Canada among many other countries have provided financial assistance to ports infrastructure development under the national stimulus packages (Slack, 2010). On the other hand, in Asia the governments (for example in South Korea) have established funds helping shipping lines to retire ships through purchasing those at commercial prices. Therefore, it can be noted the governments have realized shipping is one of the vital functions, and serve as key factors in economic development and internal trade. Short sea shipping and port gateway policies (maritime security and environmental questions) have been the most important areas in the EU region in re-balancing the relationships between public and private sector. (Slack, 2010)

Several EU Member States are dependent on maritime transport. For example, in Finland over 77 percent of imported and 88 percent of exported cargo tons travelled through sea ports in 2009 (National Board of Customs, 2010). Therefore, transport markets deregulation's effects can be reviewed via secure of supply on emergency situations: If government does not own mercantile fleet and port operations are under private companies, how will the supply chain function in a critical emergency situation? After 9/11 the United States and other countries have emphasized government's role to guard and secure critical infrastructure against external threats. Sea ports are often noted as the most important transportation route for import commodities, which are fundamental to national welfare and wellbeing. Several countries do not have own commercial fleet, and often port operations are transferred to local or multinational companies. During the last decade fleets' out-flagging has been strong among most developed countries. A very little own fleet will be a risk in emergency situations: In emergency situation is needed a fleet which is under own authorities, in order to guarantee the Security of Supply.

Liberalization Development

Regulation 4055/86 of 22 December 1986 applied the principles of freedom to provide services to maritime transport between Member States and third countries. Regulation included cargo-sharing arrangements for third countries except the linear shipping in exceptional circumstances. Furthermore, regulation 4058/86 ensured the coordinated action to secure free access to cargoes in ocean trade and enabled the Community to take retaliatory measures, if European Union ship owners or ships registered in Member States encounter restriction on the free access to cargoes. Council Regulation 3577/92 of December 1992 enacted the cabotage rules from 1 July 1993 for ship owners operating vessels registered in a Member State (Danklefsen, 2008; European Union, 2010b).

The Commission memorandum named "*Progress towards a common transport policy in maritime*" from year 1985 and communication "*Towards a new maritime strategy*" from year 1996 were the first steps in development towards liberalization and deregulation of sea ports. The Commission Green paper on sea ports and maritime infrastructures [COM (97)678] contained a detailed review of the industry and took a close look at the problems of port charges and market organization. Ports were integrated into the Trans-European Networks (TEN) as a part of intermodal transport chain (so called Marco-Polo Programme in EU). With Reference to the Green paper on sea ports, the European Parliament called on the Commission in its resolution of 13 January 1999 to submit a study of the structures of sea ports in order to help restore transparency of competitive conditions between and within European sea ports. Parliament proposed that public financing of port and maritime transport infrastructure should be assessed on the basis of three categories 1) public port infrastructure measures 2) undertaking–related port infrastructure measures 3) undertaking-related port superstructure measures.

On 13 October 2004, Commission adopted a White Paper on review of Regulation 4056/86, applying the European Community rules to maritime transport in the legislation of [COM(2004)675]. Regulation 4057/86 provided for a redressive duty to protect Community ship owners against unfair pricing practices adopted by third-country ship owners. White Paper analyses whether to maintain, modify or repeal the currently applicable provisions of Regulation 4056/86. Furthermore, the paper discusses whether it would be appropriate to replace the present block exemption for linear conferences laid down in Regulation 4056/86 with other Community instruments covering any new business framework of co-operation between linear services operators on trades to and from EU (European Union, 2010b).

[COM(2001)35] is called *port service package* including rules of opening port services to competition with EC Treaty competition rules. Due to the fact that internal and external environments vary a lot in Member States' ports, all countries have liberalized the sector to competition. [COM(2007)0616] of October 2007 set rules of the considerably broader "*Communication on a European Ports Policy*" that include framework of competition laws within and between the ports (Danklefsen, 2008; European Union, 2010b). Table 19 gathers the main acts which have affected on the sea transport's liberalization process.

Table 19. Liberalization development of sea transport in European Union.

Act	Date	Content
[COM(2007)0616]	18.10.2007	Framework of competition laws within and between the ports.
White paper, [COM(2004)675]	13.10.2004	White paper replaces Regulation 4056/86 respond to today and future requirements of maritime transport in the EU.
[COM(2001)35]	13.2.2001	Rules and set up an open and transparent procedure access to services in ports – the ports package.
Green paper [COM(97)678]	10.12.1997	Green paper considers sea ports and maritime infrastructure: Sea ports have remarkable implication to the EU (more than 90 percent of Unions trade with third countries and 30 per cent of intra-EU traffic) Therefore, sea ports should integrate to the trans-European intermodal transport chain.
Council Regulation 4055/86	22.12.1986	The principle of freedom to provide services to maritime transport between EU Member States and third countries.

Sea ports on the shores of Gulf of Finland are important part of the Trans-European Network (TEN) and therefore the European Union has interest to develop sea ports infrastructure and services with financing and subsidies (European Commission, 2010). Especially in regions with structural economic problems port-infrastructure investments are an important instrument to foster economic activity and employment. Therefore, it is justifiable from the public point of view to invest national tax income in terminal related port infrastructure (Duhme et al., 2006). Especially on the shores of Gulf of Finland many sea ports have a remarkable role in transit transportation to Russia. A problem occurs if different financing practices and cost recovery necessities are existent within the same relevant market as public financing and subsidies (e.g. EU subsidies) can cause distortion in the markets.

Shipping liberalization and deregulation have contributed to a lower shipping rates and greater choice of port calls. Due to these reasons, advantages such as saving in labor costs have caused fleets' out flagging to countries which have lower labor cost level. Nearly all European countries have different labor legislations and working advantages, wherefore great majority of fleets have been flagged to countries such as Greece, Netherland and Germany. Worldwide, Bahamas and Liberia have attracted the greatest amount of out-flagging. Generally, in the world 93 percent of ships are flagged to 35 countries or regions; Bahamas (23 percent) and Liberia (10.6 percent) are the leaders. In the EU countries shares are much smaller (United Nations, 2009): Greece (5.3 percent), Malta (4.3 percent), Cyprus (2.6 percent), Norway (1.7 percent) and Germany (1.5 percent). From Finnish fleet nearly 90 percent is out flagged mostly to Sweden, Bahamas, Germany and Netherlands (Merenkulkulaitos, 2010a).

4.4 Public-Private Partnership (PPP)

Public-Private Partnership (PPP) is a form of co-operation between the state and the private sector. The concept of PPP was introduced already in 1970s in construction industry; the idea was launched in order to facilitate the development and renewal of problematic urban zones (Scharpf, 1991). In time, the term came to include joint technology, ecological and education projects, and health services (Vaillancourt Rosenau, 2000). The concept of New Public Management was launched in 1980s in the field of administrative reform, where the aim of PPP was rescission of monopoly in public services and the promotion of privatization. According to Sagalyn (2007), Public-Private (PP) projects have three generations:

- Public sector and private partners with consultants
- Public sector and large private companies build up to PP Corporation
- PP-projects seek private sector involvement.

The idea of allowing private firms to finance projects of public sector infrastructure results in the emergence of Public-Private Partnerships (Li and Akintoye, 2003; Prapatpong, 2009). In the latest years several Scandinavian and European countries have developed own frameworks to PPP following UK, which experience illustrated advantages and difficulties to develop the competencies for partnering between public and private sectors (Bresnen and Marshall, 2002). Public-Private Partnership describes a government service or private business venture, which is funded and operated through a partnership of government and one or more private sector companies. PPPs potentially bring the efficiency of business to public service delivery and avoid the politically contentious aspects of full privatization. PPPs allow governments to retain ownership while contracting the private sector to perform a specific function such as building, maintaining and operating infrastructure like roads and ports. The structure of the partnership should be designed to allocate risks to the partners, who are best able to manage those risks and thus minimize costs, while improving performance (Prapatpong, 2009). Effective PPPs recognize that public and private sectors have certain advantages, relative to the other, in performing specific tasks (European Commission, 2010). To be successful, PPPs must be built upon a sector diagnostic that provides a realistic assessment of the current sector constraints (Asian Development Bank, 2008; RBI, 2010). Specifically, the sector diagnostic will cover: 1) Technical issues, 2) Legal, regulatory, and policy frameworks, 3) Institutional and capacity status, and 4) Commercial, financial, and economic issues. The sector diagnostic helps the government to assess status quo, identify gaps and weaknesses, and develop a sector reform strategy or road map, outlining the tools and activities required for reform. In many cases, reliable or comprehensive data on performance are not available in every sector, such as financial or technical areas. In those cases, it may be more efficient to focus on the collection of limited but key indicators which provide an overview of sector's overall performance. The diagnostic is important to: 1) identify the strengths and weaknesses of the sector and the most promising areas for efficiency increases, 2) regularly gauge and report on the progress of reform, and 3) tweak the reform program as needed (Asian Development Bank, 2008).

Tang et al. (2009) have studied risks, relationships and financing with empirical and non-empirical methods of Public-Private Partnership projects. They found that great changes have happened and that development will continue in the future in construction industry, because of PPP practices, especially to urban development and city building. For example, European Union is interested in advantages of PPP projects, wherefore the new Research and Design plan has been launched for manufacturing, construction and automotive sectors in order to attenuate the effects of recent downturn (European Commission, 2010).

Public-Private Partnership in Infrastructure Investments

Large infrastructure projects such as highways, bridges and halls have earlier been financed by public sector (de Jong et al., 2010). However, public sector has limited financial possibilities to finance alone these kinds of long-term investments at the appointed time. Public Private Partnership (PPP) can be one solution for the problem. PPP has been defined in many different ways, but there is general agreement that PPP projects should involve private parties in the design, construction, maintenance and operation on the basis of long-term contracts or arrangements (Reeves, 2005). An arrangement, where ownership is transferred back to the public sector after number of years is called Build-Operate-Transfer (BOT). If ownership remains to the private sector, form is called Build-Operate-Own (BOO). Due to arrangement's long-term nature, the fees are usually raised during the concession period (Koch and Buser, 2006). The rate of increase is often tied to a combination of internal and external variables, allowing the proponent to reach a satisfactory internal rate of return for its investment. Several operation forms between Public-Private Partnership are illustrated in Figure 14.

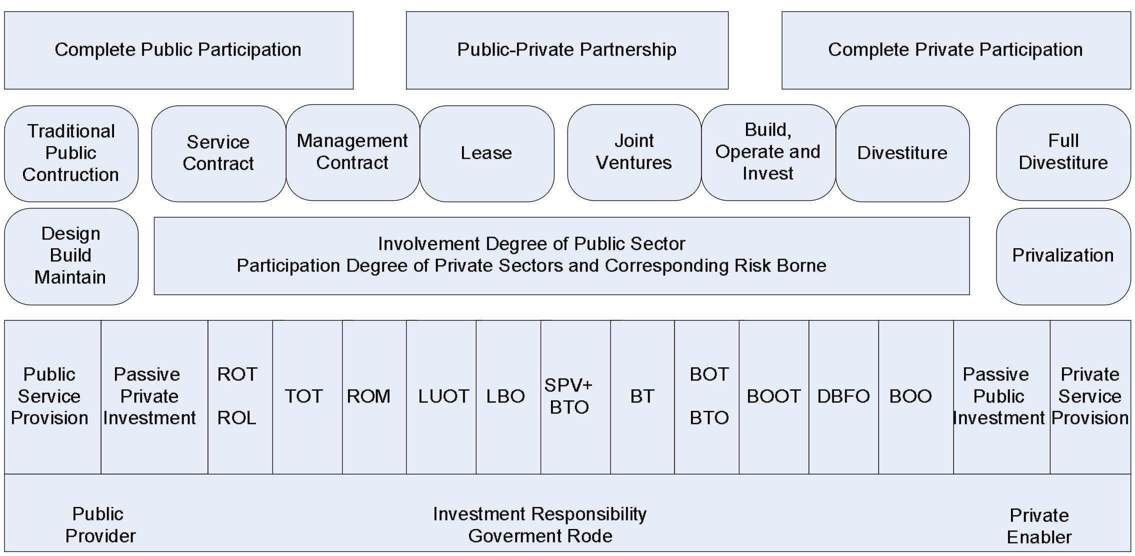

Figure 14. Forms of Public- Private Partnership. (Adapted from Xu, 2008)

Abbreviations in Figure 14:

ROT, Rehabilitate-Operate-Transfer

ROL, Rehabilitate-Operate-Leaseback

TOT, Transfer-Operate-Transfer

ROM, Rehabilitate-Operate-Manage

LUOT, Lease- Upgrade-Operate-Transfer

LBO, Lease-Build-Operate

SPV, Special Purpose Vehicle

BT, Build-Transfer

BOT, Build-Operate-Transfer

BTO, Build-Transfer Operate

BOOT, Build-Own-Operate-Transfer

DBFO, Design-Build-Finance-Operate

BOO, Build-Own-Operate

Public-Private Partnership infrastructure investment plans include generally incentives to push contractors towards certain behavior with payment methods (RBI, 2010; Skanska, 2010):

- The availability model involves the funding, design, construction and operation of the assets in return for an annual fee. For example, subscriber client pay an annual fee from use of hospitals and schools.
- The market model involves the private sector consortium funding the development, design, construction and operation of the asset, with payment coming directly from the users. For example, people utilizing a bridge have to pay a “bridge-fee”.

Life Cycle Plans are used in Finland in infrastructure investment in roads, hospitals, schools and power plants. Generally a private sector development consortia forms a special purpose company called the Special Purpose Vehicle (SPV) to develop, build, maintain and operate the asset for a contracted period that generally varies between 15 and 50 years (Skanska, 2010). After that period infrastructure plan is transferred to subscriber at the appointed condition. The public sector client enters into a concession agreement with the SPV, whose shareholders invest equity and raise debt to design and construct the asset via architects and construction companies governed by subsidiary service contracts. The most remarkable reasons to use PPP are flexibility, technical know-how, risk allocation, market and marketing experience and fast decision-making. A common problem with PPP projects has been the fact that private investors obtain a rate of return that was higher than the government bond rate, even though most or all of the income risk associated with the project was borne by the public sector. (Skanska, 2010) The standard SPV structure is illustrated in Figure 15.

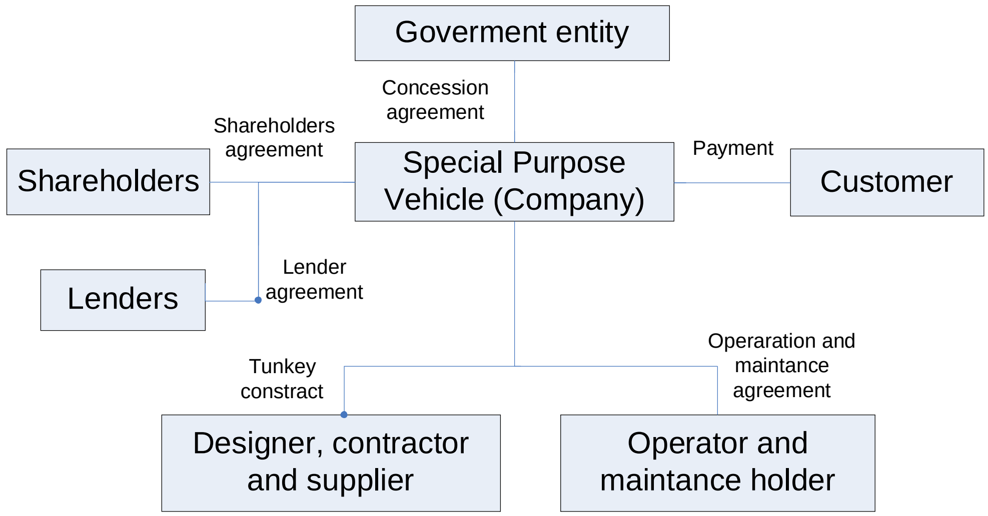

Figure 15. The Special Purpose Vehicle (Company) model. (Adapted from Skanska, 2010)

In the European Union Member States traffic infrastructure has been traditionally financed, owned and maintained by the state. In Switzerland fuel taxes has been used for travelling investment, and in Germany and Austria freight transport pays tolls that are used to travelling infrastructure investments and maintaining. In Austria state's owned ASFINAG maintains nearly all road infrastructures (2000 km). In the USA road infrastructure is financed by Highway Trust Fund that is under the Federal State. Also Specific Infrastructure Banks in thirty states finance road investments. In New Zealand roads are maintained by New Zealand Transport Agency; maintaining is mainly financed via special funds. (Holm, 2009).

During the last half century, the European Transport infrastructure has developed enormously: The amount of motorway, high-speed rail services and airport transport have increased substantially (Grant-Muller et al., 2001). Huge resources have been devoted to the Infrastructure Investment Programme. The enlargement of European Union to the East has picked up speed, because these countries' infrastructure is lagging behind; defective condition of infrastructure prevents and slows down development. Public–Private Partnership is one potential solution to this problem, because it widely decentralizes financing and risks of investments. (Tang et al., 2009)

4.5 Public Private Partnership in Critical Infrastructure

Critical infrastructure protection (CIP) has been seen as an essential part of national security in numerous countries around the world. Broad range of political and administrative initiatives and efforts are underway in the US, Europe, and in other parts of the world, which main intention is to better secure critical infrastructures (Brunner and Suter, 2008; Dunn-Cavelty and Kristersen, 2008; Dunn-Cavelty and Suter, 2009). Weak economical situation has led to services' privatization and deregulation, which has placed a large part of critical infrastructure in the hands of private companies since 1980s. However, frequently market forces alone are not sufficient to provide security in most of critical infrastructure areas (Anderson and Moore, 2006). In addition, the state cannot provide the public good of security on its own; therefore, the Public–Private Partnership (PPP), a form of co-operation between the state and the private sector, has been seen as a solution for co-operation and security problems. At the beginning PPP was used in urban construction in order to facilitate joint development and reforms of urban problems, but later it has been utilized as well in partnerships in the area of education, health care and building projects. Though at the 1980s the aim of PPP was rescission of monopoly in public services and the promotion of privatization, in time PPP has developed to the multiform networked operation method between public and private sector. Co-operation between the state and private enterprises have been seen fundamental in many sectors of society up to Critical Infrastructure, but form of co-operation has varied in each situation (Assaf, 2008). Nowadays governments' role consists of less directing and more coordinating; especially networking has been noted as an important factor in Critical infrastructure protection. The character of PPP is goaled to exploit advantages by utilizing innovative resources such as knowledge, staff and devices. (Linder and Vaillancourt Rosenau, 2000)

The basement of Critical infrastructure protection concept is "*Presidents' Commission on Critical Infrastructure Protection*" (PCCIP, 1997), which was established by President Clinton concerning all infrastructures in the US. The task of PCCIP was to assess risks, develop defensive mechanism, and to contribute to the identification of the required institutional and legislative reforms. PCCIP obligates all relevant government bodies as well as privately owned infrastructure to shared responsibility. Information Sharing and Analysis Centers (ISAC) acts as an important link between authorities and local actors, because it connects parties operating in Critical Infrastructure. Therefore, utilization of PPP has saved investments and working time (US General Accounting Office, 2006). However, in reality interest of the private industry and the state in CIP are only partially convergent and therefore synergy effects are not always reached; private companies fear that the sensitive information in the public gaze have damaging influence to the businesses (Dunn-Cavelty and Suter, 2009). Private companies that operate in Critical infrastructure are often multinational and have more interest to international approaches than national.

The majority of existing instances of Public-Private partnership are narrow, because Critical infrastructure protection are in hands of specialised agencies and selected partners from the private sector. In consequence, this kind of co-operation can not cater horizontal and vertical integration of contemporary infrastructure: The most sector-specific PPP models such as ISAC are hardly suited for efficient management of interdependencies between the various infrastructures or sectors. Large-scale businesses are able on their own to guarantee the security they operate and even as dependent on a multiplicity of smaller actors (Dunn-Cavelty and Suter, 2009). Due to these reasons, information exchange between public and private partners succeed in a small framework with selected partners who have already established a certain degree of trust.

4.6 Deregulation in Finland

Finnish transport market's deregulation has followed the European trends: all transport sectors are completely or partly deregulated. Road transport deregulation is premised on European Union regulations; although the process started in the beginning of 1990s, the national road freight transport was completely opened for competition on 1 July 1998. (European Commission, 2002)

Sea transport deregulation originates from 1992, when Ministers of Transport and Communications terminated several actions, which main intention was to gradually deregulate the sea transportation. Finally, cabotage sea transport was allowed in Council regulation 3577/92, which was enforced on 1 January 1993 (European Parliament, 2010). Furthermore, harbor's owner structure might have considerable implication on daily functions. Generally, in Finland ports are based on a mixture of operators: ports are often municipality owned and privately operated. However, there exist few industrial harbors which are privately owned and operated. When utilizing the division represented in Table 18, six harbors are counted as landlord ports (Naantali, Skoldvik, Raahe, Inkoo, Parainen and Kantvik) and four ports are tool ports (Kotka, Hamina, Helsinki and Lappeenranta). Additionally, Inkoo and Tolkkinen are private ports. (Meriaura, 2010)

Like road and sea transport deregulation, also railway freight market deregulation is founded on European Union regulations. Although the history leads back to 1990s and 2000s via the White Papers and Railway Packages, the final initiative came from the European Parliament and Council in April 2004. At that time was approved a Railway Package, which stated the national railway freight transport was to be deregulated in member countries on 1st January 2007 (Mäkitalo, 2007). Although several countries deregulated the railway freight market already earlier, Finland was among the ones which deregulated the market due to European Union legislative demands. Therefore, the railway freight market was opened for competition on 1 January 2007. Today the industry follows separated structure, meaning Infrastructure Manager and operator are own entities. In Finland the Infrastructure Manager is the Finnish Transport Agency. Although the market was opened for competition already in 2007, market still has only one operator, the VR Cargo (situation in June 2010). However, few companies have shown interest towards entering the market, wherefore changes are expected during the coming years.

In Finland several premises have been built to the state and municipalities by means of PPP, for example schools, health centers, office buildings and sewage treatment plants. Furthermore, about 30 investments plans with a total value of 1.8 billion Euros, are waiting for investment regulations (Elron, 2009). However, as described in Chapter 5.4, road investments are one of the main objectives of Public-Private Partnership (PPP). Furthermore, in some projects PPP is also utilized in railway sector. In Finland, PPP has been utilized in two highways, which are both leading to Helsinki: Lahti and Turku (see Figure 16). In Lahti highway PPP covered 69 kilometers from Järvenpää to Heinola, whereas the Turku highway part was 51 kilometers (Muurla – Lohja). Furthermore, road from Koskenkylä to Kotka via Loviisa is under construction: the road covering 49 kilometers should be ready in 2015.

Figure 16. Public-Private Partnership road investments in Finland (White bars in picture). (Adapted from Finnish Road Map, 2010)

Figure 16 represents the Finnish road network: White lines are PPP road plans, while other lines represent the main roads in Finland. Figure 17 illustrates the situation a bit more precisely. White lines are PPP roads, green lines highways, red lines main roads and yellow lines local roads. As figures well describe, the amount of privately financed Public-Private Partnership roads is low in Finland. However, due to the fact the roads in question are the busiest parts of Finnish road network, the importance is significant.

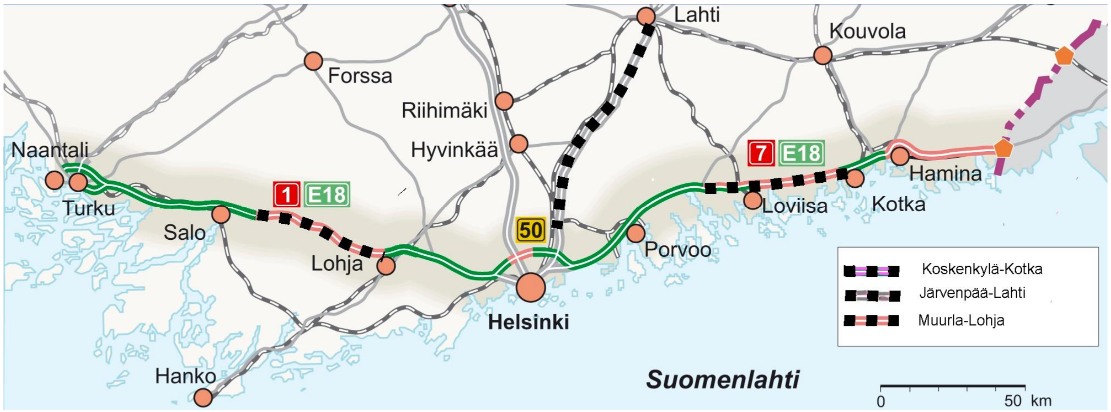

Figure 17. Public-Private Partnership road investments in Finland with black bars. (Finnish Transport Infrastructure Agency, 2010)

As PPP enjoins, the manufacturer is responsible for planning, construction and maintenance from 15 to 25 years. During the time the manufacturer receives an annual service fee. After the contract period is over, manufacturer surrenders the highway at the appointed condition to highway's owner (Finnish Road Administration, 2004). In Finland reasons for using PPP has been timing and economy: needed infrastructure investment plans have been made for users at the appointed time and money. However, Public-Private Partnership model is very flexible and the right to use a road is always open, because the soil of road is owned by State and the Special Purpose Company (PPP Company) builds the road infrastructure including maintaining of contract period. (Finnish Transport Agency, 2010a; Skanska, 2010)

One of the most significant railway project's in Finland is the re-construction of network between Seinäjoki and Oulu. The project time estimate is 2007-2011, and construction work was launched in 2008. The leg has a great importance to railway transport's competitiveness: the stage is utilized daily by 22-23 passenger trains and 15-29 freight trains. The main objective is to increase safety and decrease the environmental load. Furthermore, due to construction passenger trains can increase the speed up to 200 kilometers per hour between Seinäjoki and Ylivieska. (Rosenvall, 2008) The total project cost estimate is 800 million Euros, which is financed governmentally and utilizing Public-Private Partnership. Public-Private Partnership is utilized while constructing double track between Kokkola and Ylivieska. The part's cost estimate is 250 million Euros, and the project time is 2009-2011. (Leviäkangas et al., 2009; Finnish Rail Administration, 2010; Rosenvall, 2008)

In addition to governmentally financed railway networks, between 2008 and 2009 was constructed 27 kilometers of railway track utilizing private funding. Talvivaara Infrastructure financed an industrial track from Talvivaara mine to Murtomäki; track was constructed by VR-Track. The total building costs were over 40 million Euros. Although the track is still owned by Talvivaara Infrastructure, in 2011 the track will be transferred to possession of the Finnish Railway Agency. Until then, track is maintained by VR Track. (Talvivaara Mining Ltd., 2010)

Although in Finland exists plenty of governmentally owned networks, especially from the road network large amount is privately owned. Figure 18 illustrates the situation.

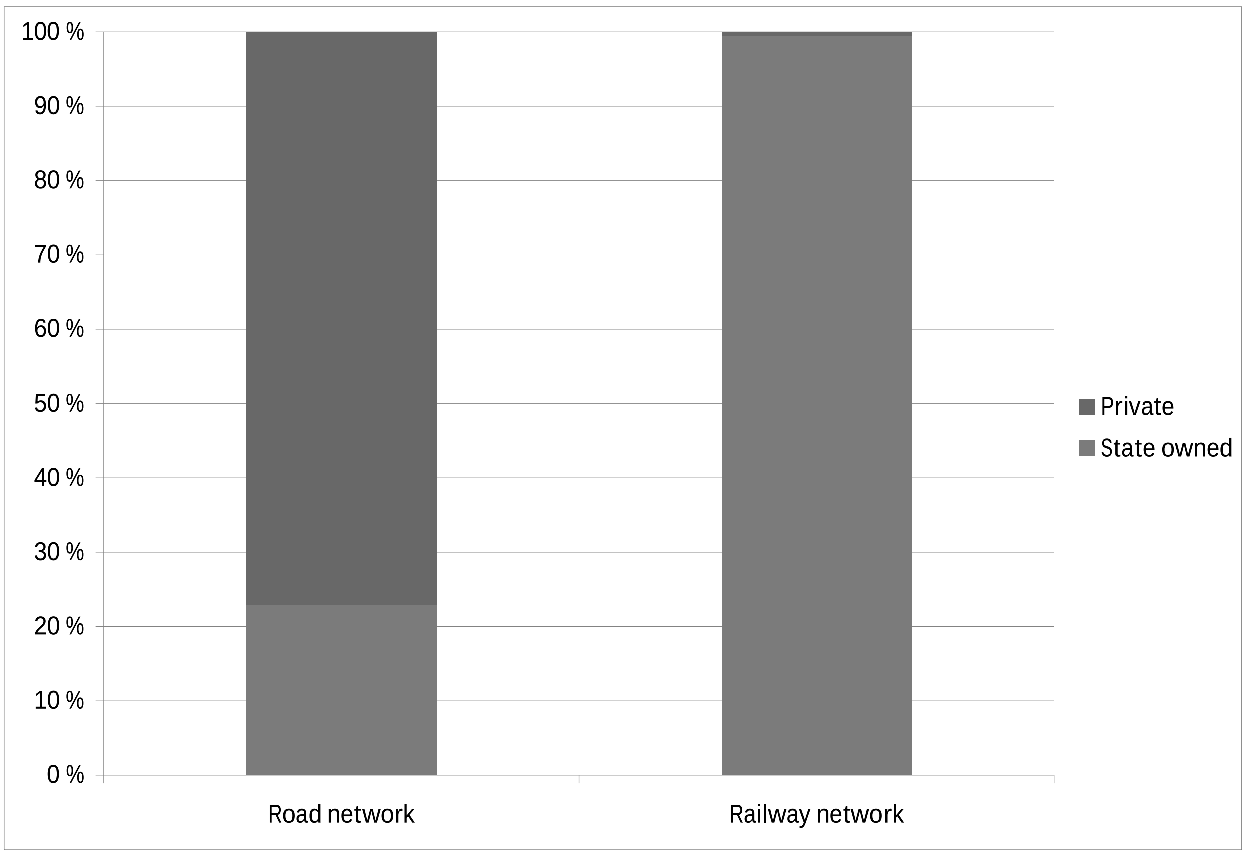

Figure 18 The portion of private and state owned network in Finland. (Rakennuslehti, 2008; Finnish Road Administration, 2009; VR Track, 2009)

As Figure 18 illustrates, 77 percent of road network is privately owned. However, these road networks are mainly gravel roads located in rural areas. The main roads are owned by the state. 90 percent of railway network is single-tracked, but overall the electrification is widely spread. As described in Figure 18, railway network is mainly owned by the state (the Transport Agency).

The privately owned networks are located in Karhula (6.2 kilometers) and between Talvivaara and Murtomäki (27 kilometers). (Rakennuslehti, 2008; Finnish Road Administration, 2009; VR Track, 2009) Normally when constructing railway tracks, the constructor is VR Track or Destia, which are governmentally owned companies. However, while building roads, the share of private companies constructing the network is much higher.

Transport equipment

Road transport

According to AKE (2010), the total vehicle fleet size in mainland Finland in the end of 2009 was 5 091 875 vehicles. The greatest group was passenger cars (2.7 million). When observing the vehicles utilized in transporting goods, vans represent the largest group (328 962). Figure 19 describes the portion of other transporting vehicles.

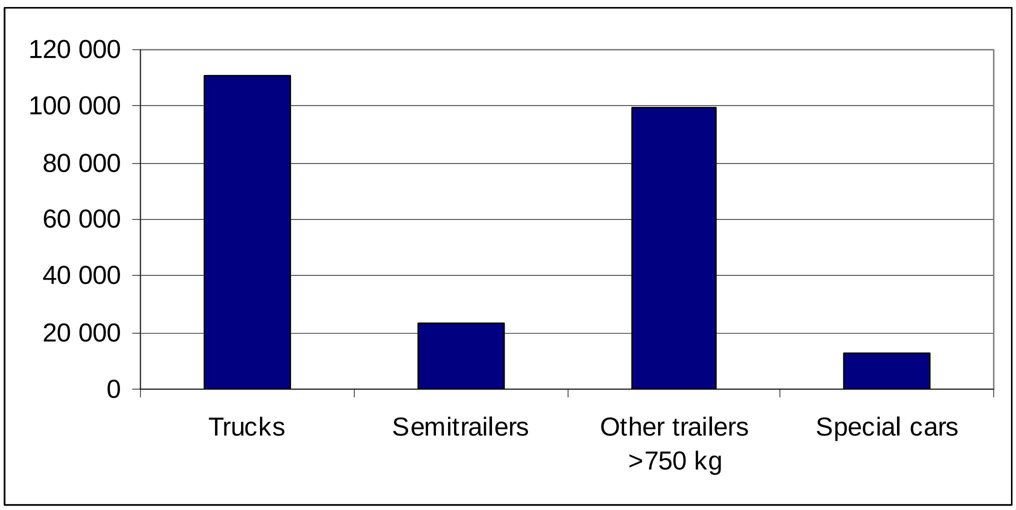

Figure 19. Vehicle fleet size in Finland 2009. (AKE, 2010)

Figure 19 illustrates road transport equipments' division. In the end of year 2009 there were registered over 110 000 trucks. However, semitrailers' portion was rather small, 23 000. Furthermore, in Finland is registered almost 100 000 other trailers (> 750 kg).

Sea transport

The amount of Finnish merchant fleet has increased during the last decades. In 1970 the fleet included 509 vessels, which total Dwt was 2 047 029. In the end of year 2008, the figures were 647 vessels covering total 1 303 407 Dwt. However, although the number of vessels has increased, deadweight tonnage has decreased significantly. Figure 20 illustrates the development.

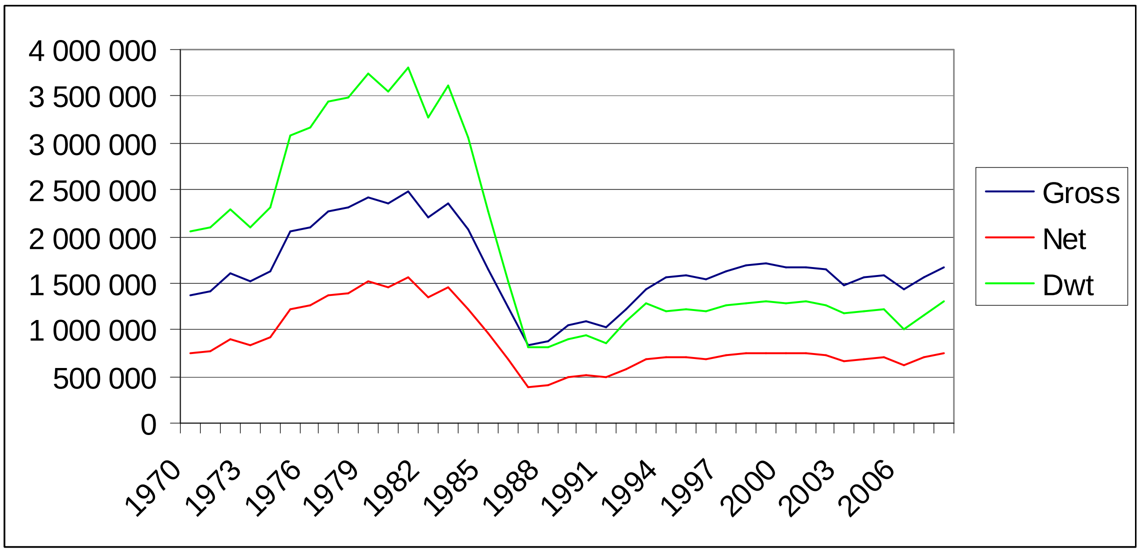

Figure 20. Finnish merchant fleet 1970-2008, tons. (Merenkulkulaitos, 2010b)

As Figure 20 describes, merchant fleet had highest figures in the beginning of 1980s. Dramatic fall occurred in 1985, due to economic downturn and increased competition in the industry. (Port of Pori, 2001)

Table 20. Merchant fleet registered in Finland in 2008. (Merenkulkulaitos, 2010a)

Vessel type	Amount	Gross	Net
Passenger vessels	235	539 853	298 903
Tank vessels	15	363 870	182 036
Dry freight vessels	116	594 242	210 720
Other vessels	281	164 687	51 848
TOTAL	647	1 662 652	743 507

Table 20 describes the merchant fleet in the end of 2008. Altogether in Finland is registered 647 vessels (as merchant vessel is calculated a vessel longer than 15 meters). Notable is the fact although the number of “other vessels” is the greatest, both gross and net weights are the lowest. Therefore, it can be concluded the Finnish merchant fleet consists mainly of passenger vessels, dry freight vessels and small vessels. When evaluating the deadweight tonnage, the fleet is 1 303 407 Dwt of which under Finnish flag is 146 368 Dwt. The percentual share is around 10 percent. Rest (1 157 039 Dwt) is out flagged, mainly to European countries and Bahamas (Merenkulkulaitos, 2010a): Sweden (484 087 Dwt), Bahamas (468 483 Dwt), Germany (98 009 Dwt) and Netherlands (87 000 Dwt).

Sea transport plays an important role in worldwide transport market. For example, 66 percent of cargoes arriving to European Union were transported by sea in 2005 (UNECE, 2008). Although vessel fleet is extensive including e.g. car carriers, LNG (liquefied natural gas), bulk vessels and tankers (“K” Line, 2010; Maersk, 2010), container vessels are the most utilized type. According to Ebeling (2009), over 90 percent of worldwide trade goods are transported in containers. Figure 21 describes the ownership of ocean shipping containers.

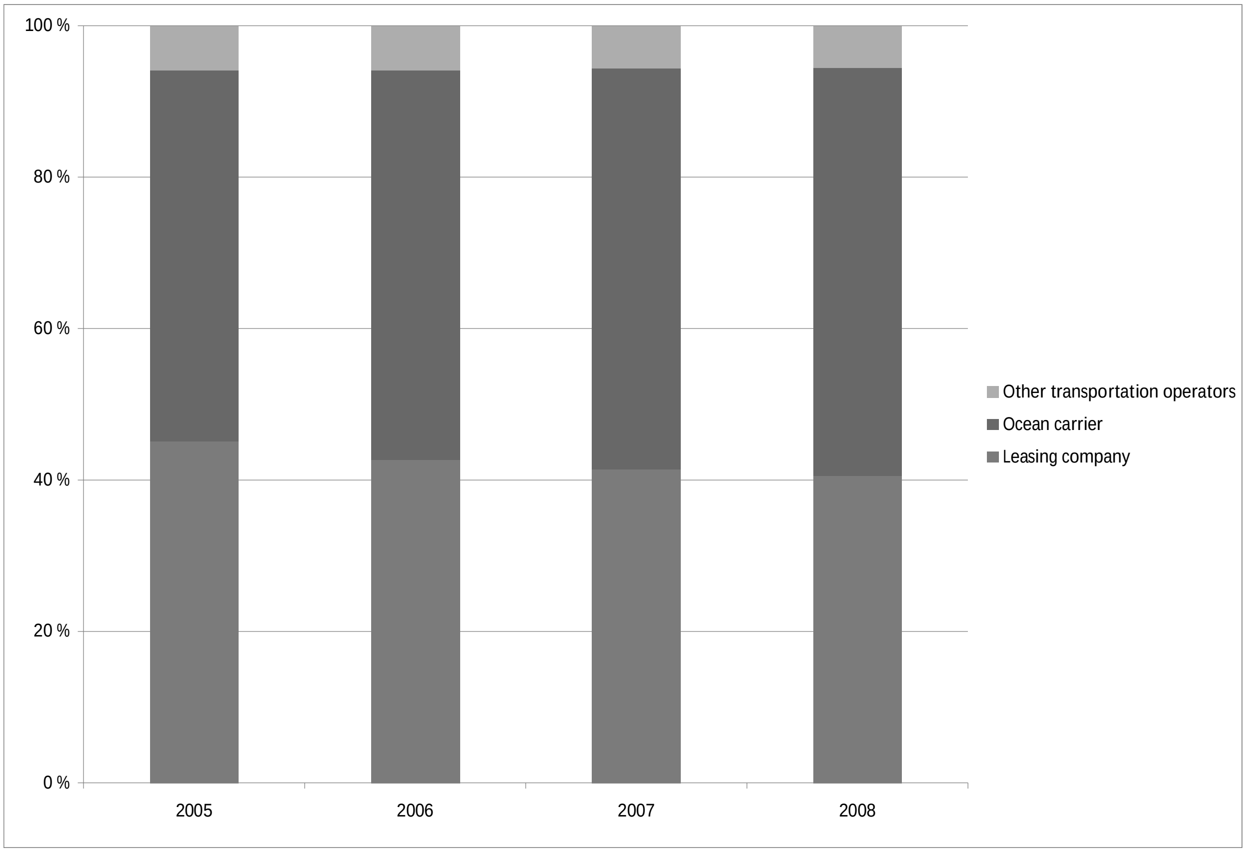

Figure 21 Container ownership, 1 000 TEUs. (Containerization Intl', 2009; 2010)

As illustrated in the figure, ocean carriers own the most of the units. According to UNESCAP (2009), top twenty lines accounted for 79 percent of global capacity, meaning the ownership structure is rather narrow. Another important container owner is the leasing companies, which entered the market due to cheap money. However, the situation presented in Figure 21 might change in the future: ocean carriers are trying to sell the units, due to problems with shipping capacity and overall cost-efficiency. (Containerization International, 2009; 2010)

Railway transport

Because VR Cargo is the only operator in railway freight market, basically whole Finnish fleet is owned by the company. The fleet size is around 10 000 wagons, covering six wagon types:

- *Flat wagons* are used for all kind of transport, for example containers, sawn goods, raw wood and steel plates. Furthermore, timber, slab, steel coin and heavy load wagons are counted to flat wagons' group.
- *Bulk freight wagons* are used to transport various materials, for example ore, waste paper, talc and powder.
- *Covered wagons* are used to transport all kinds of goods; for example paper, cellulose and sawn goods.
- In *tank wagons* are transported various types of products, such as chemicals, liquids and acid.
- *Container and lorry wagons* are utilized when transporting 20' and 40' containers, swap-bodies, trailers and vehicles.
- *Special purpose wagons* are used for example to transport heavy loads. (VR, 2010)

In addition to national operator VR Cargo, few organizations own rolling stock. However, the number of wagons is rather small; therefore, VR Cargo is the only competitive railway freight company in Finland.

How matters are handled in the case of emergency situation?

Due to Finland's location, country is dependent on sea transport. Over 77 percent of imported and 88 percent of exported cargo tons travelled through sea ports in 2009 (National Board of Customs, 2010). Although sea transport is running smoothly during normal times, its importance might lead to problems in the case of emergency situation. Due to strict rules and sharpened operations models, worldwide transport market has not confronted severe emergency situations (except natural disasters). In order to be able to function quickly and efficiently, countries should have emergency plans ready. One of the factors which have a great influence in the case of emergency situation is the transport equipments' fleet size. Most probably, in the case of emergency situation, countries would hail the own fleet. For example, in the case of oil leakage in Gulf of Finland, most probably Finland would be dependent on own transport fleet.

As described earlier in this chapter, worldwide transport market has confronted deregulations in all transport sectors. The same trend has extended to Finland. The only transport sector which is still totally under government's control is railway freight market, due to the fact there is only one operator, governmentally owned VR Cargo. However, in other transport sectors situation is interesting. In road transport market are operating hundreds of companies; although worldwide known players have large market shares, there exists several companies owning only few trucks. Therefore, it can be assumed in the case of emergency situation the vehicle fleet could cover the emerging needs. The most severe situation is in sea transport, due to harbors' various ownership structures and operators. Furthermore, the merchant fleet is rather limited, which might create problems.

5 Simulation and System Dynamics

5.1 Simulation

Naylor et al. (1966) define simulation as the process of designing a mathematical or logical model of a real system and then conducting computer-based experiments with the model to describe, explain, and predict the behavior of the real system. Simulation analysis is a descriptive modeling technique. It does not provide explicit problem formulation and solution steps like linear programming.

Borshcev and Filippov (2004) distinguish between discrete-event system simulation, agent based simulation and system dynamics modeling. In agent based modeling individual actors' behavior is modeled; the dynamics of the system is derived from the interaction between the actors. Furthermore, in discrete-event simulation discrete units flow inside the system, while resources offer services to the units.

Simulation has been widely used in transport system analysis. Applications range from elevator planning and airport baggage handling system design (Rijsenbrij and Ottjes, 2007; Tervonen et al., 2008) to evaluating segregation strategies of genetic manipulated grain (Coleno, 2008) and modeling of national freight systems (de Jong and Ben-Akiva, 2007). Godwin et al. (2008) use simulation for tactical locomotive fleet sizing for freight trains. Simulation has also been used for assessing different regulatory methods in congested transport systems (Kidokoro, 2006). Although simulation is often seen as an alternative to other analysis tools, it can also be used in combination with them. The Canadian Pacific Railway has used an optimal block-sequencing algorithm, a heuristic algorithm for block design, simulation, and time-space network algorithms for planning locomotive use and distributing empty cars when changing their service concept (Ireland et al., 2004). Cheng and Duran (2004) report a decision support system for managing transportation and inventory in a worldwide crude oil supply chain. The tool is based on a discrete-event simulation model and dynamic programming.

Recently simulation has been used also in analyzing sea transportation. For example, Engelen et al. (2006) have used system dynamics for a strategic and tactical decision making model for ship owners in the dry bulk sector. Ottjes et al. (2006) have investigated the future capacity needs of the Rotterdam port area. Their results include the requirements for deep-sea quay lengths, storage capacities, and equipment for interterminal transport. Further traffic flows on the terminal infrastructure are determined, and the consequences of applying security scanning of containers are evaluated. Douma et al. (2009) have evaluated the effect of information exchange in the Rotterdam port area on the waiting profiles. Tu and Chang (2006) have analyzed operations of ditch wharfs and container yards in future mega-container terminals by using simulation. Furthermore, Grunow et al. (2006) have analyzed strategies for dispatching AGVs at automated sea port container terminals in single and dual-carrier mode.

5.2 System Dynamics

System Dynamics (SD) was developed by Jay Forrester in the late 1950s. The first published work was “Industrial Dynamics” (Forrester, 1958) and the simulation model consisted of a supply chain. SD is part of a larger school of thought, systems thinking that studies dynamic complexity. In dynamic complexity is seen to arise from the non-linear and multi-loop feedbacks, while in detailed complexity the complexity derives from a wide array of possibilities (Maani and Maharaj, 2004).

SD uses only a couple of different kinds of elements to construct complex models. Nowadays almost all SD programs use a graphical interface where the model can be build by connecting different elements together and writing the actual equations inside the individual elements. The basic elements of which all SD models consist of are shown in Figure 22.

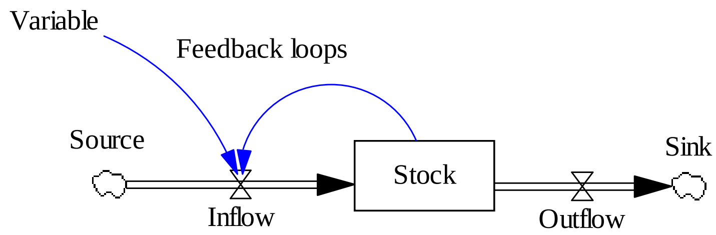

Figure 22. The basic elements in a system dynamic model.

Among the most important elements in a SD model are the stock and flows. The stocks are accumulations, which are defined by the in- and out-flows of the model. Mathematically speaking the equations are simply integrals. The stocks play an important part as the model reaches equilibrium as the stocks regulate the feedbacks in the system. For instance, in the example of Figure 22, the stock impacts the values of the in- and outflows so the system reaches equilibrium in time. As the model needs to have fixed boundaries, sinks and sources are used to represent stocks with an infinite capacity. Final parts in SD are variables / parameters and feedbacks. Variables simply store information and / or conduct different calculations during the simulation. The feedbacks represent either a positive or negative feedback, e.g. it will either have a positive correlation between the elements or a negative one. (Sterman, 2000)

SD has been used in a wide area of applications. These include ecology, economics, supply chain management, urban development, and even world development. Earlier SD has been used in studying sea ports. Munitic et al. (2003) created a SD model, where they studied the material flows in a whole port cargo system. The model was constructed on a micro-level and it contained individual fork-lift trucks, wagons, wharfs, etc. Sanders et al. (2007), on the other hand, studied the investment dynamics in larger port systems including hinterland capacity. The model also contained the competition between the different sea ports. Lättilä (2009) constructed a macro-level SD model where the focus was on the development of demand in different sea ports. The simulation model did not include competition between the different sea ports and the demand was imposed on individual sea ports using the historical values. Even though the amount of publications regarding system dynamic simulations of sea ports are low, there should be no reasons, why SD could not be a valid method in studying the development of sea ports.

6 Simulation Studies of Selected Risk Scenarios

6.1 Summary of Indentified Risk Sources

Below two tables are presenting the origins of risk and their qualities in relation to infrastructure of intermodal transportation systems from the literature (Table 21) and practice (Table 22). According to the doctoral dissertations scrutinized (Table 21), it can be stated that the single major source of risk in intermodal transportation infrastructure is related to the efficiency of timing of decisions and their implementation in relation to critical investments of physical resources. Sources of risks can be related to resources of the system, i.e. labor or information systems, or types of customers served by the system, such as foreign containers and recreational vessels or external factors, like weather. As such, no ultimate set of risk sources can be identified. The probability of a risk being realized depends e.g. on the above mentioned factors. It also seems that the duration of the consequences of identified risks is in most cases less than a month.

Table 21. Summary of the identified risks from the reviewed doctoral dissertations.

Dissertation/Factors	Risk	Description	Duration	Environment
Duan (2006)	Collaboration	Lack of collaboration can increase the effect of disturbances.	Hours, days	Hub cities, U.S.
Terahara (1999)	Bottleneck resources, institutional settings, market dynamics	Emphasizes investing on bottleneck resources in the transportation network and promotes market mechanism as a tool to achieve this.	Weeks, months	Coal transportation in China
Direnzo (2007)	Physical resources	In the United States number of foreign containers and recreational vessels contribute to maritime risk.	Hours, days, weeks	In hub cities in U.S.
Vandiver (2006)	Labor, weather	Interruptions are typically caused by labor or weather	Days, weeks	In the port of Houston, U.S.,
Fung (1998)	Scheduling	Concentrates on scheduling investments to ensure suitable capacity.	Weeks, months	In the port of Hong Kong

Table 22 provides a summary of the main risks in the case studies. Both in case of ports and railway yards risks are of similar type, but their specific nature depends on each contextual settings. In line with the findings of literature review, there is no ultimate set of sources of risks, and in most cases a timeframe of hours and days, rather than weeks, or months is involved.

Table 22. Summary of the identified risks from the case studies.

Case	Risk	Description	Duration
Port of Hamina	Electric power and gas, spillage	Port uses gas and does not have own power plant, spillage in harbor	Hours, days, weeks
Port of Helsinki	Tunnel closure	Port is accessed through tunnels, weather/ ice conditions	Hours, days
Port of Kotka	Information system, accident, spillage	Port lies in large area, port handle a lot of transit goods	Hours, days, weeks
Port of Naantali	Accident, spillage	Port lies in compact small area	Hours, days, weeks
Port of Lappeenranta	Saimaa canal closure	Port is accessed through Saimaa Canal and canal closure stops ship traffic	Hours, days, weeks,
Port of Kokkola	Accident, derrick capasity	Accident in the narrow boat lines or in the harbor	Hours, days, weeks
Port of Raahe	Accident	Accident in the narrow long boat line	Hours, days, weeks
Ports of Tallinn: Old harbor Muuga Paldiski	 Accident Spillage, accident Accident	 Accident in harbor Spillage of tank wagons in harbor Accident in harbor	 Hours, days Days, weeks Hours, days, weeks
Port of Sillamäe	Spillage, accident	Spillage or accident in harbor	Hours, days, weeks
Kouvola railway yard	Spillage	Handles a great deal of Russian liquid and chemical tankers	Hours, days
Tampere railway yard	Derailment	Derailment in building new trains in railway yard	Hours, days, weeks
Finnish Road Admistration	Information systems	Centralized Traffic Management Centre	Hours, days, weeks
Stella Corona	Accident	All warehouses located in Kotka	Hours, days, weeks
Kuehne + Nagel	Information systems	Global operator is dependent on information systems functionality	Hours, days, weeks

According to Table 22 different sea ports and railway yards have differing risk profiles depending on the infrastructure and cargo handled. The critical infrastructure is different in the ports and in the major railway yards: The ports are depending on information and energy systems whereas major railway yards are depending on transport equipment and railway infrastructure such as tracks, switches and brakes. However, a spillage is a common perceived source of risk.

6.2 First Scenario: Oil Spillage at Sea near of Kotka

In this scenario we are interested in studying the impact of insufficient hinterland capacity on the performance of sea ports in crisis situations. In the hypothetical case Hamina and Kotka sea port are going to be closed due to an oil spillage in the Gulf of Finland. The container traffic from Kotka is transferred to Helsinki sea port and we analyze what happens with different amounts of hinterland capacity. Hamina's demand is assumed to be transferred to another sea port, so it is not included in the simulation model.

Simulation Model

In the simulation model both of the sea ports have an estimated daily demand and capacity. As soon as the Kotka sea port malfunctions, the sea ports start shifting some of the capacity from Kotka (for instance mobile cranes) to Helsinki. There is also a limit to the amount of additional capacity which Helsinki can absorb, which will also impact the potential movable capacity. In this scenario we assume that the sea port cannot take much additional capacity from other sea ports so the potential for additional capacity is small. The shifting operation will require some time (loading at the Kotka sea port, transporting, and finally installing at Helsinki) and in the simulation model all movable capacity has been moved after 15 working days. Also, 15 days before Kotka sea port can start serving ships again, the capacity is going to be transferred back to Kotka in a similar fashion.

In Helsinki a fixed amount of containers can be stored. In the simulation model the containers stay in the sea port for two days on average (during the crisis situation the containers will only spend a very short amount of time in the sea port and this way the average time at the sea port remains low) and this is taken into account with the storage module.

There are two constraining factors in the maximum capacity of the sea port: available flow through the sea port (calculated with the help of hinterland capacity) and the actual cargo handling equipment. If the hinterland capacity is not large enough, the available warehouses for containers start to fill up. When the practical maximum capacity is reached, the sea port cannot handle any more ships as there is not enough space to store the goods. In this situation hinterland capacity defines the maximum capacity for the sea port. Overall the simulation model contains a lot of interactions and the total model is presented in Figure 23.

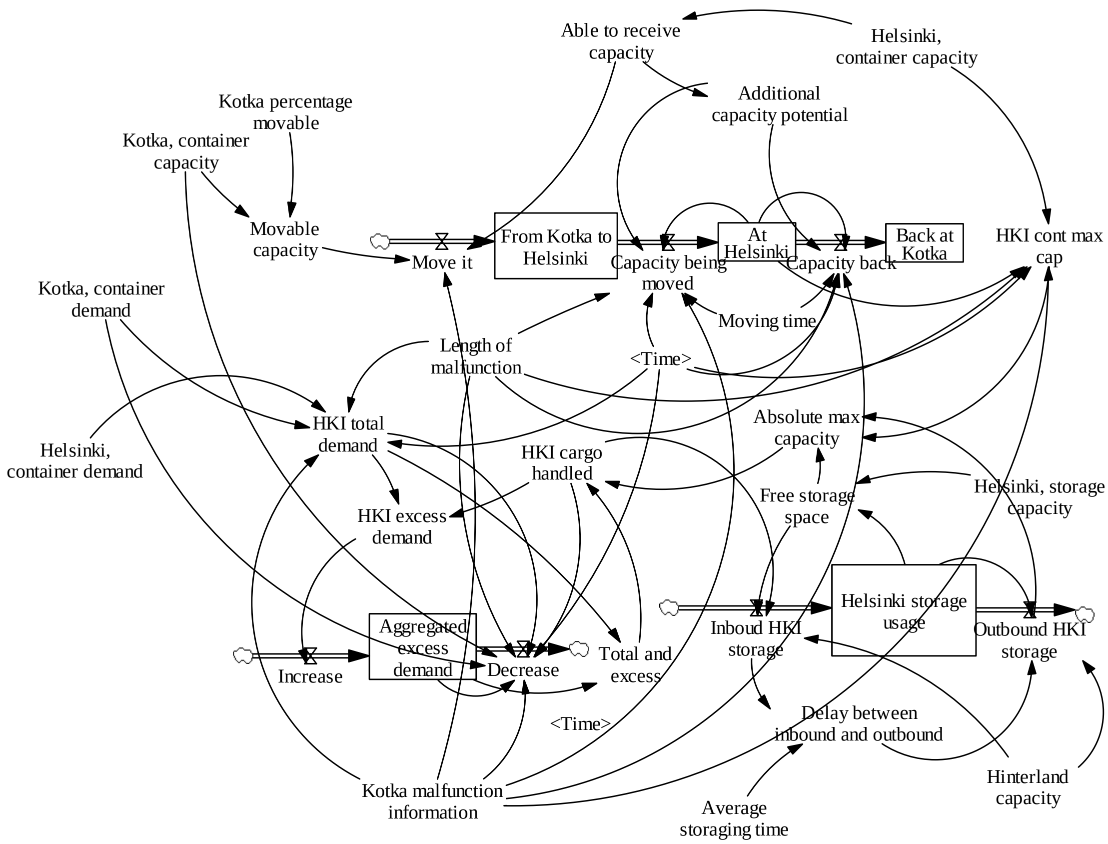

Figure 23. The system dynamics model.

We run nine different scenarios with the simulation model in order to evaluate the impact of hinterland capacity on the functionality of sea ports in crisis situations. Hinterland capacity will differ between 1500 (a little bit over Helsinki sea ports current demand) and 3500 containers (the demand of Kotka and Helsinki combined) per day. We will study the available storage space, the maximum capacity of the sea port, and the excess demand which cannot be handled by the seaport.

Results

We will first analyze the amount of aggregated excess demand, which the sea port cannot handle during the crisis, which starts on day number 90 and its duration is 60 days. All scenarios are presented in Figure 24.

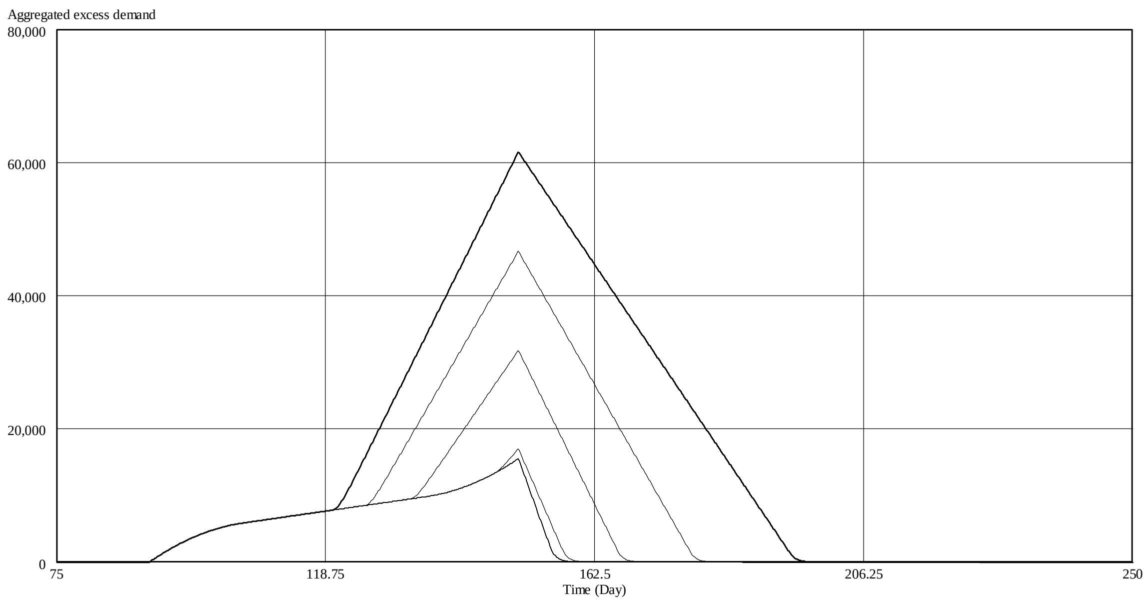

Figure 24. Aggregated excess demand in different scenarios, TEUs.

As it is possible to notice from Figure 24, all scenarios have the same amount of excess demand for the first 30 days of the crisis. Approximately day 120 the scenario with the lowest amount of hinterland capacity starts to differ from the rest of the scenarios. The scenarios with a hinterland capacity of at least 2500 TEU do not differ between each other. In these cases the additional amount of hinterland capacity will not make a difference as free storage space does not run out during these simulation runs. We can verify this by studying the available capacity in different scenarios. These are presented in Figure 25.

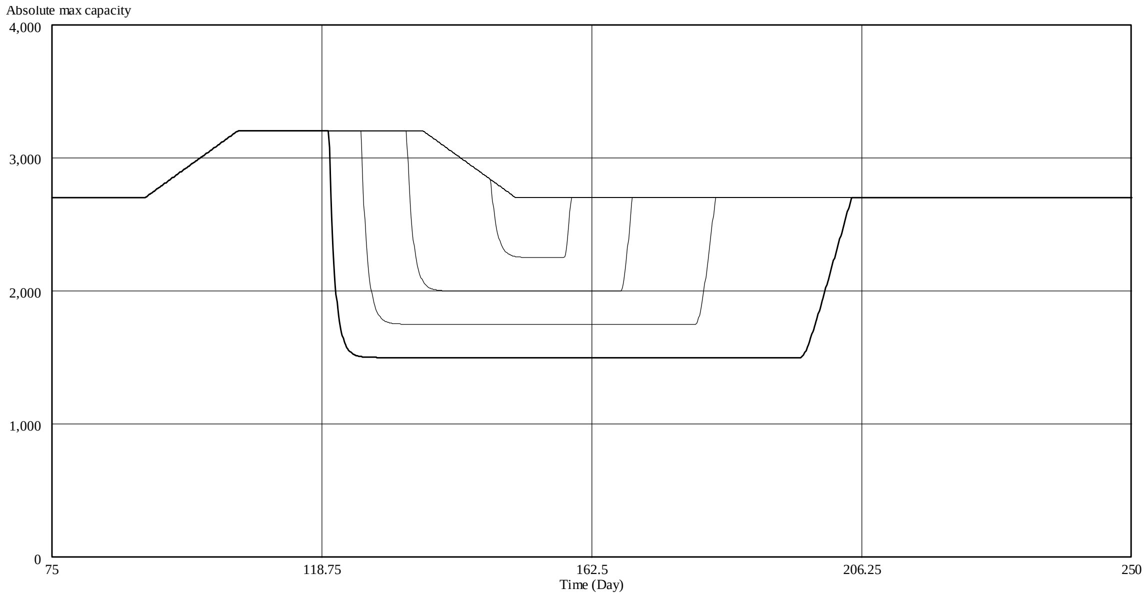

Figure 25. Available capacity in different scenarios, TEUs.

Figure 25 confirms the expectation: Available capacity does not differ between the scenarios with a larger amount of hinterland capacity. From the figure it is clearly seen how the capacity increases in the beginning of the crisis. When the free storage space starts to run out, the available capacity decreases rapidly towards the amount of available hinterland capacity. Figure 26 shows the amount of free storage space in different scenarios.

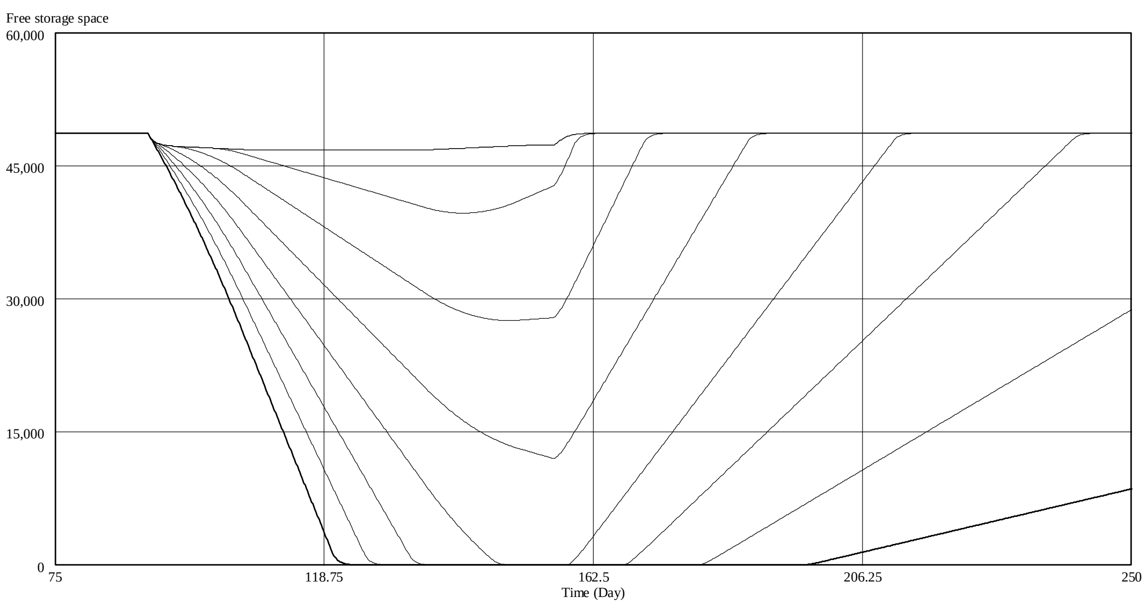

Figure 26. Amount of free storage space in different scenarios, TEUs.

The free storage space runs out in four scenarios. When there is no more excess demand in the sea port, the amount of free storage space starts to increase. Even though the crisis ends at day 150, many of the scenarios are working on full storage capacity for a long time. Even at day 210 there is still a large amount of material in storage in three scenarios.

6.3 Second Scenario: Oil Spillage in Muuga

In this scenario Muuga sea port is going to be closed due to an oil spillage in the port. 20 percent of the container traffic to Muuga (105 TEU per day) is transported via Helsinki sea port. From Helsinki containers will be transported to Paldiski on platforms with ro-ro ships. The amount of 20 percent of the containers is assumed to be sufficient in respect of security of supply. 80 percent of the containers will remain in the sea ports in Central Europe. We analyze the effect of having different amounts of platforms available for the sea transport between Helsinki and Paldiski.

In Helsinki the handling capacity is annually 500 000 TEU. In year 2009 it handled about 350 000 TEU (Port of Helsinki, 2010). Helsinki has a fixed amount container storage at the sea port. In the simulation model the containers stay in the sea port for about 1-2 days on average. Muuga cargo handling devices are not moved, they remain in the port. Tallinn and Helsinki have at least two ro-ro connections daily (Port of Tallinn, 2010a). As Muuga is closed the ferries from Helsinki visit Paldiski port. A standard platform is assumed to carry two TEUs. Empty platforms are transported back to Helsinki. The turnaround time for the platforms between Helsinki and Paldiski is assumed to be two days. Although the same platforms are not returned directly, the number of platforms dedicated to the transportation loop between Helsinki and Paldiski equals the number of daily containers. In different simulations, the number of dedicated platforms receives the values from 10 to 110 with an increment of 10. The duration of the malfunction is 60 days.

Results

During Muuga malfunction Helsinki is able to take 105 containers of Muuga sea port without any problem. Helsinki total demand increases momentarily on day 90 as the malfunction begins, but comes back to the average level as soon as the malfunction in Muuga is over on day 150 (Figure 27). The effect on the amount of free storage in Helsinki is limited in all cases (Figure 28).

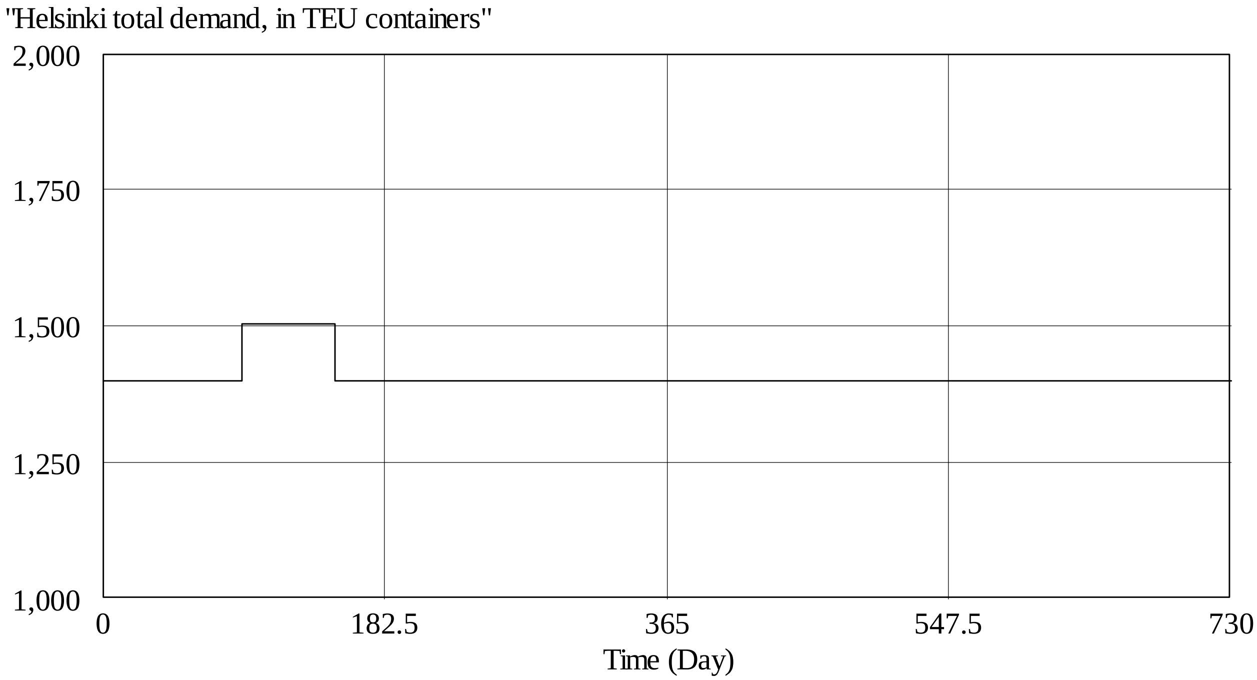

Figure 27. Total demand in the port of Helsinki, TEUs.

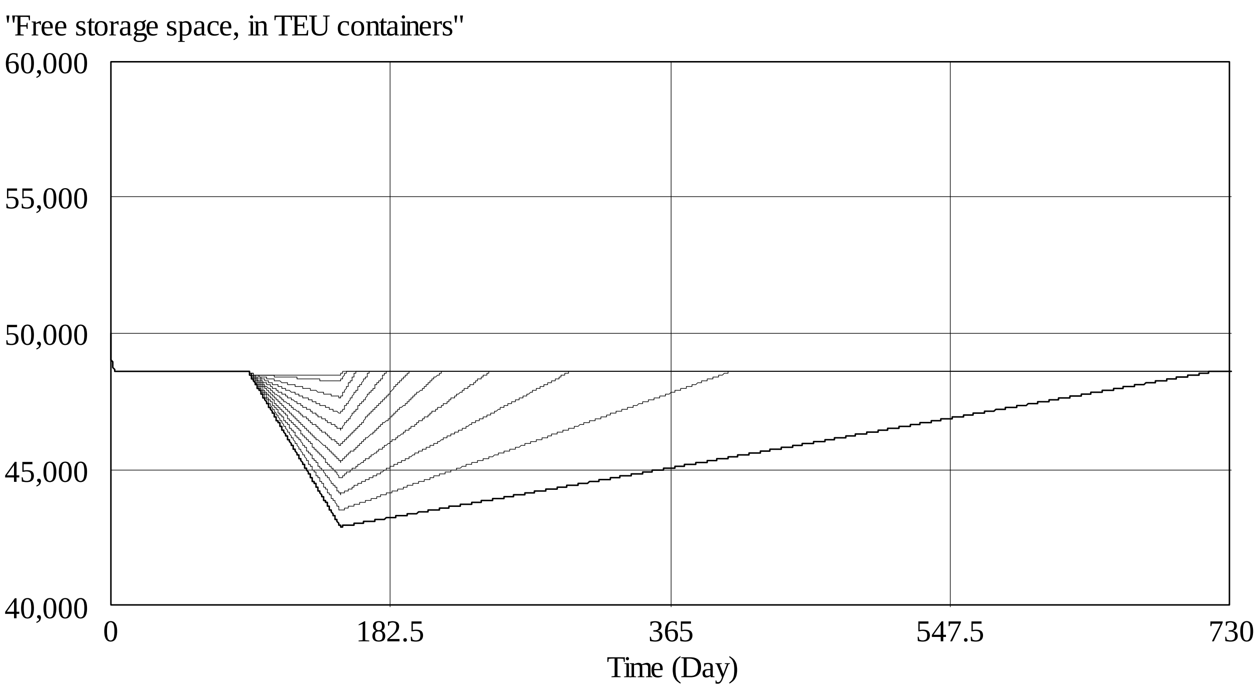

Figure 28. Free storage space in Helsinki, TEUs.

However, in Estonian perspective Figure 28 has more dramatic consequences. If the amount of platforms is not sufficient, receiving the containers will take months. As container handling capacity in Estonia is concentrated in the port of Muuga, the system is vulnerable to local disturbances.

6.4 Third Scenario: Wagon Spillage in Kouvola

In this scenario a major node of the Finnish railway network, Kouvola, malfunctions due to methanol wagon spillage. As a result, no cargo or passengers can be transported between Kouvola and the Russian border. Many bulk materials are transported using railways and it might be difficult to find specialized trucks for this kind of material in a short period of time or it is not cost-efficient to use trucks. Furthermore, we assume a normal situation, where passenger trains are still given priority over freight traffic. Thus, the capacity estimates used for the railway network in the model do not resemble the maximum that can be acquired when recovering from a crisis situation.

Simulation Model

The most important parts in the simulation model are the major railway yards connected to the malfunctioning node, Kouvola. All of the nodes have a fixed capacity. This is seen as a limited amount of storage space for trains in railway yards and sea ports.

In the simulation model we are only studying the impact on transit. Transit through Kouvola includes traffic from Hanko, Helsinki, Kotka, and Hamina to the border crossing railway stations. As Hanko and Helsinki, and on the other hand Kotka and Hamina, use the same route to access Kouvola, these locations are aggregated into two respective pairs. As such, Kouvola is going to be connected to Lahti (Hanko and Helsinki), Kotka / Hamina (mostly the same route, only a small divergence near the cities of Kotka and Hamina) and Russian border. There are delays connected to all of these routes, which have been taken into account in the simulation model. Also, each of the yards has a fixed capacity which can be reserved for temporary holding area for wagons. These two values create constraints for the system. Although, the study concentrates on freight, the disruption affects rail passengers as well. Table 23 presents passenger volumes on track parts connected to Kouvola. (Finnish Rail Administration, 2009a). Additionally, the table presents explicitly the affected international passenger volume between Luumäki and Russia.

Table 23. Passenger volumes on track parts connected to Kouvola (year 2008). (Finnish Rail Administration, 2009a)

	Lahti (West)	Luumäki (East)	Luumäki - Russia	Mikkeli (North)	Kotka (South)
Passengers, annually	2 230 000	1 305 000	430 000	750 000	125 000
Passengers, daily	6 200	3 600	1 200	2 100	350

As there is both import and export in transit, they have to be separated in the model. This requires three stocks for each individual location (imports, exports, and overall). Also, as there are capacity constraints in the rail yards, it is necessary to keep track of the amount of materials on-route to the rail yards (due to the delay). Overall there will be four additional stocks, one for each location. A simple link between two stations is presented in Figure 29.

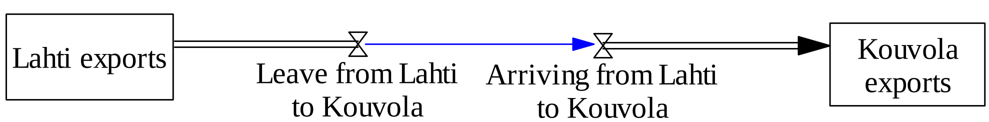

Figure 29. A link between two nodes in the simulation model.

The software "loses" all of the material, which is on-route to a location, but they need to be taken into account. It would be possible to place a stock between the nodes, but as all of the incoming material needs to be taken into account, it is better to aggregate all of the incoming material to one stock. The materials arrive to the location according to transport delay and the function in the arriving flow uses the leaving value. This is presented in Figure 30.

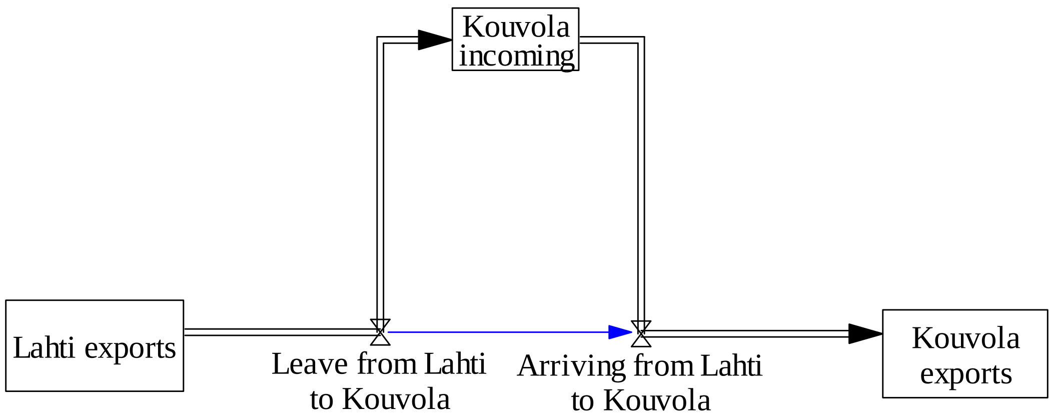

Figure 30. The aggregated amount of goods incoming to nodes.

The amount of material transferred between the nodes depends on the destination nodes' free capacity, amount of material to be transferred and the amount of capacity in the railways available between the locations. The free capacity needs to be divided between the different origins, which needs to be taken into account as well when estimating the amount of material to transfer between the nodes. This is presented in Figure 31.

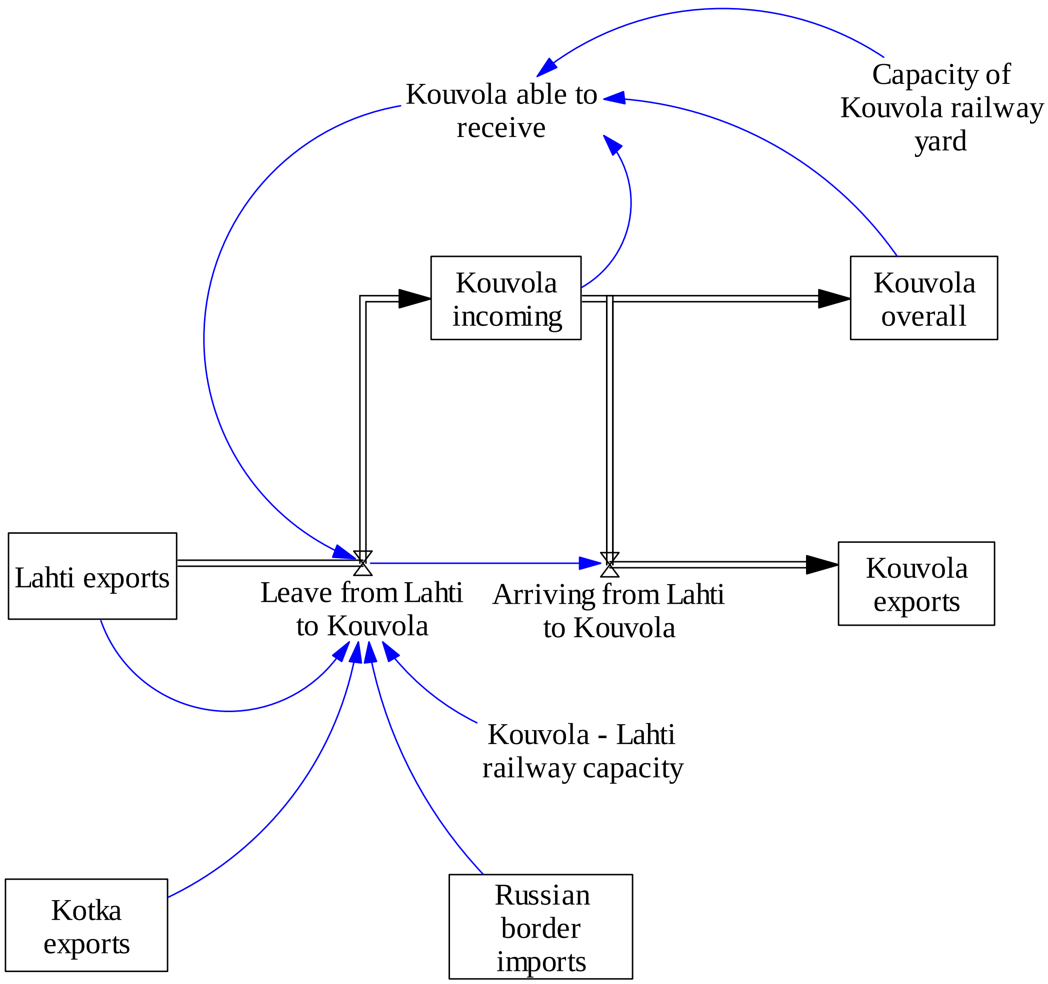

Figure 31. Estimating the transportation capability of a single link.

The model boundaries are in increase of the amount of exports and imports in Kotka / Hamina, Lahti, and Russian border, as well as the final import and export when materials leave Finland. In this version of the model imports and exports are assumed to remain the same all of the time and the amounts are independent. In order to make sure that there will not be too much of material at the nodes the potential increase depends on the free capacity at the location. This is presented in Figure 32.

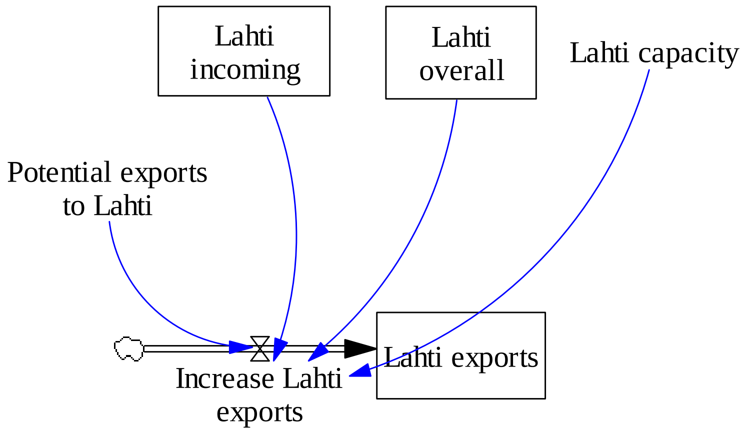

Figure 32. The boundaries of the simulation model.

The model is lacking the import or export through Finland, but it can be easily simulated. A fixed capacity can be set to the sea port and border, and the amount imported / exported is simply the smaller value from the amount of goods at the border / sea port and the amount of capacity.

In this scenario the connection between Kouvola and Russian border is going to malfunction. During the malfunctioning the leave values from Kouvola to the Russian border and vice versa is going to be zero (Shown in Figure 33). When this happens, the railway yards start to fill up. Later on the sea ports / border cannot take any more exports / imports as the whole supply chain is full. In the simulation model it is assumed that the export / import is lost and cannot be regained. This can easily be tracked by subtracting the difference between the increase and the potential increase.

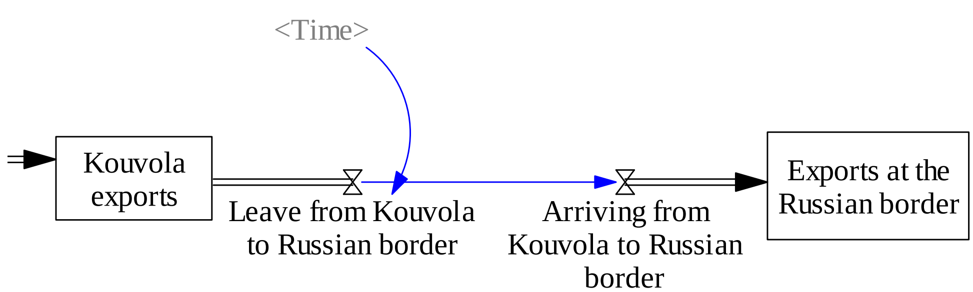

Figure 33. Malfunction in the simulation model.

The amount of westbound transit has been about 4000 thousand tons per year (VR, 2010), which is over 13 thousand tons per each day (300 working days per year). This equals to about 830 tons per hours (16 hour days), while eastbound transit is about 920 tons per hour (4400 thousand tons overall). Rail handles almost all westbound transit, while the amount of eastbound transit handled by railways is only 10 percent (Posti et al., 2009). Also, Kokkola is removed from figures as it uses separate railways. This means that the eastbound increase during each hour is 518 tons, while the increase westbound amounts to 83 tons each hour.

The size of individual rail yards is presented in Table 24. The estimate is based on rail yard track length and typical size of wagons (length 22 meters, and cargo of 60 tons). The Russian border contains Vainikkala and Imatrankoski, while Lahti contains Lahti, Riihimäki, and both the sea ports. Also, the capacity of individual links between the nodes will impact the results. The estimates for the capacity of these links are also presented in Table 24. The capacity estimate for each link is based on the daily train capacity of different track types (Mäkelä et al., 2002) as well as current utilization which is calculated from graphical time-tables (Finnish Rail Administration, 2009b). In the real life the capacities presented in Table 24 vary: For example, the capacity of a link in the rail network is typically measured in trains per unit time. However, for a given link the capacity depends on the speed and distribution of speed of the different trains (Mäkelä et al., 2002). Furthermore, the as length of a train is limited by network geometry, the capacity in tons depends on cargo type (tank wagons weight more than container wagons of similar length). The latter applies also to rail yard capacity. The parameter values presented in Table 24 have been constructed in discussions with the Rail Department of the Finnish Transport Agency. The capacities include only the part which is assumed to be allocated to transit in a normal situation, not the total capacity which is used in other transportation as well.

Table 24. Capacity in different parts of the model.

Node or link	Capacity
Russian border	12 000 tons
Kouvola	12 000 tons
Kotka and Hamina	6 000 tons
Lahti (Helsinki and Hanko)	12 000 tons
Kouvola – Lahti	800 tons / hour
Kouvola – Kotka / Hamina	600 tons / hour
Kouvola – Russian border	900 tons / hour

In a crisis situation the available capacity could be affected by prioritization of the trains. In this study such measures are not assumed to be taken.

Results

In this model we analyze the impact of the length of the malfunction. It is going to vary between 112 and 448 hours. This equals one to four weeks in length. We are mostly interested in the amount of transit volumes lost but other results are presented as well. Figure 34 shows the amount of lost eastbound transit.

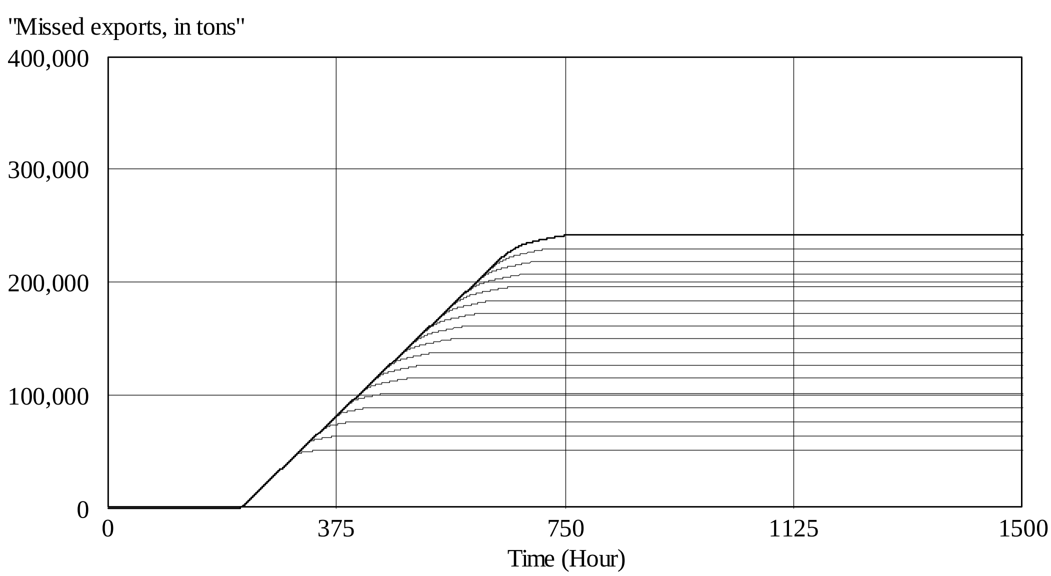

Figure 34. Aggregated amount of missed eastbound transit, tons.

As it is possible to notice from Figure 34, there are large differences between the scenarios. Nevertheless, even the first scenario contains lost revenue and the losses increase linearly. On the other hand, with the current parameters there are no lost imports in Helsinki and Hanko in any of the scenarios. There is adequate capacity to cope with four week long malfunction as the amount of imports is relatively small. In Kotka and Hamina the amount of lost imports increases linearly depending on the scenario. In six scenarios there is adequate storage capacity but in most situations capacity is lacking (shown in Figure 35).

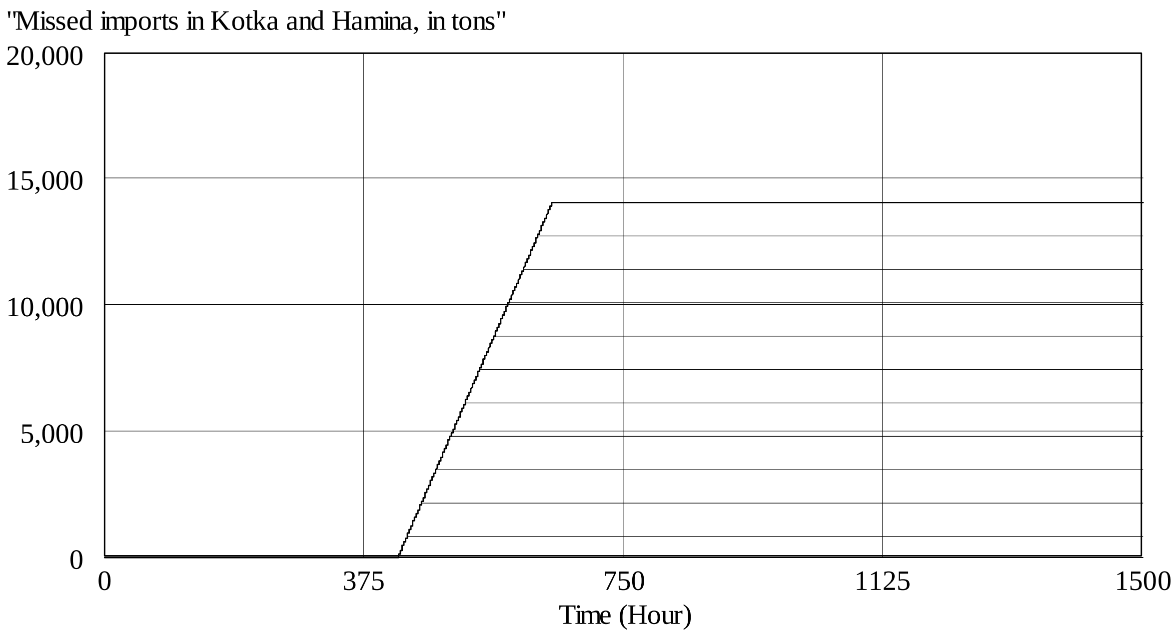

Figure 35. Aggregated amount of missed westbound transit in Kotka and Hamina, tons.

The eastbound transit in Kouvola has some sort of bullwhip effect after the malfunction (shown in Figure 36). This is due to the “clogged” Russian border as all transit start to flow to the border, when the railway link is working again (shown in Figure 37).

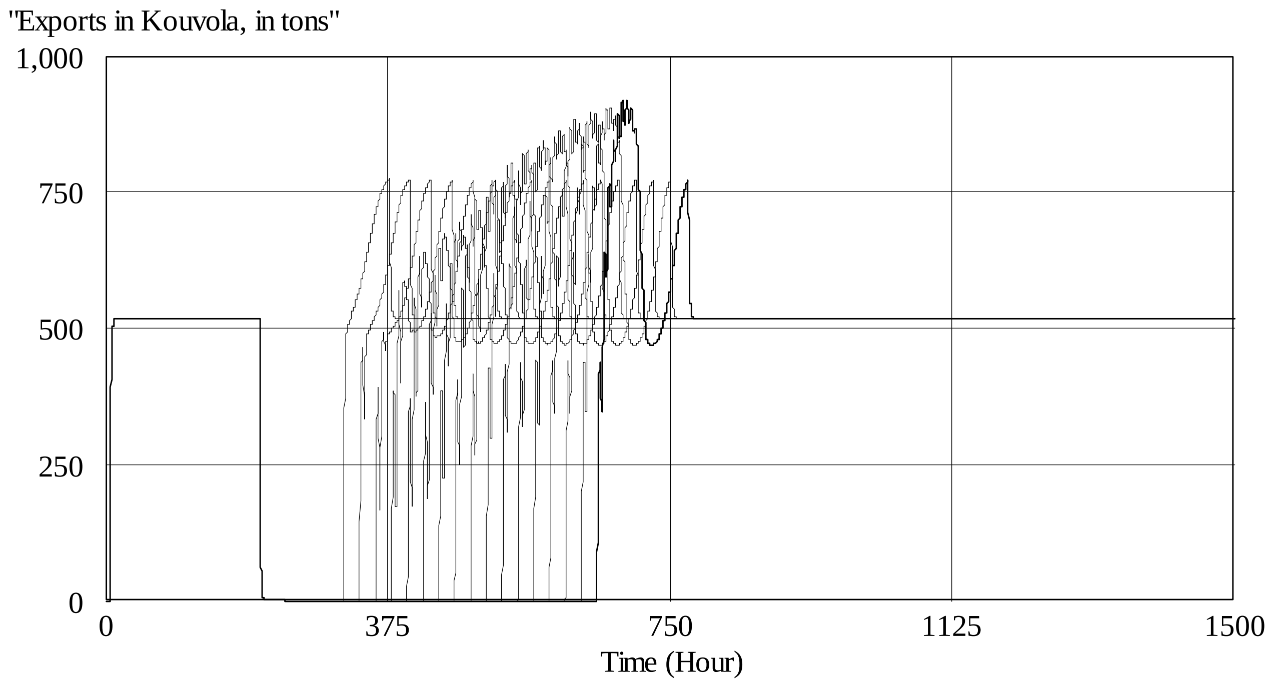

Figure 36. Amount of eastbound transit waiting in Kouvola, tons.

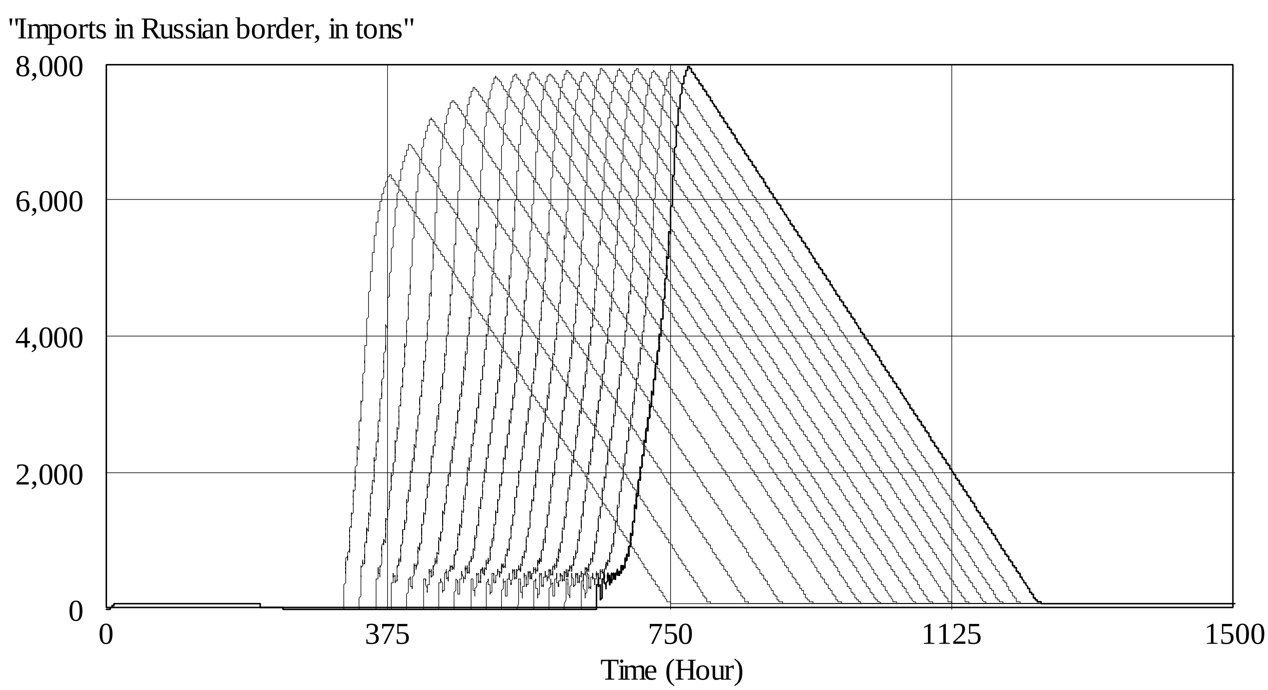

Figure 37. Amount of westbound transit waiting at the Russian border stations, tons.

Even though Helsinki and Hanko do not lose any westbound transit, some of their eastbound transit is lost. Figure 38 shows the amount of eastbound cargo during each hour. There is a period, when no cargo enters Russia even though the malfunction is over. This has a financial impact on the sea ports as there are a lot of value-added services, which are missed due to the poorly working border.

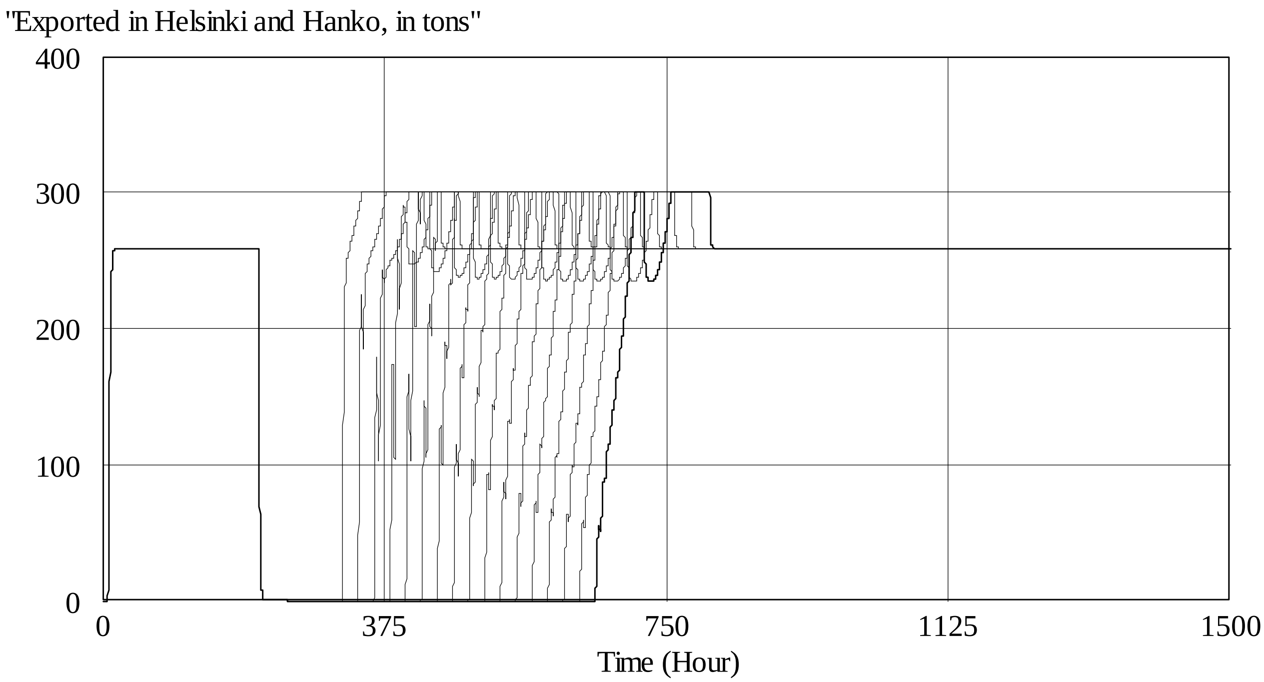

Figure 38. Eastbound transit in Helsinki and Hanko during the simulation, tons.

In overall it can be stated that a malfunction in the hinterland capacity will have heavy financial implications for sea ports. Especially export transit would suffer as most of the transit is conducted using railways. It might be possible to conduct part of the transit using trucks, but this is not cost-efficient and would still have a financial impact on the sea ports. In the simulation study it was assumed that passenger trains are given priority over freight traffic. In a crisis situation additional capacity for freight could be gained by discontinuing passenger traffic temporarily, e.g. one third of the daily trains using the track linking Kouvola to the East are passenger trains. (Finnish Transport Agency, 2010b). Additional transport capacity would speed up the recovery process once the crisis is over.

6.5 Fourth Scenario: Wagon Spillage in Tapa

As already noted Estonian ports carry a large amount of Russian oil transit. The oil is transported to the ports by rail. In this scenario the connection between Tapa and Vaivara is going to malfunction. In comparison to freight traffic, passenger traffic on Estonian railways is negliable: e.g. the track part in question is used by six passenger trains daily (Edelaraudtee, 2010; GoRail, 2010). During the malfunctioning the leave values from Tapa to Muuga and Paldiski and vice versa is going to be zero. When this happens, the whole oil transportation stops and the rail yards starts to fill up in Vaivara and Sillamäe. Later the sea port of Muuga cannot take any more imports as the whole supply chain is full between the port of Muuga and Tapa, but oil export will continue as long as oil storages last in the ports of Muuga and Paldiski. In the ports of Muuga and Paldiski the total storage capacity of oil is 1.7 million m^3 (0.7 million m^3 for light oil products and 1.0 million m^3 for heavy oil products). In addition railway yards in the ports can stock up on oil about 190 000 tons. Annual oil transportation from Muuga and Paldiski was in year 2009 nearly 23 million tons, i.e. 100 000 tons a day. (Port of Tallinn, 2010b) that is same as annually oil transportation to Muuga and Paldiski by trains. In case of disruption in oil delivery on rail full oil tanks in the harbour would last 17 days (A simple linear example is presented in Figure 39) and tanks that are 80 percent full have enough oil for 14 days. In addition wagons on the railway yard could serve demand for two additional days, enabling normal level of oil exports during a disruption of a limited time. Because of the oil reserves in the tanks consequences of disruptions are experienced at a later time and have a shorter duration than the malfunction itself.

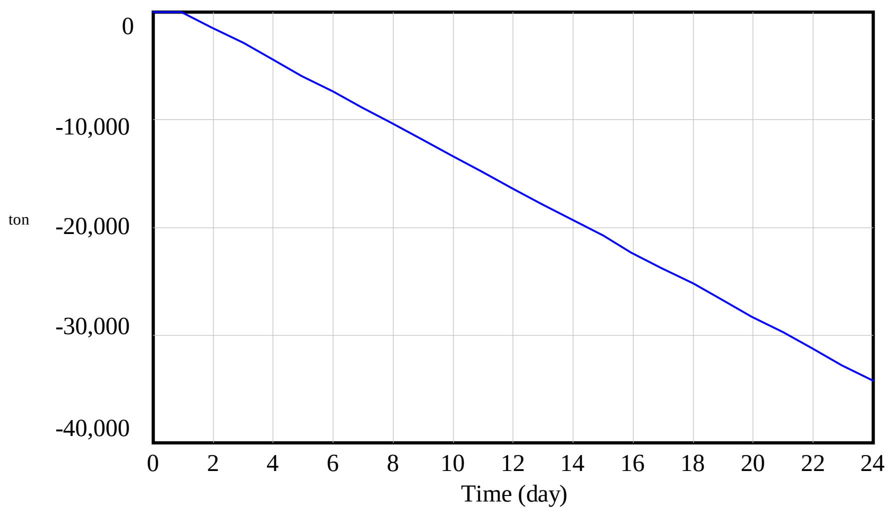

Figure 39. Shortfall of oil wares in the ports of Muuga and Paldiski, tons.

The results from the actual simulation model are presented in Figures 40, 41, and 42. The structure is similar to the structure in Scenario 3 above, but there exists only one way traffic as Russia does not conduct import transit through Estonia. Also, in this simulation case we are assuming bad winter conditions and Sillamäe is able to handle only half of the normal capacity. This is about 3000 m^3 of oil per hour. As it is possible to notice from Figure 40, there are large differences between the scenarios. Nevertheless, even the first scenario contains lost revenue and the losses increase linearly. There is adequate capacity to cope with 4 week long malfunction as the amount of imports is relatively small. In Muuga and Paldiski the amount of lost imports increases linearly depending on the scenario. In 6 scenarios there is adequate storage capacity, but in most situations capacity is lacking (shown in Figure 41).

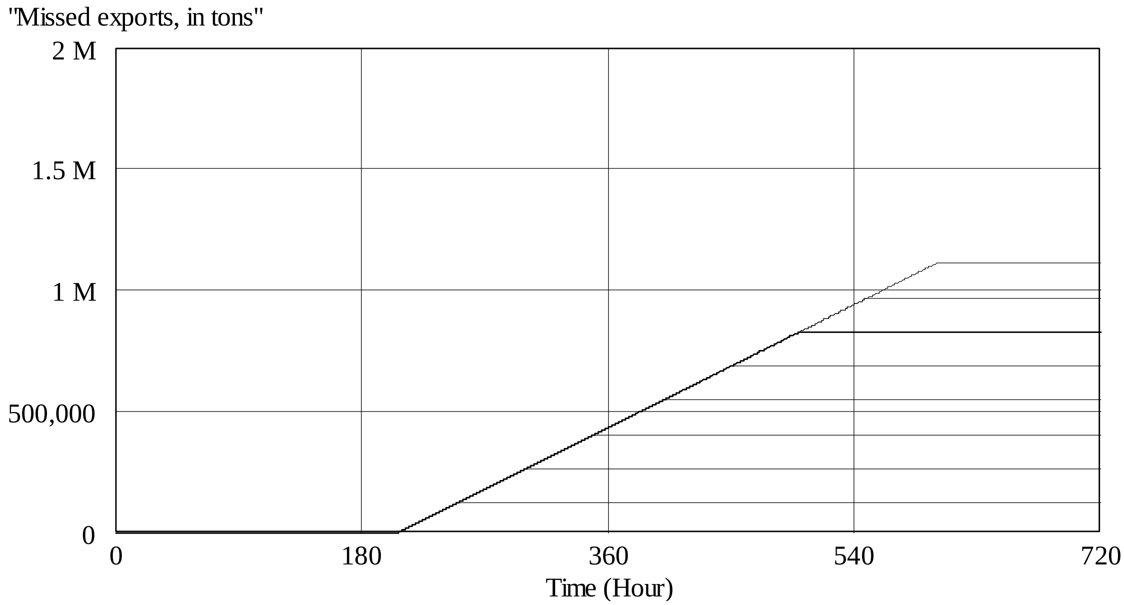

Figure 40. Missed export during malfunction in Muuga, tons.

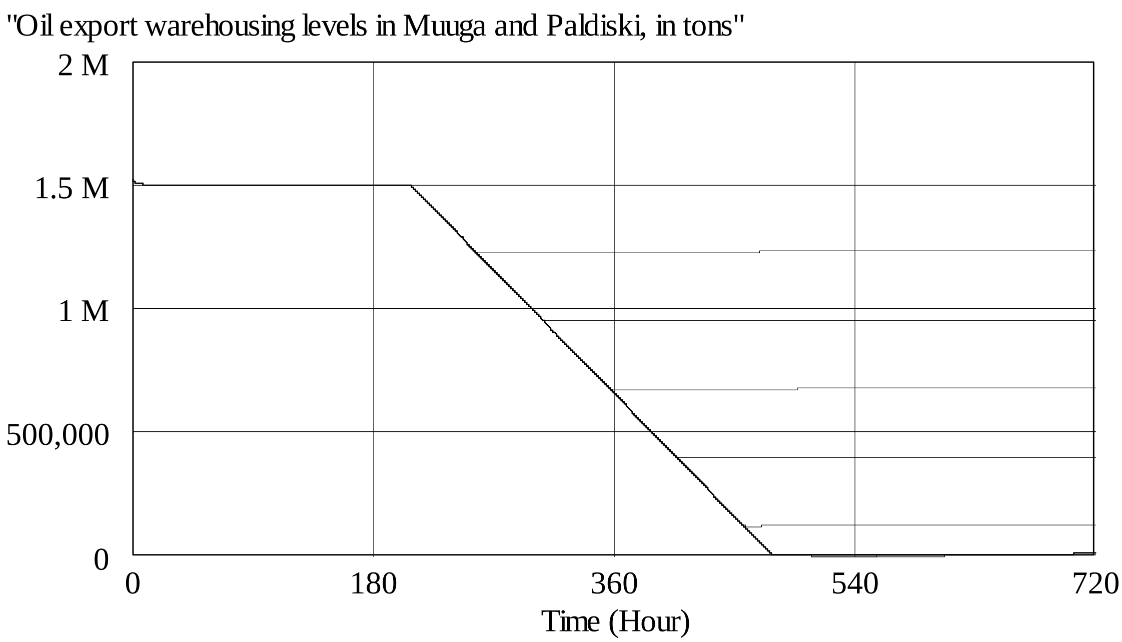

Figure 41. Oil export in Muuga and Paldiski, tons.

Even though Tapa and Vaivara do not lose any import oil, some of their export oil is lost. Figure 42 shows the amount of oil exported during each hour and there is a period, when no oil is exported even though the malfunction is over. This has a financial impact on the sea ports as there are a lot of value-added services, which are missed due to the poorly working Russian border.

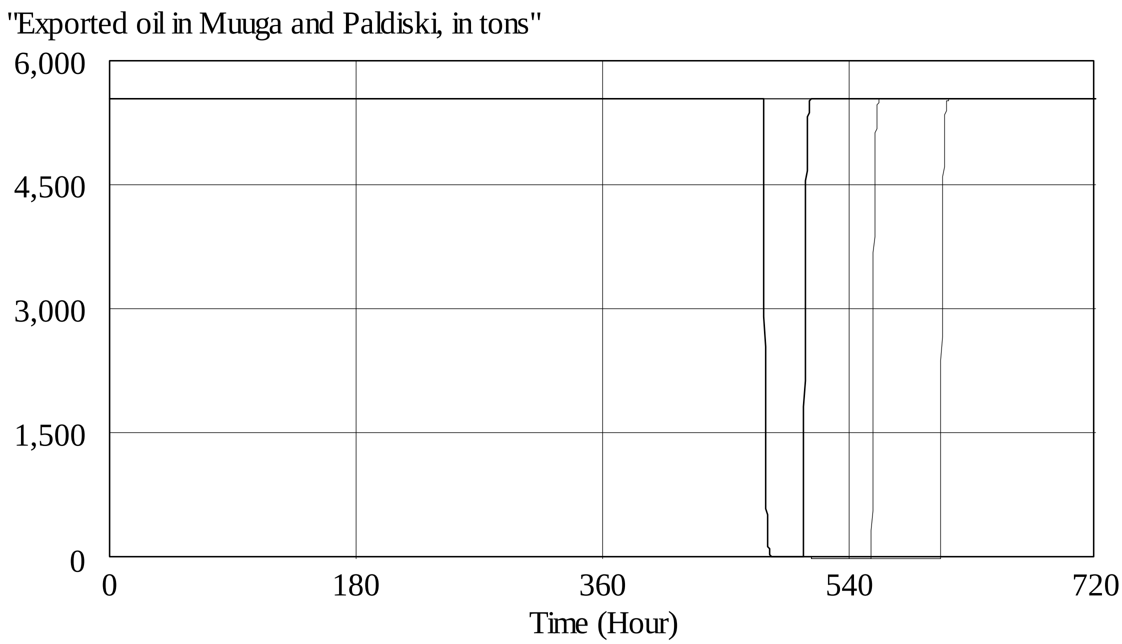

Figure 42. Exported oil in Muuga and Paldiski, tons.

If the port of Sillamäe would operate normally, Sillamäe should be able to handle all of the oil. The biggest difference is in total capacity of oil tanks; Sillamäe has only approximately 292,000 m^3 of warehousing silos for oil. Furthermore, Sillamäe railway yard can stock up on oil around 13,000 tonnes. The maximum oil pumping capacity of the port of Sillamäe is 6000 m^3 per hour (about 100,000 tonnes during an 18 hours working day). Therefore, the port of Sillamäe can substitute the port of Muuga if the stoppage will continue longer than 17 days momentarily, but longer stoppages will be hard to substitute with the limited oil tank storage and oil pumping with maximum capacity.

6.6 Summary and Discussion of the Simulation Results

In this research work system dynamic simulation analyses were conducted to experiment the impact of selected risk scenarios. The scenarios where constructed based on the case study interviews. Our results show that the functionality of sea ports should not be evaluated in isolation, but merely as parts of a wider intermodal supply chain. From our simulations it was possible to notice that hinterland capacity plays a vital role in crisis situations. As long as there is adequate storage for containers, the sea port can handle a large amount of vessels. When all of the storages are full, the handling capacity drops dramatically. Even when the crisis is over it takes a long time to return to normal situation.

The two latter scenarios analyzed what happens to sea ports when hinterland capacity is disabled for a fixed period of time. If hinterland is diminished due to a disaster, the sea ports have to pay a high price in lost revenues if there is inadequate capacity to store all of the arriving wagons. The whole network is interdependent and the whole system reacts to a malfunction.

The simulation model of the two oil spillage scenarios has some shortages. Firstly, the hinterland capacity could be simulated more accurately. Trucks and railways have different constraints and the capacity might not remain the same during the whole simulation period. Secondly, the simulation model does not differentiate between imports, exports, and transit. In crisis situations imports are the most important goods, followed by exports, transit being the least important category. If the storage area is full, more capacity can be allocated to exports, which will increase the speed at which the storage is emptied. Thirdly, the simulation model does not take into account the impact of having the right amount of empty and full containers. These are the next steps in order to improve the simulation model.

Also the latter simulation model has some limitations. Most of the values were very rough estimates and need to be checked to increase the model validity. Also, this simulation model only analyzed transit. Imports and exports should be taken into account as well. Some amount of the transit could be transported using trucks, a feature which should be incorporated to the simulation model. Different types of cargoes were aggregated in this model while they should be separated, in order to have better insight to the potential warehousing and transportation alternatives available.

System dynamics works relatively well when crisis situations are analyzed. As long as the goods can be aggregated to categories, it is easy to construct the simulation model. In the first model only one category of goods was analyzed (containers), but it would be possible to include additional categories. This could be done using arrays in a SD-model and could be achieved relatively easy. System Dynamics can be used to analyze hinterland malfunctions but a lot of feedback loops are required even to study the basic flows between the nodes. Also, the functions used to estimate the allocations to individual routes tend to be long as many parameters affect this decision. It might be possible to use discrete-event simulations or agent-based modeling to analyze this subject in a shorter period of time.

7. Discussion and Conclusions

The infrastructure of the intermodal transportation is an ever-evolving system of systems with complex dependences. Oceanic maritime transportation infrastructure promotes large-scale units in containers and port infrastructure. Currently, MSC Daniela has the largest container carrying capacity with 13 800 TEU. Justly limits of (narrow and low water) boat routes, the ports of Baltic region are served by smaller feeder containerships (200-1000 TEU) and ro-ro ropax ships from the big European oceanic ports. Besides we have a number of small ports in Baltic Sea region. Case studies evaluate infrastructure of the ports in the shores of Gulf of Finland (GOF). The dominant mode of transport in the GOF is sea with a share of 76 percent of trade, and other means of transport cover only 24 percent (Finnish Port Association, 2010). In addition to their own import and export, the ports of Finland and Estonia handle a major share of the Russian transit traffic. In transit Finnish ports have concentrated on industrial product and consumer commodities import to Russia in containers, whereas Estonian ports carry a great share of the oil export from Russia. For these facts Finnish and Estonian ports have a limited capability to compensate for each others in operations as need arises. The Finnish route constitutes about one third of transit value of Russian import in 2008.

According to the literature review conducted the functionality of a maritime transportation system is affected by the form cooperation and information exchange between the parties involved in the system. If the information exchange is disrupted for some reason, the overall efficiency of the system is reduced. Furthermore, different kinds of damages can prevent the system from operating. Special risks identified for international ports include foreign containers and recreational vessels. Interruptions have typically been caused by labor or weather conditions.

Based on the case analyses different ports and railway yards have differing risk profiles depending on the infrastructure and cargo handled. Sources of risk include energy supply, information systems, weather conditions and labor. In addition to these, the form of collaborating firms affects system performance. As multinational firms can change their transportation flows in case of disruptions, local operators might be forced to close down their businesses. Generally, the ports that have specialized to ro-ro and ropax are more flexible compared to the ports that handle containers or liquid bulk. In handling containers or liquid bulk special loading and unloading devices such as derricks, long leg spiders, pipe and pump systems, indicators of spillage and monitoring cameras are needed. Meanwhile ro-ro and ropax transportation need only quays and road connection from harbor.

Special kind of risk is connected to spillage of railway wagons, which might prevent some central parts of the transportation network from functioning, as a large amount of Russian oil and liquid bulk is transported via the ports of Finland and Estonia. Usually the tankers come very far from Siberia or other cold landscapes to the warmer places in the Baltic Sea Region where heat expansion can cause an overflow from the liquid tank. Several chemicals cause very different kind of risky situations: Some chemical are dangerous when breathed in and other flammable liquids can cause an explosion. Especially in railway yards and harbors that are situated near population centers the danger will be obvious.

In the hypothetical case the economic evaluation of a railway tunnel between the Tallinn and Helsinki was conducted. The calculation of the tunnel plan was made by using Eurotunnel as a reference plan. Based on the calculation, the tunnel connection between Helsinki and Tallinn seems to be unprofitable: the net present value using a 30 years calculating period was -2 953 million Euros with a cost-benefit ratio (BCR) of 0.468. With the forecasted incomes the tunnel connection would be profitable, if the investment cost does not exceed 7.0 billion Euros. On the other hand the amount of cargo should be threefold and the amount of passengers should double in order to turn the investment profitable. However, a calculation which includes the effect of decreasing the nationwide financial losses due to labor strikes supports building of the tunnel. The tunnel would probably end ro-ro, superfast passenger boats and air transportation, reducing thereby the probability of a collision with the east-west transportation traffic. Although the tunnel as an investment seems unprofitable, because of the high building cost, without the capital cost operating it would be economically feasible.

Based on our analysis Finnish privatization and deregulation of freight transportation has proceeded in line with EU legislation. This affects the government's ability to react in emergency situations as rail remains the only transport mode which it has direct control of.

The results of the simulation studies conducted stress the impact of hinterland capacity on the performance of the transportation system. In the short term the capacity of alternative transportation routes is determined by the handling capacity in the sea port. As all storage space is used sea port capacity is determined by the hinterland capacity. In container traffic concentration of handling capacity increases vulnerability of the transportation system. This also decreases the flexibility in rerouting containers. Container traffic needed to maintain security of supply can be handled given that a sufficient amount of platforms are available. Westbound transit through Finland and Estonia uses mainly rail. In transporting bulk, such as oil, disruptions can prepared for by inventories located in sea port. In other types of cargo disruptions have immediate effects. One of the strengths of the simulation studies is that they provide a system wide perspective on the supply chain instead of concentrating on the functionality of one part of it. Based on the simulation experiments, a long time is required to return to normal situation in the supply chain after the local crisis, e.g. in the sea port, is over. The whole network is interdependent and the whole system reacts to a malfunction. Based on our findings, the functionality of sea ports should not be analyzed in isolation, but merely as a part of a wider transportation chain.

The simulation methodology used in this report, System Dynamics, enabled the analysis of hinterland malfunctions. However, it has limitations as a lot of feedback loops are required even to study the basic flows between the nodes. Also, the functions used to estimate the allocations to individual routes tend to be long as many parameters affect this decision. To increase the efficiency in model building, it might be possible to use discrete-event simulations or agent-based modeling. By doing this we would probably be able to construct more flexible models, which could be used to analyze several cases instead of having a model for each case. This is an important aspect, especially when the models cover a larger part of the transportation network.

Equipped with a more flexible and efficient simulation tool a larger variety of scenarios could be analysed in practice. For example, feeder traffic in the Gulf of Finland is probably affected by new Russian ports, such a Ust Luga. Also, an extension to the geographical scope of the research to other countries located on the shores of the Baltic Sea could be performed, as several countries are networking when providing security of supply. Scenarios could also explore possibilities of co-operation between the EU countries and Russia in crisis situations.

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Appendix 1. Distributions used in tunnel evaluation

Normal distribution			
Variable	Mean	Standard deviation	
Investment (million Euros)	14760	3000	
EU -subsidy (percent)	30	10	
Triangular distribution			
Variable	Min	Mode	Max
Energy cost for passenger train (Euros/kilometer)	0.7	1	2
Energy cost for freigth train (Euros/kilometer)	2	2.4	4
Societal paybacks (million Euros/year)	20	35	70
Cargo traffic volume (tons/year)	5124501	7686752	10000000
Environmental benefits (million Euros/year)	15	20	30
Uniform distribution			
Variable	Min	Max	
Cargo freight price (Euros/ton)	15	25	

Appendix 2. NPV distribution of economic losses with alternative strike sensitivities

In this study three scenarios were constructed where the annual strike sensitivity of the labour union received a value of 5, 10 and 20 respectively. The distribution of NPV for the 5 and 20 percent scenarios are presented in figures below. As it is possible to notice from the figures, strike sensitivity has a big impact on the potential cost savings.

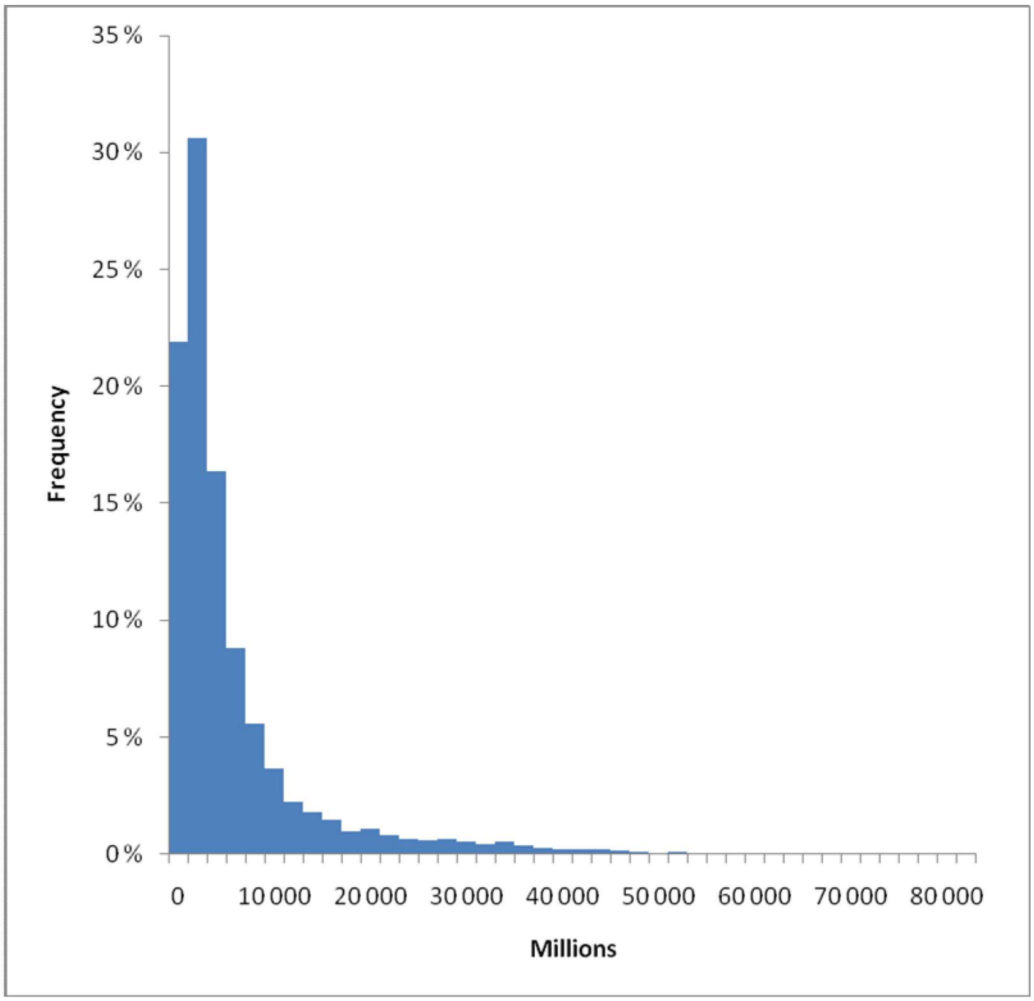

Figure A: Distribution of the NPV of the financial losses when the strike sensitivity is 5 percent, million Euros

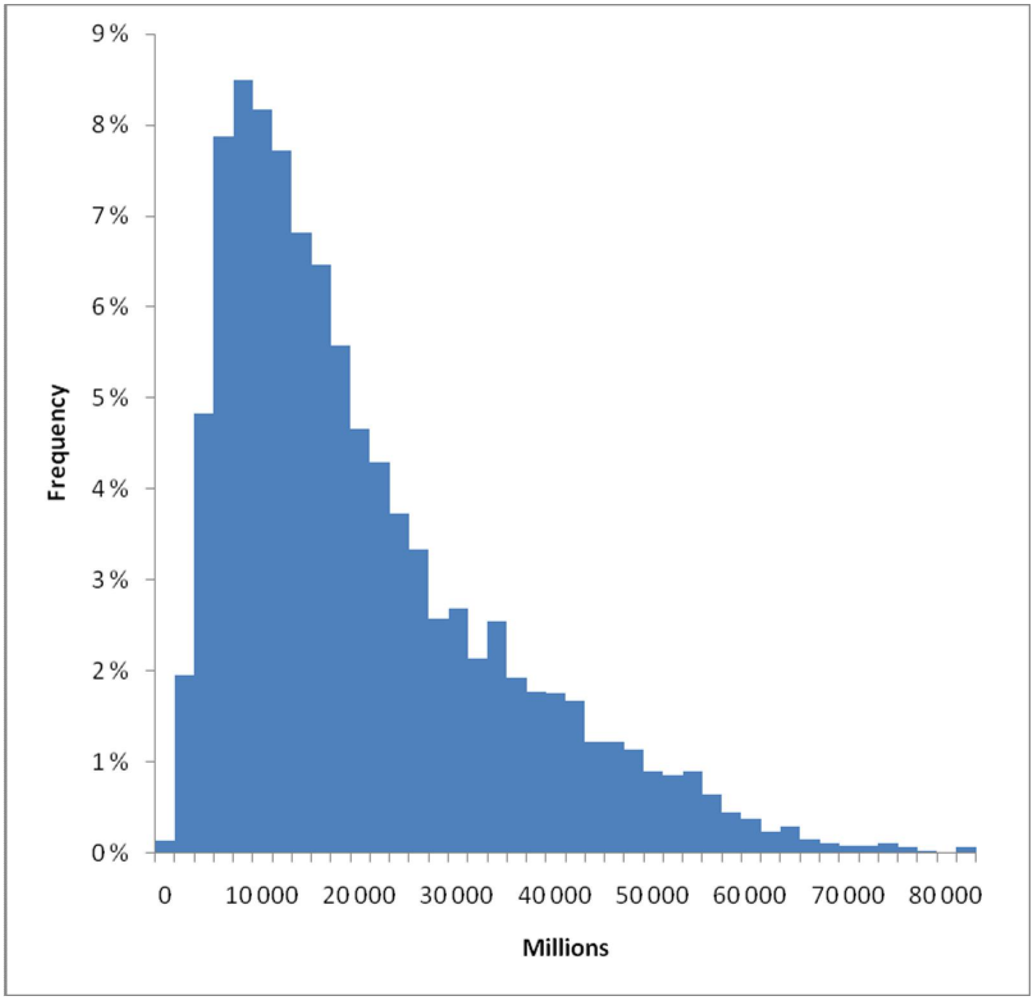

Figure B: Distribution of the NPV of the financial losses when the strike sensitivity is 20 percent, million Euros.

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