Road Freight Transport
- Transport Purchasing and Environmental Impacts

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Abstract

This paper on the environmental impacts of transport purchasing in road freight is to highlight how the adaptive capability of transport chains are affected through collaboration and the aim for sustainability through political regulations and societal demands.

This paper is divided into a theoretical framework and an empirical study, followed by the analysis, conclusions and discussions based on the framework and empirical study.

The theoretical framework will discuss the different aspects of road freight transport which impact the environment and show the interdependencies of each aspect.

The analysis will highlight the empirical chapter with a comparison of the theoretical framework in order to make substantial conclusions.

Conclusions among others are that standardization is needed although flexibility and agility is also needed. By standardizing processes, routine measures can be implemented and it creates a sense of certainty within the company. Agility and flexibility can be achieved by adding modular processes which can be implemented if the need for customization arises.

Governmental involvement is necessary for the development of infrastructure to minimize traffic congestion and improve the infrastructure for increased reliability, accessibility, and flexibility. By developing the rail infrastructure, a larger share of goods can be transferred via railway and thus reduce the environmental impacts of road freight through intermodal transportation.
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Best Regards,

Amrith Armstrong
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Contents

1. Introduction ................................................................................................................. 1
   1.1 Background .............................................................................................................. 1
   1.1.1 Business ............................................................................................................ 1
   1.1.2 Policies and Society .......................................................................................... 2
   1.1.3 Legal Aspects ...................................................................................................... 3
   1.2 Purpose .................................................................................................................... 4
   1.3 Limitations .............................................................................................................. 5

2. Method and material ................................................................................................. 6
   2.1 Research procedure and process ........................................................................... 6
   2.2 Methods of Data Collection .................................................................................. 8
     2.2.1 Primary and Secondary Data ........................................................................... 8
     2.2.2 Validity and Reliability ................................................................................. 8

3. Theoretical Framework ............................................................................................ 9
   3.1 Transport Purchasing ............................................................................................. 10
   3.2 Transport Chains ................................................................................................... 12
     3.2.1 Integration ....................................................................................................... 12
     3.2.2 Cooperation and Coordination ...................................................................... 12
   3.3 Sustainable Transport Chains .............................................................................. 16
     3.3.1 Policies and Society ....................................................................................... 16
   3.4 Adaptive Transport Chains ................................................................................... 18
   3.5 Operational Factors .............................................................................................. 21
     3.5.1 Loading Factor ............................................................................................... 21
     3.5.2 Empty Running .............................................................................................. 21
   3.6 External Factors .................................................................................................... 22
     3.6.1 Empty Running .............................................................................................. 22
     3.6.2 Fuel Efficiency ............................................................................................... 22
   3.7 Road Tonnekilometers and Total Vehicle Kilometers ............................................. 22
   3.8 Fuel Consumption ................................................................................................. 22

4. Empirical Study ....................................................................................................... 24
   4.1 Logistics Service Providers .................................................................................. 24
     4.1.1 Company 1 ...................................................................................................... 24
     4.1.2 Company 2 ...................................................................................................... 25
   4.2 Environmental impacts and influences ................................................................. 26

5. Analysis ..................................................................................................................... 28
   5.1 Overview ............................................................................................................... 28
   5.2 Company 1 .......................................................................................................... 28
   5.3 Company 2 .......................................................................................................... 28
   5.4 Environmental Research ..................................................................................... 29
   5.5 Linking the Empirical Study and the Theoretical Framework ............................... 29

6. Discussion .................................................................................................................. 31
   6.1 Research questions/purpose .................................................................................. 31
   6.2 Empirical Study and Analysis .............................................................................. 31
   6.3 Theoretical Framework ......................................................................................... 32

7. Conclusion ............................................................................................................... 35

8. Future Research ....................................................................................................... 36

References ...................................................................................................................... 37
1. Introduction

1.1 Background

1.1.1 Business

From a business perspective, freight transportation is a necessity in the globalized world we live in. Companies are becoming more dependent on goods from various different locations worldwide and the demand for coordinated transportation is increasing. With fuel prices increasing and the debate on CO\textsubscript{2} emissions affecting the environment it becomes more important to be cost-efficient in transportation (both from an economic and an environmental point of view as discussed by Nielsen et.al, 2003).

The Road Freight Transport industry is a highly competitive market with low profit margins which is why the industry needs development and operational efficiency in order to gain a competitive advantage. More and more companies are outsourcing road freight transport activities to other stakeholders in the logistics and transport chain. Morgan (2006) discusses the predicted increase of outsourcing activities as a result of profit being a great business motivator.

As a result, Europe and other regions experience an increase of transport and usage of fuel which counteracts the attempts made by vehicle manufacturers and government agencies, to minimize fuel consumption and environmental impacts of road freight, which is mentioned by Matos & Silva (2011).

Transport purchasing plays an important role in the entire supply chain structure of Small and Medium sized Enterprises (SMEs) as efficiency of transport chains makes the difference between success or failure to meet customer demands. It is therefore imperative that Logistics Service Providers (LSPs) improve the transport chain.

Morgan (2006) mentioned in his analysis, that more and more companies outsource transportation in order to reduce costs and let the ‘experts’ do the transportation while they focus on their core competencies.

As Road Freight Transport companies are in a competitive market with low profit margins it is important for companies to improve adaptability and efficiency in order to achieve a competitive advantage. European Union regulations stipulate free movement of people, goods/services and monetary transactions throughout the union. The regulation opens up the possibility for European transport companies to provide freight distribution services in any of the member countries.

Furthermore, transportation is according to Nielsen et.al. (2003), difficult to determine actual relationships between logistical structures of the business world and transportation as transportation is perceived as an integrated part of logistics. It is also mentioned that freight transport growth has changed in several ways. Some examples are the increase in transportation by road freight and a simultaneous reduction of freight by train as well as increase in transportation distance referred to as logistical reach by Nielsen et.al. (2003), resulting from an increased demand for flexibility in production as well as distribution.
The perception that transportation is integrated in the logistical system also makes it difficult to isolate transportation as an independent activity (Nielsen et al., 2003). Therefore companies/stakeholders in the supply chain purchasing transport, need to consider the consequences of their logistical strategies as they inadvertently affect transportation and environment negatively. In addition, Logistics Service Providers (LSPs) are affected by environmental policy initiatives in Europe which is discussed by Nijkamp et al., (1997).

1.1.2 Policies and Society

Political initiatives and societal demands arise in the pursuit/need for sustainability in a growing market. As businesses develop and the demand for transportation increases, the need for political regulations will increase for economic and environmental sustainability. Nijkamp et al., (1997) mentions the environmental policy initiatives which are taken by some European countries as Austria with its policy decision on night and weekend freight transport, and the Swiss referendum on banning through traffic by imposing a 28 ton truck size limit. Furthermore, Nijkamp et al., (1997) also mentions that in order to reverse current trends, a global policy including the entire transport network, will be needed since development of the multimodal transport system depends mainly on its competitiveness (for road freight) regarding delivery times, safety issues, reliability and flexibility.

A common issue is that many companies seem to outsource the transportation of goods to Logistics Service Providers (LSPs), avoiding the administration and planning of each transport. This increases the requirements for LSPs to implement efficiency in the transport chain and improve sustainability through political and societal regulations and demands.

A transport chain is according to Woxenius (2012, p.64), focused upon consignments and extends over the movement, handling and activities directly related to transportation. Thus, an adaptive transport chain implies the ability to anticipate and adapt to the changing policies and demands of governments and society. Most transport chains need an improvement in integration, cooperation and coordination toward an adaptive transport chain, which is regulated by policies and demands from the society. Operational and External factors are also affected by, and influence the adaptive transport chain which adheres to transport chains with the aim to improve sustainability.

The common trend however, seems to be pointing towards a reduction of inventory storage which in turn will lead to a need of collaboration between manufacturing companies and transport companies in order to improve loading factors of vehicles.

These are some of the reasons why this paper is focusing on the research of how political regulations and societal demands influence adaptive supply chains along with the combination of the transport chains need for integration, coordination and cooperation in order to achieve sustainability.

This in turn leads to complexities that arise with local restrictions that are hard to implement and variations of labor conditions are likely to occur. In addition, Logistics Service Providers are looking for means to reduce costs of transport in order to attract new customers as well as increase their own marginal profits. The search for cost-effectiveness in the industry is
leading to further cost-cutting and results in a search for outsourcing labor costs to low wage countries.

Nielsen et.al.(2003) describes the gap between political & societal demands as a measure for welfare maximization versus the corporate extreme being toward profit maximization. Companies aiming toward Supply Chain Optimization under a win-win situation would benefit from a tactical and strategic point of view. If political regulations and societal demands would consider geographical or industrial goals, it would lead to optimization from an operational point of view.

Furthermore, Uherek, et.al.,(2010) mentions that emissions from land transport and road freight in particular, has a significant impact on the atmosphere and climate change. It is also mentioned that technical measures could offer a reduction potential, but as markets do not tend to initiate necessary changes, strong interventions will be needed.

1.1.3 Legal Aspects

Ricci & Black (2005) discusses trending/ current political orientations of forceful promotions toward intermodal transports, but also mentions that detailed assessments of the overall competitiveness of intermodal transport is required. It is mentioned that hardly 10 per cent of the total volume of freight movements in Europe is performed with intermodal options while road freight still transports the largest volume of freight.

Wieberneit (2007) mentions different aspects of influences changing the business operations and planning, such as globalization, the opening of borders in Europe (as a result of the EFTA agreement in the EU and the stipulation of free movement of people, goods, services and capital), increased costs for fuel and tolls as well as customer requirements for improved service in supply chain networks.

Marcoucci & Danielis (2007) mentions that freight transportation stands for an estimated 20% to 30% of vehicle kilometers and 16% to 50% air pollution emissions and in addition that van and truck traffic increases congestion noise and air pollution. It is mentioned in the article that city administrators in Europe have designed and implemented a wide range of policies to deal with the issues of urban goods transport. Some of these polices are regulatory in the sense that they comprise access restrictions, time restrictions, etc. Another set of policies affect costs of goods distribution within urban areas by requiring an acquisition of time-based access permits or the use of environmentally friendly vehicles.

The forming of the European Union (EU) and the European Free Trade Association (EFTA) and the setting-up of the European Single Market (in accordance with the EU stipulation of free movement of people, goods, services and capital), have induced changes in economic and social relations giving rise to considerable growth in distribution and mobility of goods (Nijkamp, et.al., 1997).

Nijkamp et.al.,(1997) also mentions that it is becoming increasingly recognized that an increase in trade and transport have highly negative impacts on the environment in Europe. Examples of environmental policy initiatives in Europe are the outcome of the Swiss referendum on banning through traffic by imposing a truck size limit of 28t (Nijkamp, et.al., 1997), or the Austrian decisions night and weekend freight transport as well as road taxes/ toll roads (Nijkamp, et.al., 1997; Einbock, M., 2006).
Governments in the European Union (EU) are hindered in certain ways from regulating trade and industry from foreign nations in the EU since the stipulation is for free movement of people, goods, services and capital.

Political involvement seems to be inevitable in a growing industry and it does not get any easier with the opening of borders in the case of the European Union, or with globalization as the demand for transportation increases at a faster pace. Political involvement will be required to help solve the issues of freight distribution and the competitive advantages of modal choices (other than road freight) as infrastructure development is needed for increased accessibility, flexibility and reliability (based on the articles from Marcucci & Danielis, 2007; Wieberneit, 2007; Ricci & Black, 2005).

1.2 Purpose

The intention of this paper is to conduct a research on the following questions, in order to follow up on the background issues:

1. What are the environmental impacts from road transport and what are their implications for transport purchasing?

2. How does governmental involvement adjust the road transport market by regulations for environmental issues?

The aim of this paper is to study how governmental and regional policies as well as societal demands have an impact on the operational and external factors of the transport chain. More specifically, loading factors, empty running and fuel efficiency will be analyzed in relation to the outputs of the transport chain, being: Road Tonnekilometers, Total vehicle kilometers and Fuel Consumption.

Following regulatory guidelines will be studied in order to review possible effects they may have on the transport chains which in turn affecting operational and external factors;

1. EU Road Transport Policy

2. DIRECTIVE 2009/30/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL

3. WHITE PAPER Roadmap to a Single European Transport Area – Towards a competitive and resource efficient transport system

These reports and guidelines will be reviewed in order to establish which regulations affect the transport chains as well as operational and external factors. These guidelines set the norm for sustainability and transport companies are forced to comply with these regulations and guidelines. Some of these regulations force companies to develop resilience methods which counteract the goals set by managers’ in transport chains. In aiming for resilience, a common tendency is to outsource transports in order to increase cost-efficiency.
1.3 Limitations

This thesis will not be covering the aspects of political and societal influences affecting the system development and operations as a result of conflicting regulations. Furthermore, the relation between supply chain optimization and welfare optimization will not be covered in this thesis.
2. Method and material

2.1 Research procedure and process

The method used in this thesis is to conduct a literature review within transport purchasing and environmental impacts, as well as literature of Transport Economy. Furthermore, resilience and sustainability within the transport chain will be discussed in relation to the regulations and demands which are set by policies and societies.

A study of the logistics performance has been conducted at two Logistics Service Providers to establish the following data for the operational factors;

1. Tonne-kilometers
2. Total vehicle kilometers
3. Fuel Consumption

with the following variables;

- Loading Factor
- Empty Running
- Fuel Efficiency

For external factors, the buffering capacity of the company is studied with the assistance of marginal capacity and tolerance levels in the supply chain.

Supply Chain flexibility vs. stiffness is studied to determine the restructuring ability within Supply Chains due to the regulations and demands set by policies and society.

From a business perspective, political regulations will affect freight transportation planning and operations from an economic and environmental point of view as mentioned in chapter 1.1.1 by Nielsen et.al.,(2003). Political involvement is usually needed to regulate sustainable solutions in a growing industry and this thesis has researched and analyzed how these political regulations and societal demands affect the flexibility vs. stiffness of a supply chain.

Due to certain regulations, companies need to develop upward resilience as mentioned by Hollnagel et al. (2006, p.23). Corporate attempts of workarounds and innovative tactics are often used as a way to influence more strategic goals and interactions in order to achieve cost-efficiency. In turn, these attempts may interfere with the management’s attempts to command compliance (Hollnagel et al., 2006, p.23).

Nielsen et.al.,(2003) also discusses that it may be difficult to determine the actual relationships between logistical structures in manufacturing companies and transportation as the perception is that transportation is an integrated part of logistics which is discussed in the previous chapter. The aim has been to study how an increased customer demands for flexibility in production and transportation has increased the share of goods transported by road freight while reducing the share of goods transported by other modal choices.

The marginal analysis will aim to highlight how close a system is to the economic limit and how this can be compared with tolerance levels, which affects the company’s ability to absorb or adapt to changing circumstances without a fundamental breakdown in the supply chain.
An analysis of tolerance will be performed to test system behaviors near boundary levels: whether a system declines gradually or collapses when pressure is added on the system. This will be done by calculating cost-changes due to changes in demand and regulations, which affect operational and external factors.

Loading Factor, Empty Running and Fuel Efficiency are affected by how operational factors function as well as the effects of external factors.

With the aid of the theoretical framework, this paper will examine how companies can increase the road tonne-kilometers and reduce the total distance of vehicles. An increase of the loading factor and a reduction of empty running should increase the marginal profits by reducing the costs of transportation and at the same time, reduce the environmental impacts.

The literature review of transport purchasing and environmental impacts (operational and external factors) will be compared to the theories of Transport Economy. The theories will be analyzed with the data gathered from the company visits.

Transport Economy material:

This paper will aim to review the current economic resource utilization within a company and suggest improvements. In order to do so, following information is used; Vehicle Capacity (m$^3$ + tonnes) and Vehicle cost per day. With this data, comparisons can be made between combinations of light products vs. heavy products, volume densities, and combinations of weight and volume, in order to calculate scenarios for maximization of resource utilization.

The Hinterland regional and Hourglass hub system will be reviewed and compared in order to estimate which configuration is the most suitable solution from current conditions. A literature review of Hinterland and Hourglass hubs has been performed.

Key Performance Indicators (KPIs) which seem relevant to this research are Loading Factors (Lf), Empty Running (E), Fuel Efficiency (FE) and Fuel Consumption (FC), in order to find possible solutions for improvement and how all these KPI's are affected by government involvement for environmental sustainability and how CO$_2$ emissions can be reduced.

Resilience material:

Hollnagel et al. (2006, p.250) discusses the three key components of operational risk being; people, systems and processes. The correlation of these components in transport chains will be assessed. An analysis of how sustainability in transport chains are affected by the operational risks is also performed.

Furthermore, an analysis of how the 3 components of operational risk, are related and how they in turn affect the aim for sustainability in the transport chain.

Hollnagel et al. (2006, p.357) states: “It is fundamental for resilience engineering to monitor and learn from the gap between work as imagined and work as practiced”, referring to the gap between the regulations and demands which is imagined as optimum and the optimum of operational factors which implies the work as practiced.

The thesis will study the relation between the aim for sustainability in transport chains from governments and society and the aim for optimization of operational and external factors to
minimize the effects of transport (how organizations can increase the tonnekilometers, reduce total kilometers and minimize fuel consumption).

2.2 Methods of Data Collection

2.2.1 Primary and Secondary Data

Primary data used in this paper are the variables for Fuel Efficiency based on calculations provided by cooperating Logistics Service Providers (LSPs). Data provided by one LSP involves total fuel consumption for specific routes as well as total distance. The other LSP provided information regarding fuel efficiency for vehicles under their ownership. They also provided information about total transport distances for outbound and inbound transportation (delivery and backhauling).

Primary data for external factors affecting the adaptive transport chains will be information gathered through an empirical study performed by Lammgård, Andersson & Styhre (2013). This study was also presented at the annual Logistik och Transportmässan 2013 in Göteborg, Sweden. In addition, scientific articles have been reviewed for input on environmental impacts of road freight.

KPI's has been used in the empirical study (Fuel efficiency and Fuel Consumption) in order to estimate the average CO2 emissions on certain transportation routes by road freight.

2.2.2 Validity and Reliability

For verifying the validity and reliability of data received, a study of carbon emissions from vehicles and combustion engines has been performed based on figures gathered from ECOSCORE (2013) and certain assumptions. Furthermore, a review of multiple articles has been performed to corroborate the validity and reliability of data gathered.
3. Theoretical Framework

Transport Economy:

Transport economic articles and concepts will be studied in order to gain insight and knowledge on handling of loading capacities and empty running.

This thesis will study the concepts and theories on allocation of goods. Since the aim is to find opportunities to reduce total fuel consumption, this paper will aim to compare data from a company in order to establish; how transport rates and related charges can be reduced, how to reduce transit times, increase transport visibility, increase on-time deliveries and optimize the cost of transport management as mentioned by Holter et al. (2008, p.23).

Furthermore, the concept of the ‘Ambulance Problem’ and the concepts of direct links, corridors, and hub systems will be compared to establish how an optimum configuration of these systems can help improve the operational and external factors, improve the adaptive transport chains and minimize fuel consumption.

The impact of oil prices on cost-to-serve will demand more from companies to develop operational excellence and efficiency to counteract the effects of increasing oil prices and fluctuations. Development of subcultures for continuous improvement is also needed in enterprise supply chains in order to gain competitive advantage and operational excellence/efficiency. Transport chains needs to be able to cope with the spread of national, regional and global supply chain networks as outsourcing is increasing and a shift towards third-party logistics (3PL) is becoming more popular (Gattorna, 2010, pp.391-393, 405).

Dicken (2011, pp.454-475) discusses the destruction of value as a result of negative environmental impacts. Vehicles in the transport chains consume a huge amount of fuel which contains pollutants affecting the environment. An increase of transport would lead to increased consumption further affecting the environment. Dicken (2011, pp.458-466) mentions the aspects of CO2 emissions and climate change. He states that “It is now abundantly clear that this balance is dangerously disturbed by human action”, and quotes:

“The causes of contemporary and future changes in climate, their rate and their potential significance for the human species ... are all notably different from anything that has occurred previously in history or prehistory. The causes are now dominated by human perturbation of the atmosphere, the rate of warming already exceeds anything experienced in the past 10 000 years and is set to be more rapid, probably, than anything experienced in human history, and the significance for humanity is qualitatively different from the previously given ecological imprint made by our current and growing population of 6 billion and more”.

The statement and quote above implies that all human action in the transport chain has an effect on the environment. The increase in transport increases the fuel consumption and leads to air pollutions and emissions of hazardous substances to nature and human health.

Therefore, actions which have been taken in the attempt to minimize the environmental impacts are making vehicles more fuel efficient and developing alternative fuel systems. Although these attempts have been made, the amount of transport vehicles in the system is increasing and thereby counteracting the attempts of minimizing fuel consumption.
The research in this thesis will search for opportunities to improve operational and external factors to improve the loading factor while increasing the average loading capacity of each vehicle, reduce the empty running and improve fuel efficiency.

Vehicles with more loading capacity will automatically help minimize the total amount of transports in the system and therefore help reduce fuel consumption. An analysis of vehicle fleets with regard to loading factor, empty running and fuel efficiency, should consider the variation of average vehicle loading capacity when comparing efficiencies with other Logistics Service Providers (LSPs).

Supply Chain Management;

This will be used in the analysis of the framework addressing Just-In-Time (JIT) and Collaborative Planning, Forecasting and Replenishment (CPFR). These concepts will be used to analyze and suggest improvements on operational and external factors in order to minimize the environmental impacts. This paper aims to review how supply chain integration benefits from internal and external coordination.

As Supply Chain Management affects the transport chain, it can improve the adaptability by integrating, coordinating and cooperating in all aspects of the operational factors involved in transportation. Sustainability can be implemented by optimizing the economic, social and environmental benefits. It is often political regulations and societal demands in which transport chains adhere to.

### 3.1 Transport Purchasing

Transport purchasing is a growing occurrence since many companies tend to outsource transportation activities to Logistics Service Providers (LSPs). Outsourcing is a result of corporate decision-making to focus on what is considered core competencies and a desire to increase profits. Transport purchasing is also increasing because of growing trends in Lean Management and Just-In-Time with reduction of safety stock levels and a shift from Make-To-Stock to Make-To-Order.

Van Weele (2005) describes three different changes in the business context which influences the corporate decisions for purchasing and outsourcing. The three main changes are; Globalization of trade, Information Society, and Changing consumer patterns.

Van Weele (2005, p.7) states that “Today’s consumers, by contrast, use an expanded concept of value that includes convenience of purchase, after-sales service, dependability, uniqueness and so on”.

He also states: “Increasingly, customers are demanding quality products which are tailored to individual needs and tastes. During the 1990s, the well-informed and highly-educated consumers became more aware of their purchasing power, and showed more critical buying behavior. … In essence, people will no longer settle for whatever companies are offering. Instead they will seek out and command their first choices in products and services. Consumers take charge: they now tell manufacturers what they want, when they want it, how they want it and what they are willing to pay. They demand products and services designed for their uniqueness and particular needs.” (Van Weele, 2005, p.7)
Since customer behavior is becoming more volatile and unpredictable, more and more companies try to minimize fixed assets and outsource activities which require fixed assets. This is seen quite clearly in the transportation industry where companies are increasingly outsourcing transportation activities to Logistics Service providers in order to focus on core competencies and reduce the fixed assets.

The increased level of outsourcing is directly connected to the increased level of transport purchasing, and therefore, it is highly important to consider implementing a purchasing strategy to gain competitive advantage in a competitive market. Not only due to internal efficiencies, but also because the entire supply chain is becoming more dependent on efficient and dependable transportation due to reduced inventory and safety stock as a result of Lean Management and Just-In-Time solutions.

Holter et al. (2008) mentions five vital parameters which need to be considered among shippers/ freight forwarders. These parameters are; Freight cost & related charges, Transit time, Transport visibility, On-time delivery, and Cost of transport management.

Most companies tend to focus on the freight cost and related charges as these are the easiest to influence and make profits on. This however, poses a problem for transport operators as the goal of covering costs and keeping a reasonable profit margin comes in conflict with the goals of transport purchasers to gain more value from lower pricing of transports. As more transport operators are available in the market than the demand for transport capacity, prices are pushed downwards and operators are finding it hard to cover the operational costs.

Transit times are also considered since long lead times require longer foresight and planning which creates uncertainty in demand. At the same time, companies try to reduce their cost of inventory. For these reasons among others, companies try to find the supplier/ transport operator who can deliver the products in the shortest time provided where freight costs and related charges are reasonable.

Transport visibility is the ability to track and trace deliveries with up-to-date information in order for transport purchasers to plan production/ operations efficiently and economically. Transport visibility is also important for transport operators and Logistics Service Providers (LSPs) as it helps give information if the deliveries will be on time or delayed due to various circumstances.

On-time delivery becomes more important to transport operators since this is considered a Key Performance Indicator (KPI). Many customers (distribution centers, retailers etc.) have delivery time windows which mean that deliveries can only be made between certain given times. This puts added pressure on transport and delivery planning of vehicles and goods. Increased traffic congestion due to an increase of traffic in general as well as infrastructure development lagging behind can cause unwanted delays and therefore, contingency plans need to be considered when planning transport operations.

Cost of transport management is a parameter which many companies do try to reduce in order to raise profit margins. Many companies outsource transportation activities to Logistics Service Providers (LSPs) and Transport Operators in order to focus on internal core competencies. LSPs in turn, try to focus on market orientation instead of asset orientation since assets (vehicles, warehouses) incurs fixed costs, which is not desired in an unstable market. LSPs tend to create networks of transport operators to cover a larger geographic area of the market and thereby minimizing the need for acquiring assets. LSPs tend to partner up
with operators under contracts extending up to a year or more, and in some cases, these contracts involve bearing the LSP company logo on the vehicles and running under the LSP flag.

### 3.2 Transport Chains

#### 3.2.1 Integration

Integration is vital for the successful operation of transport chains since outsourcing is a common occurrence in this contemporary society. Integration is needed to bridge the gaps between internal company goals and external supply chain objectives.

As Mason & Lalwani (2006) mentions that by taking a systems perspective in Supply Chain Integration, the goal of “... integrating processes along the components of the supply chain to reduce costs and improve services” is well established as a main objective within logistics and supply chain management. However, Mason & Lalwani (2006) also mentions that all supply chain processes and decision-making in the freight transportation invariably remains as a different function, often secluded within functional silos, operating between supply chain partners rather than the entire supply chain.

In the chapter of transport purchasing, it is mentioned that customer behavior is changing and becoming increasingly demanding and knowledgeable. Therefore, integration is vital for creating improved information and product/service flow along the entire supply chain to create higher value for the consumers. Another reason for the importance of integration is that the customers now specify their demands and needs and are in many cases reluctant to wait longer for the delivery of the product and or service.

Information and Communication Technology is a tool for creating a collaborative logistics system which is mentioned by Mason & Lalwani (2006) as a measure to enable developments for information flow in supply chains as well as transport chains.

#### 3.2.2 Cooperation and Coordination

As transportation activities are increasingly outsourced, companies are becoming less influential and it is also likely that they are less up to date with the latest information regarding transportation. This is one of the reasons why collaboration and integration is needed, and ICTs (Information and Communication Technologies) are tools for implementing integration and collaboration within transport chains.

Stefansson (2006) describes the transportation and logistics system used by Woxenius & Sjöstedt (2003) and mentions that distribution consists of many different activities. Stefansson (2006) adds the topic distribution structures in the supply chain or transport chain as a complement to the model and states:

“A production, distribution and transportation network consists of nodes and a connection between these nodes, i.e. links. Figure 2 shows a network structure with several entities, where products can visit on the way from the shipper (supplier) to the receiver (buyer)”.
As mentioned in chapter 3.1, many LSPs tend to outsource physical transportation activities to transport operators owning their own vehicles in order to achieve flexibility in the transport chain. Integration, cooperation and coordination along the transport chain is needed for an efficient and agile transport chain.

In a globalized market, networking is needed and companies tend to use economy of networking as a way to minimize cost of ownership in vehicles, as well as gain access to a larger geographic market.

The requirements of on-time deliveries are becoming more common among transport purchasers and collaboration in the transport chain is a tool for making progress and improving the reliability of information flow within the transport chain.

The issue which arises in transport chains would be the gap between logistics operations and transport operations. Logistics Service Providers who do not own any vehicles are considered
forwarders of products between locations which are sourced and distributed between different locations. Some LSPs have a combination of own vehicles for transportation and purchased transports from external transport operators (within corporate networks). Transport operators are responsible for the movement of goods (referred to as products in logistics operations) as well as the physical transportation trafficking between ways and terminals.

The gap between logistics and transport operations is the lack of collaboration between transport purchasers and transport operators (customer and supplier). The purchasing strategy which is often used for flexibility and adaptability excludes different stakeholders in the supply chain. Mason, Lalwani & Boughton (2007, p.189), compares three theoretical constructs surrounding the debate of networking.

Most companies tend to treat the Supply Chain as a ‘market’ where each supplier is compared to other suppliers like end customers treat core companies. This approach is based on the buying strategy which is a vertical dis-integrated Supply Chain. The opposite approach would be treating the Supply Chain as a ‘hierarchy’ where the core company includes supplier and/or customer activities as one. A network implies vertical synchronization among all stakeholders in the Supply Chain and an Integrated SCM strategy. The three theoretical constructs are depicted by Mason, Lalwani & Boughton (2007, p.189) as below;

\[\text{Figure 1} \quad \text{Theoretical constructs surrounding the networking debate}\]

\[\begin{array}{ccc}
\text{Supplier} & \text{Supplier} & \text{Core Company} \\
\text{Core Company} & \text{Core Company} & \text{Core Company} \\
\text{Customer} & \text{Customer} & \text{Core Company} \\
\hline
\text{Market} & \text{Network} & \text{Hierarchy} \\
\text{Vertical Dis-integration} & \text{Vertical Synchronisation} & \text{Vertical Integration} \\
\text{A Buy Strategy} & \text{An Integrated SCM Strategy} & \text{A Make Strategy} \\
\end{array}\]

\[\text{Figure 4. The three theoretical constructs combining vertical and horizontal collaboration (Mason, Lalwani & Boughton, 2007, p.189).}\]

Therefore, collaboration is vital for the successful closing of the gap between logistics operations and transport operations where all stakeholders in the Supply Chain are integrated with each other and information is kept up-to-date and synchronized.

Stefansson (2006) also depicts the production, distribution and transportation (PDT) model more detailed in the figure below;
A common and growing issue within transport chains is the issue of the “Last Mile” problem which can to some extent be explained by growing trends of Lean Management and Just-In-Time (JIT) solutions.

With more frequent transport of goods as a result of Lean Management and JIT as well as the increased level of outsourcing to Logistics Service Providers (LSPs), effective collaboration and integration becomes more crucial to the success of transport chains.

According to Dicken (2010), by lacking the knowledge of the meaning of globalization, confusion and uncertainty is created in the globalization of logistics and transportation. Another reason is also the reluctance to distinguish the important issues from the trivial whether it would be causes or consequences.

Collaboration in the transport chains are needed to bridge the gaps and to minimize any misconceptions which would adversely create uncertainty and confusion.
3.3 Sustainable Transport Chains

3.3.1 Policies and Society

Transport Chains are affected, not only by the level of integration, cooperation and coordination as mentioned earlier, but also by political regulations both domestically and internationally.

In the aim for sustainability in transport and supply chains, governmental involvement and regulatory policies become necessary although it may inadvertently create problems within the transport and/or supply chain operations. The other viewpoint of political regulations is that they may help in minimizing the external effects of transport operations such as traffic congestion, added fuel consumption, CO₂ emissions etc.

The European Commission (2011) has described some aspects about transportation in Europe:

“Transport is fundamental to our economy and society. Mobility is vital for the internal market and for the quality of life of citizens as they enjoy their freedom to travel. Transport enables economic growth and job creation: it must be sustainable in the light of new the challenges we face. Transport is global, so effective action requires strong international cooperation.”

“The future prosperity of our continent will depend on the ability of all of its regions to remain fully and competitively integrated in the world economy. Efficient transport is vital in making this happen.”

“Infrastructure shapes mobility. No major change in transport will be possible without the support of an adequate network and more intelligence in using it. Overall, transport infrastructure investments have a positive impact on economic growth, create wealth and jobs, and enhance trade, geographical accessibility and the mobility of people. It has to be planned in a way that maximises positive impact on economic growth and minimises negative impact on the environment.”

With these statements made by the European Commission (EC), it is clear that transportation will remain as a fundamental activity promoting economic growth and social wellbeing. It is also stated that integration is needed not only vertically but also horizontally (internal and external integration).

Furthermore, infrastructure development is crucial to the development of mobility. According to the EC (2011), development of infrastructure has positive impacts on economic growth and needs to be planned in a way that minimizes the environmental impacts of transportation.

Therefore, end consumers and society can influence transport chains and transport purchasers by increased knowledge of environmental issues and setting demands on efficient transport chains. Together with political regulations, nations as a whole can help create more efficient and eco-friendly transport chain solutions.

Citizens of a nation are considered the society of the nation and it is the citizens that elect governments. Therefore, it is natural that political regulations should be aimed at improving
the quality of life and sustainability for the nation. The political regulations are often needed to set norms of how things should be done in accordance with the constitution of the nation.

According to the European Commission (2006), 44.4% of the modal split in EU was performed by road based on the amount of tonne-kilometers performed in 2005. Road Freight had the largest share of transportation (and probably still is the leading modal choice of transportation) in Europe.

As the transport market is being opened for all EU members, the EC (2006) has stated that responsible operators are sought. The report also outlines three specific criteria to be fulfilled in order to be considered as a *bona fide* operator;

```
* Good Repute – professional operators are expected to comply with rules and regulations, those who do not must be weeded out.

* Sound financial standing – hauliers and passenger transport operators must be able to guarantee the viability of their businesses.

* Professional competence – to ensure that customers receive safe, reliable transport services, operators have to show a level of competence in the way they run their business and check their vehicles. In practice, this has led to the harmonizing of professional competence certification throughout the EU. Now operators must hold a Community certificate of professional competence.” (EC, 2006, pp.4-5).
```

In addition, the EC (2006) also added three key points in relation to driver working conditions in order to improve the driving conditions. These key points include a compulsory minimum daily rest of nine hours for drivers and breaks during driving hours; a resting period of minimum 45 consecutive hours every two weeks; and measures to prevent professional drivers from driving more than 56 hours per week. These key points aim at improving the safety on European roads as well as in terms of liability, which means that the drivers’ employers are now responsible for following the rules and regulations.
3.4 Adaptive Transport Chains

The accelerated geographical mobility created by technological innovations in transportation, as mentioned by Dicken (2010, pp.82-83), is a result of rapid technological improvements enabling opportunities for marginal profits. Although these advancements would be beneficial for many companies, it would also be costly and cause problems in implementation. Another aspect which needs consideration is how new technology and the implementation of it would affect the corporate business strategies and routines.

The changes in technology often lead to operational and communicational benefits which create a profit making environment. But political regulations and societal demands will eventually change the market rules in pursuit of sustainability.

The globalization of logistics and transportation increases the total amount of stakeholders exponentially. This leads to the trend of outsourcing since many organizations cannot maintain the same level of effectiveness throughout the supply network in the globalized world today.

The common trends of Logistics Service Providers (LSPs) or in some cases Logistics Service Intermediaries (LSIs) is to transnationalize in order to expand their operating network and reduce the asset orientation. While they reduce the level of asset orientation, they also try to maintain or improve the market orientation.

Logistics Service Intermediaries do not own any fixed assets such as vehicles and warehouses like many Logistics Service Providers do. Furthermore, the trend of companies purchasing transportation from LSPs or LSIs show an increasing trend of outsourcing and reduction of fixed assets as a means to become more flexible to changing circumstances.

Dicken (2010) illustrates transnational corporations (TNCs) as networks within networks. It is mentioned that the corporate headquarter can acquire subsidiaries in foreign regions to gain administrative control over other networks to extend their own as well as increase operability in a larger geographical area.

Although there seem to be many advantages of outsourcing transportation to Logistics Service Providers, companies need to consider the geographical embeddedness of TNCs which is mentioned by Dicken (2010). These could be the home-country influences which are invariably pushed downstream through subsidiaries which will affect the supply network as a whole.

The interests of the corporate stakeholders and those of the society and nations are often contradictory whereby governmental regulations can be set in motion in the pursuit of sustainability in the transport chains, which is why adaptability is a key success factor for survival in a competitive industry as transportation. Collaboration is therefore vital in order to achieve collective goals which lead to profitability by increasing sales and reducing costs, as mentioned by Fugate, Davis-Sramek & Goldsby (2009).

Fugate, Davis-Sramek & Goldsby (2009) also mentions that contingency theories suggesting managerial action often fail since they neglect certain contexts of the environment in which they operate.

In order to create an adaptive transport chain, companies will need to mitigate which risks they face and the consequences of those risks.
Hollnagel et al. (2006) describes three risk assessment categories; Linear prediction, conditional prediction and concurrence. The first two categories are more logical to implement as they can be used to assess the likelihood or causes of an event. Concurrence as a risk assessment is less accurate as it is difficult to predict any likelihood or cause for an event. Linear prediction refers to the “domino” model which implies that one action or event triggers other events leading to disturbances. An assessment strategy for the “domino” model would be the event tree analysis to determine how risks may occur. The Event-Tree Analysis (ETA) is suitable for assessing the causes of accidents and which events are triggered. A conditional prediction is more suitable since many organizations use machinery/equipment which have redundancy systems. For risk assessment, a Fault-Tree Analysis (FTA) is the feasible tool to use. The conditional prediction refers to the “Swiss cheese” model as an event is the result of several single failures leading to the main disturbance.

Therefore, the ETA and FTA analysis could be used to both anticipate and/or avoid any unwanted events from occurring. Organizations need to be resilient since the world market is changing at faster rates and the changes are increasing. According to Hollnagel et al. (2006, p.16), dictionaries often use the definition of resilience as the ability to recover quickly from illness, change or misfortune.

There are three aspects to threats which organizations need to consider building up resilience against (Hollnagel et al., 2006, p.55);

1. The predictability of the threat.
2. The threat’s potential to disrupt the system.
3. The origin of the threat (Internal vs. External threats).

Hollnagel et al. (2006, p.23) also mentions that monitoring and management, or the lack of it being brittleness, is based on the level of understanding of the system reaction to environmental disturbances such as;

1. Buffering capacity.
2. Flexibility vs. stiffness.
3. Margin.
4. Tolerance.

Organizational strategies of Lean Management and Just-In-Time leads to a reduction of buffering capacity which reduces the binding of corporate finances and allows them to be more adjustable to market conditions. On the downside, the reduction of buffering capacity leads to lower margins for errors or undesired events/disturbances. Companies need to mitigate tolerance levels to establish how the network will react near certain boundary levels, if the system collapses or degrades stage by stage as the adaptive capacity is exceeded as described by Hollnagel et al. (2006).

Hollnagel et al. (2006, pp.96-98) mentions an approach which could be used for thinking about accidents which may or may not occur. The book refers to the System-Theoretic Accident Modeling and Processes (STAMP) which integrates all aspects of risk, including organizational and social aspects.

In this paper, organizational aspects refer to the transport chain and social aspects refer to political regulations and societal demands in the pursuit of sustainable transport chains.
STAMP is not simply an event, but a system which is viewed as a hierarchical system posing constraints on each level below. This means that constraints or lack of constraints at higher levels allow or control lower-level behavior (Hollnagel et al., 2006, p.98) as depicted below.

Figure 5. The general form of a socio-technical control/STAMP (Adapted from Hollnagel et al., 2006, p.100).
3.5 Operational Factors

3.5.1 Loading Factor

The loading factors on road freight vehicles depend mainly on the way consumers/customers behave. Common behavior among companies is to outsource transportation since most of them aim to focus on core competencies and improve profitability. Outsourcing enables flexibility and a reduction of fixed costs/assets. In addition, companies are often implementing Lean Management and Just-In-Time solutions to reduce wastes in production and improve flexibility to cope with demand variations.

As a result of these strategies, the demand for transportation and operational performance increases with lower volumes and more frequent transports. Consolidation of goods becomes more difficult resulting from increased demand of faster and more frequent transportation with fewer goods. The directness of transport chains as a performance indicator (Woxenius, 2012) becomes lower since many carriers take detours/additional stop-overs to collect more goods for regional consolidation. According to Woxenius (2012) there does not seem to be any extensive analysis to the causes of detours in freight transportation but literature seems to be addressing network configurations and sustainability.

The operational factors are influenced and formed in two aspects according to the STAMP model depicted in figure 5 by Hollnagel et al., (2006). The two aspects are System Development and System Operations and serves as a link between management and operations of a company. In the case of LSPs and Transport Operators, it could be considered that LSPs function as Management and Transport Carriers function under operations.

Loading factors can be increased by improving the operating process under collaboration with the Management groups for maintaining and developing operational processes. The globalization and opening of borders in the EU (Wieberneit, 2007), makes it easier for transport companies to collaborate and transport goods across nations and thereby increasing the opportunities of improving loading factors in their vehicles and reducing the necessary empty running of vehicles and thus significantly benefitting the environment.

3.5.2 Empty Running

Empty running is the outcome of vehicle movement without any freight which occurs when unloading at one location and collecting goods at another location. Effective resource and material planning could improve the loading factors described above and minimize the empty running of vehicles. Empty running is partially a result of trade imbalances between either domestic regions or international regions.

Integration, coordination and cooperation within the transport chains are essential to improve the loading factors and reduce the empty running, but as companies tend to focus on Lean Management and Just-In-Time solutions, the need for transportation increases. As the need increases and is more frequent, it may be difficult to increase loading factors and reduce the empty running.
Furthermore, demand variation can also result invariably in moving vehicles longer distances without any goods.

3.6 External Factors

3.6.1 Empty Running

External factors affecting the empty vehicle movement are those which cannot be influenced by an individual company or source. An example of an external factor affecting empty running is trade imbalances between domestic or international regions. In regions with a cluster of manufacturing industries, it may be easy to fill up vehicles and transport them to other regions. In other regions where there are clusters of service companies and regions consuming more than others, trade imbalances occur due to the variation of goods transported to and from these regions.

3.6.2 Fuel Efficiency

Fuel efficiency is greatly affected by external factors, either by weather conditions or infrastructure. Traffic congestion is an external factor which definitively affects fuel efficiency and CO₂ emissions. Improved road infrastructure could be a counter-measure for increased congestion, but in the long run, traffic will keep increasing and the benefit of infrastructure development will be reduced.

3.7 Road Tonnekilometers and Total Vehicle Kilometers

Road Tonnekilometers are equivalent to the freight weight multiplied by the distance in kilometers (mass * km). The tonnekilometers could be manipulated by loading more weight in larger vehicles containing larger loading capacities, but it is not always optimal to use longer and larger vehicles. For regional and long-haul transports, longer and heavier vehicles are suitable, while for urban and last-mile distribution it would be more suitable with smaller and shorter vehicles.

The globalization and opening of borders mentioned by Wieberneit (2007) could potentially reduce the total vehicle kilometers while increasing the Road Tonnekilometers as companies can find it easier to form partnership collaboration with other LSPs to expand the geographic coverage and network.

3.8 Fuel Consumption

Fuel consumption varies depending on a number of factors. External weather conditions can increase the average consumption due to outside temperature leading to greater loss of engine heat or precipitation causing added friction on the road. In both scenarios fuel consumption rises. The external factors which influence the occurrence of traffic congestion could be specific delivery time windows which are conflicting with rush hour traffic (often during morning and afternoon). To cope with punctuality and time windows, transport operators may
have to increase and exceed speed limits, which will lead to increased fuel consumption and CO₂ emissions.

However, there are factors which can influence the average fuel consumption positively. Assuming that tire pressures and engine calibration is optimal, keeping a steady velocity can help optimize fuel consumption.

The framework below (Figure 1) depicts the interdependencies of how collaboration in the transport chains and the aim for sustainability affects the adaptive capability of transport chains and how operational and external factors affect the total fuel consumption:

![Diagram of transport chain collaboration and sustainability](image)

Figure 1. The framework is a combination of two, using limited sections from Ivanov et al. (2010, p.411) and Piecyk & McKinnon (2010, p.32).

The theoretical framework and the approach to this thesis in relevance to academic placement, is to prove that by combining the mentioned scientific theories, the efficiency of adaptive transport chains can be improved as well as minimizing the necessary fuel consumption.
4. Empirical Study

4.1 Logistics Service Providers

An empirical study was conducted briefly at two international companies. Due to reasons of confidentiality none of the company names will be mentioned in this paper.

There was no formal interview performed but the information in this paper is the result of information that was acquired during meetings with corporation representatives.

Both companies have their main base of operations in Europe with offices in Sweden.

4.1.1 Company 1

Company 1 does not own any vehicles, but they have contracted 76 vehicles through different transport operators. However, they do own their own trailers which could be located at customers for optimizing the Loading factors and Tonnekilometers.

Most of the transportation in which company 1 is involved, is cross-country transportation meaning that there are no transports performed where origin and final destination is within the same country.

Following data is calculated based on total route distance and total fuel consumption provided by Company 1 for the routes Göteborg – Malmö, Göteborg – Stockholm, and Örnsköldsvik – Helsingborg:

<table>
<thead>
<tr>
<th>Origin - Destination</th>
<th>Distance (km)</th>
<th>Total Fuel Consumption (l)</th>
<th>Average Fuel Consumption (l/km)</th>
<th>Fuel Density (kg/l)*</th>
<th>CO₂ Intensity (kg/l)*</th>
<th>CO₂ Emission (g/km)</th>
<th>Total CO2 (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Göteborg - Malmö</td>
<td>285.2</td>
<td>96.99</td>
<td>0.34</td>
<td>0.835</td>
<td>2.640</td>
<td>898</td>
<td>256.11</td>
</tr>
<tr>
<td>Stockholm - Göteborg</td>
<td>461.1</td>
<td>164.52</td>
<td>0.36</td>
<td>0.835</td>
<td>2.640</td>
<td>950</td>
<td>438.05</td>
</tr>
<tr>
<td>Örnsköldsvik - Helsingborg</td>
<td>1061.7</td>
<td>359</td>
<td>0.34</td>
<td>0.835</td>
<td>2.640</td>
<td>898</td>
<td>953.41</td>
</tr>
</tbody>
</table>

Table 1. CO2 emission calculation based on distance and fuel (diesel) consumption (Vehicle Category: Heavy Goods).

As seen in Table 1, an increase of the average fuel consumption by 2cl per km increases the CO₂ emission by 52g per km which is equivalent to an approximate 5 per cent increase of CO₂ emissions. The calculations are based on assumption that the fuel used is diesel in all vehicles.

Furthermore, Company 1 has provided average loading factors during 2012 and the target for empty running during 2012 & 2013. The average loading factor for import and export in Europe was 89% and the target was 90%.

The target for maximum empty running of vehicles 2012 was 130km and increased to 140km in 2013. The actual outcome varies due to seasonal variations in demands and the peaks can be seen during January and July corresponding with Christmas/New Year season and the vacation period in July.

4.1.2 Company 2

Company 2 owns 17 vehicles in the Gothenburg region which are not trucks but vans used for more frequent deliveries and collection of goods. 15 vehicles are of the model VW Crafter and the other 2 are VW Transporter. The average fuel consumption of the vehicles is 8.14 l/100km (the fuel consumption was discussed during the meeting with the representative of the company).

Two of the vehicles are hybrid models while the rest of them use diesel as fuel. During the period of 11 weeks (5-15) a total of 665,587kg of goods were transported. The weight of goods delivered was 448,563kg while goods collected was 217,024kg. The total transportation distance was 279,808km. These figures add up to a total of 665,587kg * 279,808km = ca. 186.24 million tonnekilometers.

Based on the data given above, the total CO₂ emissions would be;

<table>
<thead>
<tr>
<th>Distance (km)</th>
<th>Total Fuel Consumption (l)</th>
<th>Average Fuel Consumption (l/km)</th>
<th>Fuel Density (kg/l)*</th>
<th>CO₂ Intensity (kg/l)*</th>
<th>CO₂ Emission (g/km)</th>
<th>Total CO₂ (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>279,808</td>
<td>22,776.37</td>
<td>0.0814</td>
<td>0.835</td>
<td>2.640</td>
<td>214.9</td>
<td>60,130.74</td>
</tr>
</tbody>
</table>

Table 2. Fuel (diesel) consumption and total CO₂ emissions based on figures discussed during a meeting with a company representative. * http://www.ecoscore.be/en/how-calculate-co2-emission-level-fuel-consumption

The company has mentioned that the environmental policy is to purchase environmental friendly vehicles for distribution (ultimately gas and electric vehicles) but as infrastructure for renewable energy is lacking and due to high maintenance costs, the company has chosen to revert to using fossil fuels (diesel, as it is more environmental friendly with particle filters).

The policy for purchasing vehicles is that the CO₂ emissions do not exceed 120g CO₂/km but as Table 2 shows, the average CO₂ emission is 215g CO₂/km.
4.2 Environmental impacts and influences

An empirical study performed by the Swedish Environmental Research Institute and Chalmers University of Technology has been based on a survey of major Swedish shippers.

Lammgård, Andersson & Styhre (2013) mentions that there are six Kyoto Greenhouse Gases where CO$_2$ accounts for the largest part of 85 per cent. This is a major concern for reducing CO$_2$ emissions. The empirical research showed that the use of trucks as transportation mode was 73.6%. The combination of truck with other transport modes (intermodal transports) were 4.5% for Truck/Train combination, 11.8% for Truck/Ship, and 5.6% for Truck/Air. These figures represent the share of volumes between transport modes as depicted by Lammgård, Andersson & Styhre (2013) below;

![Table 1 Percentage of shippers that to some extent use the transport modes. (n=163).](image)

Table 1 Percentage of shippers that to some extent use the transport modes. (n=163)

Figure 2. The share of volumes and shippers between different transport modes.

(Lammgård, Andersson & Styhre, 2013, p.8)

In 65% of all cases (based on the survey responded by 166 companies), it is the logistics/transport manager that makes the decision of which transport mode to use. However, it is also noted that in 38% of the cases, customers could also influence and demand which transport mode to be used. The environmental impacts of transports vary depending on the modal choice and 41% of respondent companies stated that they do calculate emissions from their transports. The other 59% (95 companies) responded that they did not calculate emissions and the main reasons behind this were that either the transport operator/provider calculated the data, or the customer did not demand the information. This implies that the majority of major shippers rely on the transport service providers for the calculation of environmental impacts (Lammgård, Andersson & Styhre, 2013). Furthermore, a majority of the transport volumes (62%) constitute outbound transportation whereas the remaining 38% are inbound.

The relative importance of environmental aspects when deciding transport mode is only 8% for environmental efficiency leaving it at the bottom of the significance list. Price, Time Precision and Transportation Time, are more significant with 54%, 22% and 16% relative importance (Styhre & Andersson, 2013-05-29; Lammgård, Andersson & Styhre, 2013).

Styhre & Andersson (2013-05-29) summarized the four most important criteria for the choice of transporter as; Reliability, Service Level, Punctuality, and even level of Quality. Another aspect which is considered is the modal choice which depends on the following criteria; Reliability, Costs, Geographic coverage, and Flexibility.
Styhre & Andersson (2013-05-29) also summarizes that transport purchasers believe that the transport sector will be affected by regulations, increased taxes, increased fuel prices and improved infrastructure. Many of the transport purchaser customers do not have any demands on environmental efficiencies, only on quality and price. It seems like governmental involvement is a necessity for creating clear regulations and guidelines toward environmental goals and sustainability according to Styhre & Andersson (2013-05-29).
5. Analysis

5.1 Overview

Empirical studies have shown that both Logistics Service Providers and Transport Operators have environmental policies. Although they have these policies, it is hard to maintain the policy in practice due to various factors. Some of these factors depend on external issues like delivery time windows where customers demand delivery during a certain time period. These time windows could be implemented for different reasons, some may have it to cope with and improve the loading/unloading capacity, or for time reasons where consolidation needs occur.

5.2 Company 1

The emission calculation model according to Table 1 in chapter 4.1.1., shows that an increase of 2cl fuel consumption per km increases the total CO\textsubscript{2} emissions by 52g CO\textsubscript{2}/km. Trucks transporting heavy cargo emit approximately 7-8 times more CO\textsubscript{2} than that of passenger vehicles (cars). For reducing the environmental impacts, LSPs and Operators may need to increase the lead time to improve consolidation of goods and loading factors.

Currently, the empirical study shows that company 1 has a target of 90 per cent loading factor (sometimes referred to as filling rates) on either weight or volume. The aim of moving vehicles as little as possible with empty load may become more challenging due to external factors such as customers demanding more frequent transports with less goods. The demands of more frequent deliveries and smaller volumes is a result of many companies implementing Lean Management systems and Just-In-Time for reducing the cost of inventory and improve profitability. Although the costs for inventory may be reduced, the costs for resource and material planning increases in order to make production/manufacturing systems as efficient as possible. It leaves the system vulnerable to external threats and hazards and companies will need to assess the possible risks and mitigate possible solutions. Company 1 may find it easier for consolidating goods since most transports are international. The strategy of using trailers for loading purposes grants the possibility of using domestic based vehicles in any country and thereby minimizing the extent of cabotage. Cabotage is described as a free market essential by the EC (2006) and basically means the transportation of goods performed by a haulier within a foreign country. By allowing cabotage within the EU, Logistics Service Providers have the possibility of performing transportation within foreign nations in order to minimize the back-hauling issue, where trade imbalances may occur.

5.3 Company 2

Company 2 performs local/regional distribution and faces other issues. The main issue would be identified as the “Last Mile” which often incurs the highest transportation costs. The CO\textsubscript{2} emissions are generally higher in local distribution due to traffic congestion in city areas and driving speeds are significantly lower compared to speeds on motorways/highways. The speed factor in city limits increases the CO\textsubscript{2} emissions and fuel consumption when accelerating at a higher ratio than on highways and motorways. This can be seen as conflicting with the company policy of only using vehicles that emit 120g CO\textsubscript{2}/km or less, when the average CO\textsubscript{2} emission was calculated at 215g CO\textsubscript{2}/km. This difference can be explained by the “Last Mile” issue, but also that vehicle manufacturers often measure the CO\textsubscript{2}
emissions as a general, within cities & on highway, based on average fuel consumption. All vehicles used by company 2 are using diesel engines. In comparison, if all vehicles were using regular petrol engines and had an assumed average fuel consumption of 10 l/100km, the average emission of CO$_2$ would be at 264g CO$_2$/km bringing the total emission of CO$_2$ to 73,869.31 kg CO$_2$ which is almost 22.85% higher than calculated according to Table 2 in chapter 4.1.2.

5.4 Environmental Research

The empirical study performed by Lammgård, Andersson & Styhre (2013) shows that 73.6% of the volumes transported were done by road freight which is extremely high and affects the environment negatively. Although fuel efficiency in vehicles are improving as a result of political regulations and implementation by vehicle manufacturers, the reverse effect may occur due to lower transport costs leading to increased demand, which to some extent is discussed by Matos & Silva (2011).

It is noted in the empirical study performed by Lammgård, Andersson & Styhre (2013) that in 65% of the responding companies, it is the logistics/transport manager that makes the decision regarding transport mode and 38% responded that it also could be the customer that makes the choice.

When deciding upon which transport mode to use, there are 4 specific criteria that stand out according to Lammgård, Andersson & Styhre (2013). These are; Reliability, Costs, Geographic Coverage and Flexibility. In context, Road Freight is more reliable in the sense that trucks have easy access to the transport infrastructure, as the road network is highly developed, Costs are relatively low for local and interregional transportation (in many cases, cross-country transportation as well), The geographic coverage using vehicles is extensive compared to shipping (in the case of Europe), and using road freight brings more flexibility to adapt to disturbances in the infrastructure.

5.5 Linking the Empirical Study and the Theoretical Framework

Although costs are relatively low for regional and local transports, many transports involve long-distance transporting, which is more costly in the long run causing negative environmental impacts. In these cases it would be more appropriate to use more intermodal transportation and increase the share of volumes more evenly. For the successful and efficient use of intermodal transports, governmental involvement is needed to improve the infrastructure for intermodal transportation and creating a competitive advantage for the other transport modes (train, shipping and air).

Basically, the choice of Logistics Service Provider or Transport Operator is based on; Reliability, Service Level, Punctuality and Quality. Therefore, in order to maintain a competitive advantage, companies need to improve efficiencies and collaboration within the supply chain instead of treating each stakeholder as an external entity. By integrating certain collaborative systems between supplier, service provider/transport operator and customer, a free flow of information could pass through the entire supply chain without any further delays, since information would be accessible on data systems. Collaboration in the transport chain (Integration, Coordination and Cooperation) is therefore vital in order to maximize
loading factors, increase possibilities of intermodal transports and minimize the outcome of empty running or back-hauling issues.

An issue which was mentioned briefly at both companies was the fact that the organization is decentralized in decision making (local offices often plan and execute orders). This causes other issues since companies may have an increased need for administration. Although decentralization has its positive effects, there are also the downside effects of decentralization. As a result of customers requiring more frequent transports and less transported volumes per time, companies need to adapt to changing situations due to increased uncertainty. Therefore, the consolidation of goods to increase loading factors becomes increasingly difficult.

Governmental regulations affect companies in two ways; System Development and System Operations. The local and union legislators and congress impose regulations to be followed through Regulatory Agencies, Industry Associations etc., which in turn impose a set of parameters for company management to abide by. Thus, system development and operations are affected differently by these constraints. Companies therefore need to align systems development and operations as one in order to maximize the potential benefits of new guidelines and adapt to new regulations.

The empirical study suggests that a deeper understanding of the needs within the supply chain would benefit all stakeholders and thus improve the potential for reducing the environmental impacts from road freight as a result of the logistical structure. Optimizing the logistical structure from an internal or focal firm point of view may not be optimal for other stakeholders and thereby create sub-optimization.
6. Discussion

6.1 Research questions/ purpose

The purpose of this thesis is to study the environmental impacts of road freight transport and the implications for transport purchasing. The study has also focused on how governmental involvement can adjust the road transport market by enforcing certain regulations.

It has been established by Nielsen et.al.,(2003) and Nijkamp et.al.,(1997) that the demand for transport and changes in economic and social structures have occurred as a result of the EU stipulation for free movement of people, goods, services and capital which is a cornerstone for the European Single Market and the European Free Trade Association (EFTA).

From a transport economic point of view, creating an economy of unitization could be beneficial for loading factors, but as trends go toward lower volumes and a more frequent flow of goods it often becomes the opposite scenario where units become smaller and heterogeneous in size and weight. Twenty-foot Equivalent Unit (TEU) containers are the most frequent measured units in global freight through shipping, but units are most often classified as pallets. Both TEUs and pallets are easy to load and unload, but as the transport chain shifts from Long-distance to local distribution units often become smaller.

Another economic aspect which tends to increase the demand for lower volumes and more frequent deliveries is the cost of inventory which increases as products/goods are stored further downstream in the supply network. As each stakeholder in the supply network has a marginal profit on each product, the cost of inventory increases for the next stakeholder in line.

6.2 Empirical Study and Analysis

The fuel consumption and emission calculations in the empirical chapter are based on data system calculation from company 1, where the total fuel consumption and distance was given between origin and destination. Company 2 gave information of total weight of goods transported during a period of 11 weeks and also the total distance traveled. Further information revealed was the fuel consumption for the vehicles and models. The weighted average fuel consumption could then be calculated and used in Table 2 in chapter 4.1.2, where the g CO2/km could be determined as well as the total CO2 emission.

The difference in the emissions calculated in Table 2, and the emission target stated in the environmental policy of company 2, could be explained by the fact that; vehicle manufacturers probably test emission levels without freight load and calculate on mixed driving (city/highway). In the case of company 2, the local distribution involves mainly transports within city limits, keeping the traveling speeds low and fuel consumption raises more for acceleration and maintenance of speed. Traffic congestion adds to this issue.

The analysis suggests that transport purchasing companies need a deeper understanding of the needs and goals of other stakeholders in the supply chain for potential optimization to become a reality. Supply Chain optimization would require collaboration between stakeholders although this may be in conflict with certain needs for privacy (for example: trade secrets, processes, customer information etc.). By increased collaboration, it would be possible to
reduce the transport frequency and improve the loading factors of vehicles further reducing the environmental impacts.

6.3 Theoretical Framework

Directness of transports are less likely in local distribution as volumes are low and frequency of transports are higher, meaning that for consolidation and delivery, vehicles need to travel in corridor systems to improve loading factors.

The “Last Mile” transportation issue is a result of outsourcing and lean production systems, creating a demand for more frequent delivery of goods and in lower volumes. Hinterland hubs functions as hubs linking global gateways to inland terminals as mentioned by Rodrigue (2013). The “Last Mile” issue occurs mainly in local distribution where transports are usually performed with Less than Full truck Load (LTL). These can either be transported directly to end customer without any detours or collect goods on the way to an inland terminal for consolidation.

As the level of demand uncertainty (variable) increases as a result of Lean Management and Just-In-Time solutions, risk assessment and mitigation plans become more important for implementing countermeasures for the more (potentially) critical disturbances. An Event-Tree Analysis (ETA) could be feasible for assessing simple issues in more isolated circumstances, but as the industry and the entire world is becoming more globalized, a Fault-Tree Analysis (FTA) is more appropriate for assessing a more complex system configuration. These tools will ultimately need an understanding of the system reaction due to environmental disturbances. For example, How does the; Buffering capacity, flexibility/ stiffness, margin and tolerance affect the transport chains ability to perform its assignments without significant interruption in the supply chain?

There is often a correlation between environmental disturbances. Reduced buffering capacity results in lower tolerance and margins for error in manufacturing/ production and transportation. This is the resulting trend due to more outsourcing, increased demands for more frequent delivery with lower volumes. In the aim for reduction of waste, Lean Management and Just-In-Time trend is a tool for minimizing the necessary inventory storage. The allocation of resources is also more costly further down in the supply chain. Allocation of goods is referring to inventory storage where each stakeholder in the supply chain adds a marginal profit to the product which in turn gives a mark-up of the price for a product further down the supply network.

As the road freight industry is highly competitive, adaptability in Yield Management is increasingly important for transport operators/ carriers. Road Freight stood for 44 per cent of the modal split in the EU-25 according to the EC (2006). A tool which can prove beneficial in Yield Management is Economic Resource Utilization (ERU). ERU is used to calculate the utilization of loading capacity in vehicles and is variable. Economic Resource Utilization as a Key Performance Indicator (KPI) can be manipulated by using smaller vehicles, but this may result in a need for more vehicles to transport the goods leading to increased environmental impacts.

ERU can be based on light weight goods, heavy weight goods or a combination of both. Combining both categories improves the utilization significantly and thus improves the
potential profit. If low density goods are being transported, bulky factor could be used for determining if the transported goods are to be debited by weight or volume.

Therefore, in order to achieve resilience and sustainability in transport chains it is also important that each stakeholder has an understanding of the underlying environmental disturbances which affect the transport chain which thereby pose a threat to supply chain efficiency and productivity.

Governmental involvement becomes more important since the need for sustainability increases as the market increases. An increased demand for transportation will lead to more vehicles on the roads. Governments can help improve the road network to cope with increased traffic and also increase the share of goods transported by rail, by improving the rail infrastructure, creating more flexibility and reliability.

As the transport industry is growing significantly, integration of the transport chain becomes imperative for successful performance and increased profit margins. Collaboration within networks will further help reduce the total vehicle usage and thus reduce the environmental impacts. Political regulations and societal demands increase as the market and industry grows and it is therefore important that the transport chains are well integrated and coordinated with selective partnerships for extended network coverage.

The road freight transport is in a competitive industry with low profit margins. These margins could be an effect of the shift toward lean management and flexible solutions with lacking standardization. Although a certain level of flexibility and adaptability is needed, standardization is needed to create a clear operating process which could be adapted with more adaptable/ flexible processes as an addition to the standard process.

Transport purchasing is increasing as more companies tend to outsource transportation activities to external companies in the pursuit of focusing on core competencies and increased profit. At the same time companies are also implementing Lean Management and Just-In-Time solutions to their business, reducing the total cost of inventory by reducing the safety stock levels. Although these solutions optimize corporate finances and productivity it leaves challenges for other stakeholders in the supply chain. The optimization of processes within manufacturing companies are causing issues for the transport industry since it is becoming more challenging for transport carriers to achieve satisfactory and profitable loading factors.

The increased demand for transport services with lower volumes leads to less road tonnekilometers in relation to total vehicle kilometers. This leads to increased fuel consumption and CO₂ emissions.

In a globalized market companies are trying to be more flexible and agile which is a preferable strategy, but being flexible and agile becomes more costly. Standardization of processes is therefore important to gain economic and environmental viability while creating modular/ adaptable processes which could be implemented if necessary and desired. If the transport industry as a whole would impose additional lead time on deliveries, environmental impacts could be reduced resulting from increased loading factors by improved consolidation. If manufacturing companies/ transport purchasers were to increase the safety stock levels marginally, loading factors will increase and necessary transportation will reduce resulting in less consumption of fuel and lower CO₂ emissions. The corporate strategies of Lean Management and Just-In-Time could be considered an optimization of core/ single company processes but it is in conflict with the aim for optimization in the Supply Chain with
collaboration in transport chains. This is a sub-optimization where the transport industry is required to perform more transportation than necessary.

Therefore, it would be wise for manufacturing companies to increase their safety stock levels to reduce the need for planning, increase the possibility for consolidation of goods and reduce the environmental impacts of vehicle usage, fuel consumption and carbon dioxide emissions (CO₂) in road freight transportation. Governmental involvement is also necessary to ensure economic and environmental viability by regulating lower-level/corporate behavior as depicted in the STAMP model mentioned in chapter 3.4 in this paper.
7. Conclusion

With the research and the empirical studies conducted, this paper reflects the following conclusions (based on the two research questions mentioned in the introduction of this paper):

The environmental impacts of added road freight transport will be increased traffic congestion resulting from more frequent demands for delivery with lower volume shares, increased fuel consumption and emissions of CO$_2$. The transport purchasers need to get more involved in collaboration within the supply chain in order to share information more rapidly and adapt to changing situations.

By standardizing and making certain procedures more centralized, a company gains the possibility of categorizing and reducing the supplier base for improved relationship and evaluation of partnership. It also allows a company to combine fixed procedures with more adaptable ones when necessary, creating a form of modulation process. Increasing the lead time would further increase the consolidation, and reduce total transportation, adding environmental benefits. Ultimately, Transport purchasers and end-customers have an important role in the environmental impacts of road freight. 41% of the companies that responded in the empirical study performed by Lammgård, Andersson & Styhre (2013), stated that they calculate emissions from transports while 59% did not. Main reasons for not calculating emissions were that either the transport provider/operator calculated the emissions or that there was no demand for that information from customers.

Transport Operators need more time to consolidate goods to increase loading factors in order to avoid unnecessary transports, leading to more fuel consumption and emissions. Transport purchasers need to consider a balance of increasing safety stock levels in order to reduce the external costs of transportation and reduce the added costs of planning.

Although customer behaviors are changing more rapidly and the role of transport purchasers change, considerations need to be taken on environmental impacts. Not only does the transport purchaser have a responsibility in the outcome of environmental impacts, so does all the manufacturing companies implementing Lean Management Systems and Just-In-Time. Although these systems benefit companies through lower inventory costs and exposing inefficiencies that can be improved, added costs are put on the environment as traffic congestion, increased transportation, adding to the fuel consumption and CO2 emissions.

Governmental involvement is needed to improve the infrastructure and develop the competitive advantages (Ricci & Black, 2005) of other transportation modes in order to create a more sustainable environment and reduce the effects of CO2 emissions from road freight. Currently, the road network in Europe is highly developed, but the infrastructure network needs major improvement in order to make freight transportation by other modal choices more profitable and flexible. Road freight will continue to be the largest modal transport sector in Europe. An increased share of goods on other transport modes will reduce the environmental impacts of road freight. Governments can also influence the transportation by enforcing road taxes as Austria has done (Einbock, M., 2006). Road taxes can be either time-dependent or kilometer-based although the latter one has better potential of changing driver behavior and even corporate strategies.
8. Future Research

Based on the outcome of this thesis, following suggestions are given for future research:

- The link between infrastructure development and choice of transport mode. How to improve the infrastructure of other transport modes to reduce the share of goods transported by road freight. Improving the infrastructure could increase the flexibility and reach of transports and enable the increased use of multimodal transport.

- The link between logistics structure of a focal firm and the effects it has on transportation. As Nielsen et al. (2003) mentioned, transportation is often perceived as an integrated part of logistics. It is therefore difficult to isolate transport as an independent activity.

- How the European Single Market and EFTA affects the possibilities for regional development as a single market tends to open national borders and create imbalances in labor conditions.

- Can collaboration between nations/governments aid in creating sustainable environmental policies? If so, what preconditions are needed?
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