UNIVERSITY OF GOTHENBURG
SCHOOL OF BUSINESS, ECONOMICS AND LAW

Master Degree Project in Logistics and Transport Management

Green Corridors

-An evaluation of a Tool for Shippers for measuring Carbon Footprints of Transportation

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Abstract

In a more globalized and connected world, trade between countries is growing. Consequently, transport work and the related emissions have been increasing significantly within the last decades. More priority is given to this issue by authorities and society whereby a shift away from road transport towards environmentally better modes can be perceived. Yet, there are challenges associated to calculating the emissions from dedicated transports. The Swedish Transport Administration provides a simple tool to companies to calculate and compare their emissions from different transport solutions; this tool was created in the context of the EU concept of Green Corridors. The purpose of this study is to evaluate the tool from a theoretical and empirical perspective. The empirical findings consist of interviews and cases from three companies with cargo flows across Europe. The results from the evaluation indicate that the tool is not used very commonly and that it might have a different target group from the one envisioned by the Transport Administration. Furthermore, areas of improvements for the tool are provided.

Key words: transport, measuring, tool, emissions, carbon, footprint, green, Green Corridors

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Abbreviations

CO	**–**	Carbon Monoxide
CO_2	–	Carbon Dioxide
CO_2e	–	Carbon Dioxide equivalents
CSR	–	Corporate Social Responsibility
Dwt	–	Dead weight ton
GHG	–	Greenhouse gas
g/tkm	–	Gram per ton kilometer
GDP	–	Gross domestic product
GWP	–	Global warming potential
HFCs	–	Hydrofluorocarbons
HGV	–	Heavy goods vehicle
HM	–	Heavy metals
IWW	–	Inland waterways
KPI	–	Key Performance Indicator
LCV	–	Light Commercial Vehicle
Lm	–	Lane meter
NMHC	–	Non Methane Hydrocarbon
NMVOC	–	Non Methane Volatile Organic Compounds
NO_x	–	Nitrogen Oxide and Dioxide
N_2O	–	Nitrous Oxide
NTM	–	Network for Transport and Environment
O_3	–	Ozone
PFCs	–	Perfluorocarbons
PM	–	Particulate Matters
Ro/Pax	–	Roll on-Roll off and Passenger Vessel
Ro/Ro	–	Roll on- Roll off Vessel
SECA	–	Sulfur Emission Control Area
SF_6	–	Sulfur hexafluoride
SO_2	–	Sulfur Dioxide
SSS	–	short sea shipping
TEU	–	Twenty Foot Equivalent Unit
Tkm	–	Ton-Kilometer
Toe	–	Tons of oil equivalents

1 Introduction

1.1 Changes in trade and climate

In a more globalized and connected world, trade between countries is increasing (The Center for Global Development (CGD), 2006), as consumers face almost no limitations regarding available information about different products and their respective quality and price (DHL - discover logistics, 2013). That is because costs of trade are declining, productivity increases and the average incomes are also increasing (Dean, 2004). Therefore, consumers are able to buy goods from different locations spread all over the world. Nowadays many companies procure what they need from distant business partners or they do outsource or offshore different business activities such as manufacturing, assembling and packaging to foreign markets (Okolo, 2008). To be able to provide consumers and companies with all the goods from all over the world logistical solutions are needed, as the products need to be moved from one point to another usually with restrictions regarding time windows.

An important part of different logistical challenges arising with ongoing globalization is the actual transport of the cargo from its point of origin to its final point of consumption. For that reason, a lot of different modes of transport are used. For trans-continental shipments the most common mode of transport is deep-sea shipping, as it has high volume capacities. For urgent, trans-continental shipments often planes are used. For transport within one geographical region the most commonly used mode of transport is road transport (World Industrial Reporter (WIR), 2012). But growing globalization is just one phenomenon nowadays. As trade, and in general, consumption of goods has been growing for the last decades, the world is now exposed to the challenge of dealing with the consequences that come along with manufacturing processes and transporting goods. These consequences create a climate that is changing too fast in order for nature to adapt, leading to extreme weather occurrences such as heat waves and floods. In general the sea level is rising, because the polar ice caps are melting due to global warming (Greenpeace International, 2013). This is caused because for many years, people have been deforesting, burning gas and coal and becoming more mobile than before (Greenpeace, 2013). As stated by Greenpeace (Greenpeace, 2012) the world climate changed by + 0.74°Celsius within the last 100 years. This is in accordance with the Stern report from 2007 (2007) that states the same numbers. According to experts, an increase by 2° Celsius will cause severe consequences. Due to this, the aim is to keep the rate below 2° Celsius; but, the challenge coming along with this is that the total greenhouse gas

(GHG) emissions of the world need to be reduced significantly. Yet, up till now GHG emissions are continue to rise from one year to the other. Nonetheless, there is still a controversy going on about the effects of greenhouse gas emissions on the global climate. As stated by Akasofu (2010), the world is still recovering from the last ice age and the temperature level is increasing as a natural change and not as the result of extreme GHG emissions. However, it is better to think about and control GHG emissions now, rather than keep on emitting even more, until finally the effects are known. This leads to the other phenomenon, which can be observed these days: consumers do care more about environmental and societal issues.

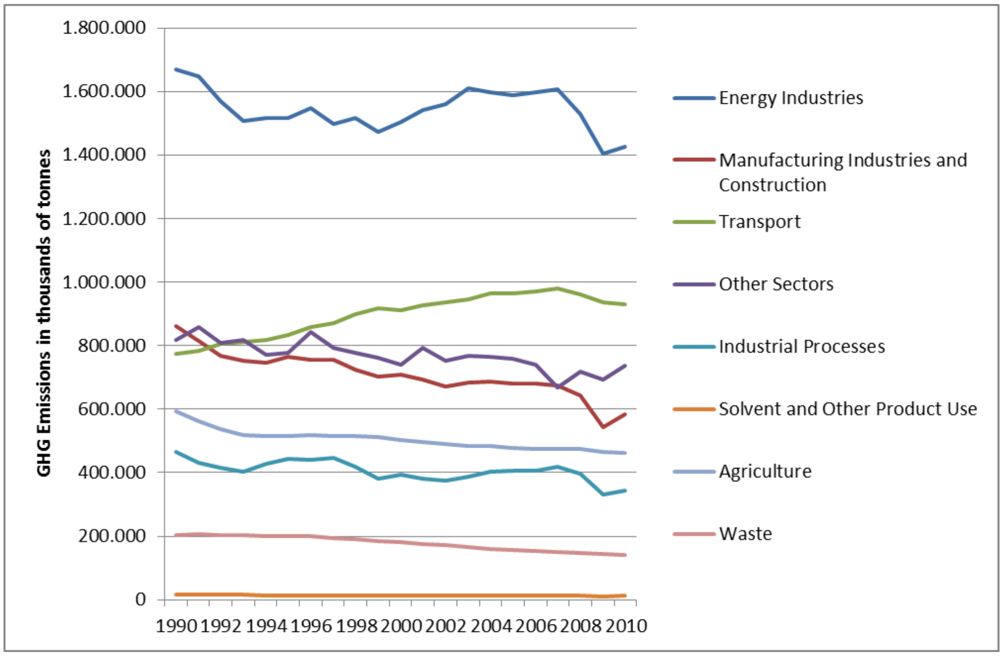
To sum up citizens, authorities and companies are aware of the fact that all the different transport modes do harm the environment and society in one way or another. Modes create environmental problems due to, for example, emissions and social problems such as accidents, noise, visual intrusion and others (Coyle, 2011).

The two described phenomena of the modern world are building a paradox, as people do not want climate changes potentially leading to severe catastrophes in the future, but at the same time people do not want to refrain from all the conveniences that the industrialized world brings along. The responsibility for dealing with this paradox lies with the authorities of the different states. They are able to lower the impacts on the environment by initiating the development and implementation of concepts for environmental protection and also enforcing these. Thus, an increased societal and political pressure is arising for the industry to control and reduce their emissions. But companies are not acting towards more environmentally efficient transports solely based on social responsibility reasons. As long as it is not legally enforced, a company must have economic or other advantages for changing their operations. Additionally, companies need to be able to measure their impacts, improvements and potential benefits of changes somehow, as only a measurement adds value to a change in the transport structure.

1.2 Environmental and societal problems caused specifically by transport

The graph below describes that the transport sector is the only sector within the EU-27 states with an actual increase of GHG emissions from 1990 to 2010. All the other sectors managed to have lower GHG emissions in 2010 compared to the Kyoto Protocol Base year 1990.

Figure 1 GHG Emissions 1990-2010 different sectors



Source: (eurostat - European Union Database, 2013) Source of Data: EEA

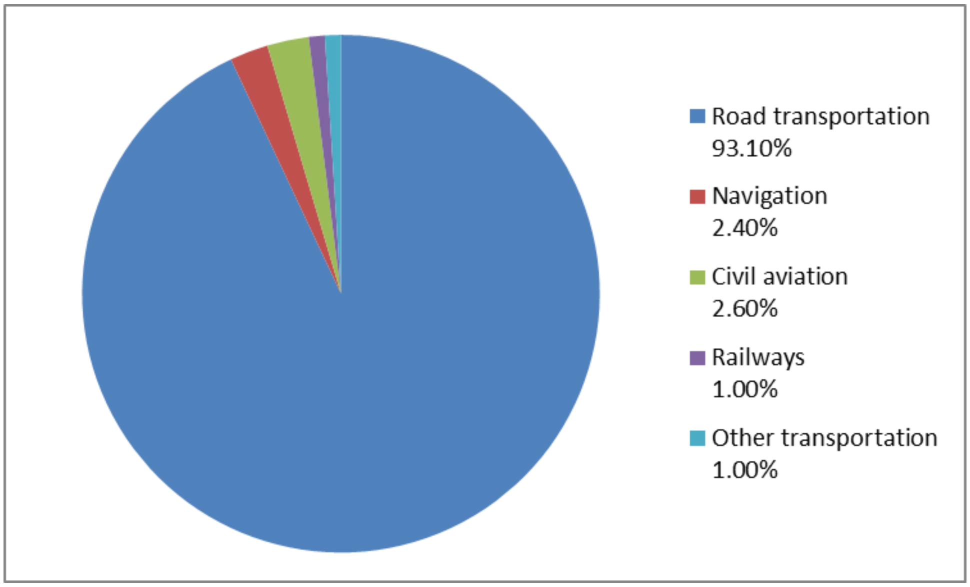
Table 1 Modal split of freight inland transport in EU-27 in percent of tkm

		2000			2008			2009	
	Road	Railway	IWW	Road	Railway	IWW	Road	Railway	IWW
EU-27	74	20	7	76	18	6	78	17	6

Source: (European Union, 2011 p. 108)

From Table 1 it can also be recognized that the share of road freight transport is increasing and railway and inland waterways (IWW) are decreasing. This is especially interesting when looking at the impacts that each of the modes has on the environment, but this will be discussed in more detail in section 2.1. Indeed, already Figure 2 shows that in 2006 road transport caused by far the most GHG emissions within the EU-27. This is on the one hand due to the fact that around 75% of the cargo inland transport (excluding Short Sea and Deep Sea Shipping) is performed by road mode. On the other hand, it is also due to the fact that trucks use up a lot of energy and have high emissions compared to the volume they can carry.

Figure 2 GHG Emissions by mode in EU-27 in 2006



Source: (eurostat - European Commission, 2009 p. 170)

Most energy in the transport sector within the EU is consumed by the road sector. Still, most of transport is performed on the road. But the consumption of energy in Table 2 also includes private vehicles and passenger transport.

Table 2 Energy Consumption Transport Sector EU-27 in 2006 in toe

	Transport	Road	Rail	IWW	Air
EU-27	370 304	303 317	9 199	5 932	51 856

Source: (eurostat - European Commission, 2009 p. 158)

Furthermore, the demand for transport is usually referred to as derived demand (Coyle, 2011), which means that demand for transport also increases, if trade increases. As stated by the European Commission (2009) this applies for the EU-27 states, too. Thus, that transport work is growing within Europe.

When environmental and societal impacts of freight transport are discussed, it can be distinguished between three different levels they affect: local, regional and global. On the local level these are effects that are perceived directly in the surroundings where the pollution is caused. The different pollutions are in detail: noise, visual intrusion, land take, vibration, accidents, and emissions of Ozone (O_3), Particulates (PM), Heavy Metals (HM), Carbon Monoxide (CO), Sulfur Dioxide (SO_2), Nitrogen Oxide and Dioxide (NO_x), Nitrous Oxide (N_2O) Volatile organic compounds (Methane (CH_4), and non-methane compounds (NMVOC)) Hydrocarbons, and Carbon Dioxide (CO_2) (see Appendix 1). The repercussions of these factors range from annoyance and loss of work productivity to serious health issues with fatality (Cullinane, 2010). On a regional level the consequences are acid rain and photochemical smog. Acid rain originates from emissions of NO_x and SO_2 and it weakens the nature and biodiversity (Encyclopædia Britannica Inc., 2013a). The smog comes from sunlight reacting with NO_x emissions and can lead to health issues affecting the respiration system. It has its highest concentration in urban areas (Encyclopædia Britannica Inc., 2013c). On a global level environmental impacts are referred to greenhouse gases (GHG) and its impacts on the global climate were mentioned in section 1.1. A lot of different emissions contribute to the greenhouse gas; nevertheless, carbon dioxide has the highest impact, as it is emitted the most in absolute numbers. Therefore, commonly the effects are calculated in CO_2e, thus, equivalents in carbon dioxide. This means that the GHG gases which contribute per kg more to the global warming are converted into kg of CO_2 with the respective GWP factor (Global Warming Potential) (Piecyk, 2012). In this way the effects of the other Kyoto Protocol greenhouse gases (CH_4, N_2O, Hydrofluorocarbons (HFCs), Perfluorocarbons (PFCs) and Sulfur hexafluoride (SF_6)) can be stated in CO_2e, too (see Appendix 1) (Piecyk, 2012; Swedish Institute for Transport and Communication Analysis (SIKA), 2005). An overview of all different emissions and their impacts on the different levels are summarized in Table 3.

Table 3 Effects of different emissions on different levels

Effect	PM	HM	NH_3	SO_2	NO_x	NMVOC	CO	CH_4	CO_2	N_2O
Global										
GHG – indirect					X	X	X	X		
GHG – direct								X	X	X
Regional										
Acidification			X	X	X					
Photochemical					X	X	X			
Local										
Health and air quality	X	X	X	X	X	X	X			

Source: (Piecyk, 2012 p. 34)

According to the Encyclopædia Britannica (2013b) externalities or spillovers are “economic relationships […]” that are “not efficiently controlled by price”. Therewith, there are effects of trade that have effects on parties, which are not involved in that specific business. The impacts occur either at the time the transaction takes place or later. To encounter especially the negative externalities, such as pollution and emission, these effects should be internalized. Hence, the party/parties, which are involved in the incurrence of the effect, should pay for it. Though, this is rather complicated or even impossible with factors such as air and water, which are mainly affected by externalities (Robbins, P., 2007). External effects of road transport are air pollution (specific emissions were mentioned in 2.1.1), accidents, congestion and more social impacts such as visual intrusion, land take, noise, and vibration. In Europe the costs of congestion are about one per cent of the GDP (European Commission, 2011), which accounts for approximately 128 billion Euro for 2012 (Europäische Kommission - eurostat, 2013). Moreover, nine out of ten fatal accidents that happen in connection to transport are caused by road transportation.

1.3 Framework of policy actions of the EU towards more sustainable transports

Within the last two decades the European Union has been working on the issues that come along with transnational transports in the European area. Such issues are bottlenecks in the network, which are limiting the transport efficiency, congestion on the roads, social and environmental effects of transportation. Especially as trade and transport are growing within Europe those issues became more relevant and there are a lot of proposals and projects coming up and being implemented. The most important proposals will be presented in the chapters to follow in order to get a rough overview of the EU work in the transport sector and to put the concept of Green Corridors into a broader framework.

White Papers on Transport and Transport Networks

In 2010 the European Union published a White Paper titled “European Transport Policy for 2010: time to decide”. Some of the main parts that the White Paper is dealing with are the shift of modes in transport sector within Europe, hence, supporting railway and sea transport/ inland waterways. Furthermore, the different modes of transport should be better and more efficiently connected in order to support intermodal transports. Especially “motorways of the sea” and the Marco Polo programme are dedicated projects to the above mentioned tasks. Additionally, the development of the gross domestic product (GDP) and transport should be decoupled; particularly transport should not grow at a similar rate as the GDP. Finally freight transport bottlenecks within the European Transport network shall be removed. Accordingly, corridors with multimodal options and priority to freight flows should be built up (Commission of the European Communities, 2001). Albeit, one of the guidelines of the paper is that the developments happen in a sustainable way for the environment. In the White Paper from 2011 “Roadmap to a Single European Transport Area – Towards a competitive and resource efficient transport system" it is stated that dedicated freight corridors with more efficient and environmentally better transports are needed (European Commission, 2011).

Marco Polo programme

The Marco Polo programme is a funding program, which started in 2003. It supports shifts of modes of transport financially. The goal of the project is to reduce traffic on the roads within Europe and so also emissions caused by road transports (European Commission, 2013a).

TEN-T

The abbreviation TEN-T stands for Trans-European Transport Networks. Its aim is to harmonize the transport networks within the European Union across borders (European Commission, 2013b). This shall be reached by creating a multimodal network within Europe by providing infrastructure and equipment. The modes of transport rail, road, sea and inland waterways should be connected through terminals. This should also be enabled through technologies such as intelligent transport systems (European Commission, 2012b).

The concept of "Green Corridors"

The concept of "Green Corridors" supports the development of

> *"long-distance freight transport corridors where advanced technology and co-modality are used to achieve energy efficiency and reduce environmental impact"* (European Commission, 2009b) .

The concept of Green Corridors was published by the European Commission in 2007. It is meant to be a concept that supports transports in Europe in a way that is less harming to the environment, but also more efficient for the users (Lindström, 2010). Of special importance is the decarbonizing of transports (European Commission, 2009b). The concept is part of the Freight Transport Logistics Action Plan from the EU. A freight corridor is defined as traffic between hubs with long distances in-between and high concentration of freight flows. The "green" part of the concept is that along dedicated freight corridors co-modality (multimodal) and new technologies of transport are supported by the authorities in order to have more sustainable and energy efficient transports. On these grounds, the authorities need to provide these corridors with the appropriate infrastructure (Commission of the European Communities, 2007b). Sweden defined the Green Corridors in more detail as

"Sustainable logistics solutions with documented reductions of environmental and climate impact, high safety, high quality and strong efficiency,

- *integrated logistics concepts with optimal utilization of all transport modes, so called co-modality,*
- *harmonized regulations with openness for all actors,*
- *a concentration of national and international freight traffic on relatively long transport routes,*
- *efficient and strategically placed trans-shipment points, as well as an adapted, supportive infrastructure, and*
- *a platform for development and demonstration of innovative logistics solutions, including information systems, collaborative models and technology."* (Trafikverket, 2012a)

This concept is financially supported by the TEN-T and the Marco Polo programme (Motor Transport, 2007). However, the commission proposing the concept of "Green Corridors" in 2007 stated that it is difficult to measure the effects that the implementation of the concept will have, especially measuring environmental effects (Commission of the European Communities, 2007a).

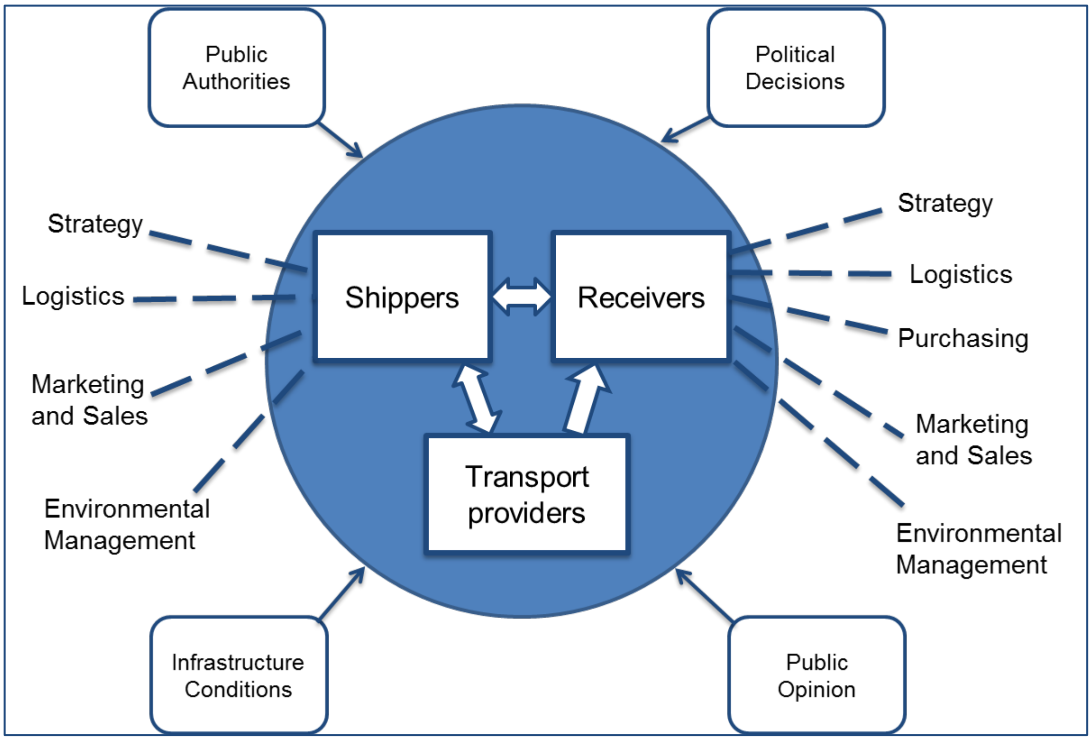
1.4 Problem discussion

As aforementioned there is a paradox between reducing emissions and growing trade. The industrialized regions in the world have been and are still causing a main part of the emissions and, therefore, they have to take the lead in attempts to reduce it. The EU is eager to work on those issues as it contributes around eleven per cent of the total CO_2 emissions in the world. For more than 20 years they are working on that issue now with a main focus on manufacturing processes and shift to renewable energies (European Commission, 2012a). Yet, in Europe 20 per cent of CO_2 emissions are caused by traffic, both transport of cargo and private people (Greenpeace, 2011). Especially for transports within Europe road transport is the leading mode by far (see Table 1).

Hence, the concept of Green Corridors was developed. A Green Corridor consists of different perspectives: infrastructural, policy and logistics. Transports should be avoided, wherever possible, the different modes are developed and shifting towards environmentally better modes of transportation and terminals. However, it is often unclear what the actual benefits of using such a Green Corridor are and what makes it less damaging to the environment than the common ways of transport. The fact that it is referred to as Green Corridor does not make it per se “greener” than other ways of transport. There needs to be some kind of measurement, which shows that new transport solutions enable more efficient ways of transportation. Otherwise it will not be used.

In Figure 3, the different actors and influencing factors for the modal choice of transport are illustrated.

Figure 3 Actors and influencing factors for modal choice of transport



Source: (Lammgård, 2007 p. 63)

According to Lammgård (2007) the transport buyer is the instance, which makes a decision about the mode of transport and thereby the environmental impact. Nonetheless, there are many factors and instances around the shipper, which influence the modal choice of transport. Eng-Larsson and Kohn (2012) show in their study that all actors involved in the system might have a common goal, but different drivers for this. Whereas, the shippers and the carriers are driven by economical and productivity reasons, the external instances are driven by sustainability. Furthermore, they grouped the influencing factors in three categories: external pressure, business strategy and logistics strategy. External pressure would be in the categories of Lammgårds (2007) illustration infrastructure conditions, public opinion, public authorities and political decisions. Strategy, environmental management, and marketing and sales are influenced by this and build the business strategy, which in return impacts the logistics strategy.

Consequently, companies have an increased interest in more environmentally efficient performance. Hence, this includes solutions for transport of goods. But any performance improvements need to be measured, to be of any value. Additionally, changes in the modal choice of transport in favor of less environmental damaging solutions will only be realized, if, beforehand, its positive repercussions can be compared to the current setup.

As a consequence, the Swedish Initiative for Green Corridors developed a tool on calculating emissions for dedicated transports.

1.5 Purpose and research questions

The purpose of this study is to evaluate a tool developed in the Swedish Initiative for Green Corridors for measuring emissions of transport solutions of shippers.

This purpose is broken down in several research questions, which need to be answered to fully capture the purpose of the study. These questions are:

1. To what extent is the tool sufficient in measuring the emissions of shippers' transport solutions?
2. To what extent is it possible to compare different transport solutions in an efficient way?
3. How is the usability of the tool rated by the target group (i.e. shippers)?

Question one and two are analyzed and answered through theoretical and empirical findings. Thus, the tool will be rated through theoretical findings but also with data from the target group. The third question will be answered through an analysis of empirical data gained through a case study with the target group.

1.6 Delimitation of the study

There are different external effects of transports, besides emissions, for society. This thesis focuses strictly on environmental problems of transports as these are the factors, which the tool under evaluation covers. As so far there is no possibility to capture and measure the impacts on visual intrusion, noise, vibrations etc. for a specific transport and company.

The thesis deals with greening of transports in the context of Green Corridors in Sweden, thus, with land and water transport. Therefore, plane as mode of transport is left out. Additionally, aviation accounts in Europe for less than one per cent of total goods transported (eurostat - European Commission, 2009), hence, making it an uncommon mode for goods transport in Europe. There is a geographical restriction, as it does only cover Sweden and companies located in Sweden. The study will only focus upon the tool provided by the Swedish Transport Administration, and by this, neglecting other tools that might have been developed by other institutes or authorities for the same reasons, as this tool was published in the context of Green Corridors. The study will not be a comparative study. Other tools are only mentioned in the context if necessary, but not analyzed. The paper focuses on the shipper's perspective, thus, neglecting carriers and their perspective on measuring emissions. The reasons for this limitation are listed further down in the methodology chapter. The shippers in focus are big companies operating within different branches, which are more likely to focus on measuring environmental effects of transport. As small and medium sized companies do not have the same bargaining power on carriers and, therefore, influence and information about the mode and specific vehicle in use. Furthermore, according to Constantinos et al. (2010), those kinds of companies are also not aware of their environmental impact, and that they do not want to carry the extra costs as long as there is no legislative requirement for environmental issues. In Sweden, the larger companies with more than 100 employees represent 72 percent of all freight transported by Swedish shippers (Lammgård, 2007).

1.7 Outlook on the study

In the next chapter a theoretical framework is developed, including definitions for the further study. An analysis of different modes of transport is done and transport efficiency is discussed. Moreover, it includes a description of the process of "Going Green" and how emissions can be measured and if they are used as performance measurements, what they need to fulfill. In the third chapter the methodology and the appropriate methods, that are used, are described and analyzed how these methods helped to explore the research problem. Also, the validity and reliability of the research will be discussed. In the fourth chapter the tool is introduced in detail and connected to the theory. In the fifth chapter the results from the real logistics cases and the interviews will be presented. In the sixth chapter the tool will be analyzed based on the theoretical framework and the results of the interviews and logistics cases. Whereby, in this chapter the research questions will be wholly answered and summarized and conclusions are drawn. The last chapter is a short summary of the main findings and what can be concluded from it. It provides an outlook on further research needs in the field of greening transports and how to measure changes in in transport chains.

2 Theoretical framework

In the following section of the paper a theoretical framework is developed. First the different modes of transport and their environmental impacts and then transport efficiency will be discussed. It will be reviewed where the expression "Going Green" comes from and what ie means from a business perspective and different approaches on how to measure emissions from transports and how it could be used as performance indicator in companies will be presented.

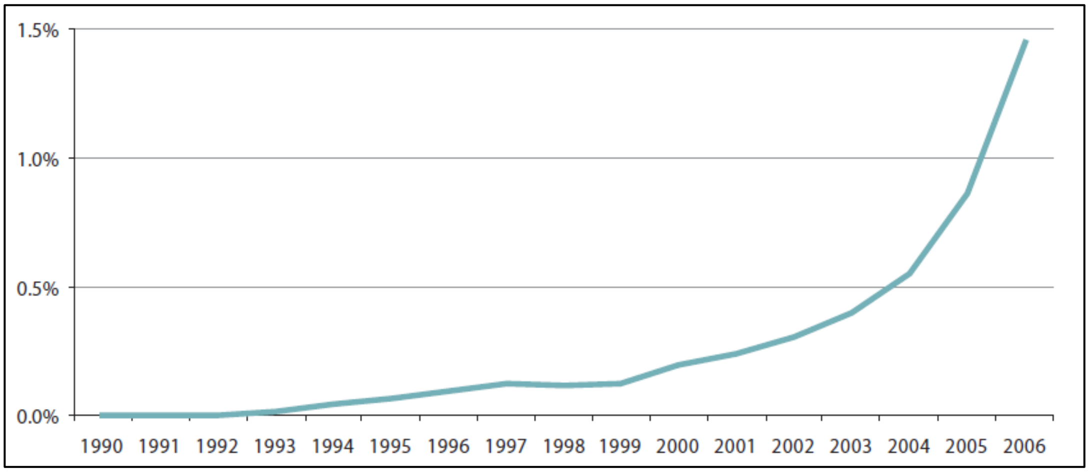
2.1 Environmental impact of the transport modes and terminals

2.1.1 Road transport

Road transport causes the most emissions by tkm. Furthermore, transport by road uses up the most energy as can be seen in Table 2 p. 4. Though, this high energy consumption compared to the other modes accounts for the high share road transport has in the modal split of freight transport. Road transport causes the following emissions: CO_2, NO_x, CO, and non-methane volatile organic compounds (NMVOCs); and also in rather small amounts N_2O, CH_4 and NH_3. The various repercussions of the different emissions were already discussed in the introduction of this study. The relevant emission which will be looked at in more detail is CO_2e. The amount of CO_2e emitted to the environment depends on the amount of fuel that is consumed by the vehicle. This indeed, depends according to Eggleston and Walsh (2000), on factors such as speed, load factor, vehicle type, the type of fuel and technology of the vehicle.

The EU is promoting the use of biofuels instead of the common petrol or Diesel. There are even targets for the percentage share of biofuel should increase within the next years (European Commission, 2009a). In fact, it can be seen as a positive development in road transport that the use of biofuels is growing within the last years as can be seen in Figure 4. As there is lower direct CO_2 emissions caused by biofuels than by fossil fuels (Dekker, 2012). Nonetheless, according to Crutzen et al. (2008), the reduction of CO_2 by using biofuels, might be evened out or even exceeded by the newly caused emissions of NO_2 in the production / growing of the biofuels. Additionally, often fossil fuel is used to produce biofuel (Dekker, 2012). In such cases a life cycle assessment or well-to-wheel approach of calculating emissions becomes rather important.

Figure 4 Use of biofuels in transport



Source: (eurostat - European Commission, 2009 p. 163)

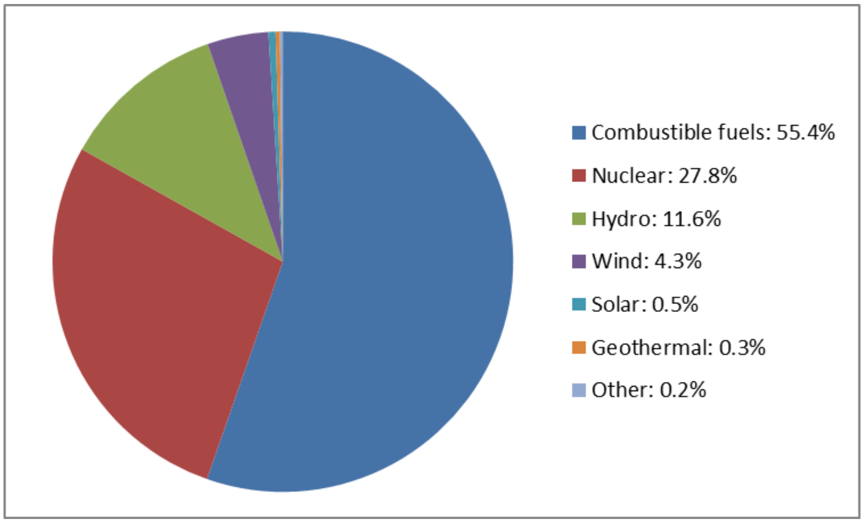
The emissions for road vehicles have been constantly reduced through governmental regulations since the late 80s through the European emission standards (EURO I to EURO VI) (eurostat - European Commission, 2009). However, these regulations only concern CO, NO_x, HC and PM but not CO_2 (see Appendix 2).

2.1.2 Railway

For rail the emissions depend on the type of rail locomotive that is used. Locomotives that are powered with Diesel cause around twice as much CO_2 emissions than trains that are electricity based in Europe, according to McKinnon (2007). In contradiction to this, Dekker et al. (2012) state based on data gained from NTM[1] (Network for Transport and Environment) that Diesel based rail causes approximately the same amount of CO_2 emissions as electricity run locomotives. These contrary statements result from the point of view that is taken by the researchers. During usage, electrified trains do not cause emissions themselves, but rather emissions are caused for providing the train with energy. So the emissions of an electrified train depend on the type of energy that is used to power the rail. If the electricity is produced by a coal power station emissions are significantly higher than by nuclear power. But, in fact, nuclear power has other severe impacts on the environment, which are not further discussed in this study.

[1] NTM is a non-profit organization with the goal of establishing common values for emission calculations of transports. Calculations are based on scientific data. http://www.ntmcalc.se/index.html. (NTM)

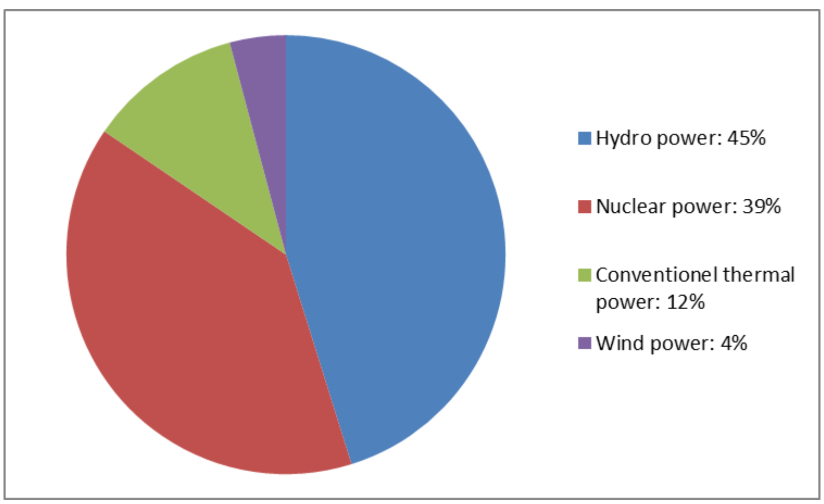
Figure 5 Electricity Generation EU 2009



Source: (eurostat - European Commission, 2012 p. 558)

In 2009 still the major share of energy came from “unclean” sources such as natural gas, oil and coal (eurostat - European Commission, 2012) (see Figure 5). This worsens the environmental performance of electrified rail. Globally, there is an average CO_2 emission of 400 g/kWh for rail (Klell, 2009). Yet, in Sweden the sources of energy are better, when it comes to environmental impacts such as emissions (see Figure 6).

Figure 6 Electricity Generation Sweden 2011



Source: (Statistics Sweden, 2013)

Furthermore, the emissions depend on the length and weight of the train, the load factor, the speed and conditions of the environment (IFEU Heidelberg et al., 2011). Shifting the mode of transport from road to rail is often going along with reductions in energy and fuel consumption and, consequently, in emissions. However, this does not always apply (Lowe, 2005).The larger the share of nuclear power, the greater the environmental benefits regarding CO_2e from using rail (IFEU (Institut für Energie- und Umweltforschung Heidelberg GmbH) & SGKV (Studiengesellschaft für den kombinierten Verkehr e.V.), 2002) and the other way around. Even further IFEU and SKGV (2002) conclude that only if the following three conditions are partly or totally fulfilled, combined transport is better regarding environmental issues than pure road transport:

- Initial and final leg do not cause extra miles,
- High fill rates in trains,
- Trains have a certain length.

2.1.3 Sea transport (short sea shipping and inland waterways)

Sea transport is the slowest of all available modes and often there are huge delays due to handling operations in ports (Rodrigue, 2013). Nevertheless, sea transport is often referred to as the "Green" mode of transport (Hjelle, 2010; McKinnon, 2012). Paixão and Marlow (Paixão, 2002) and Blonk (Blonk, 1994) state the environmental and energy advantages over other modes as two out of several strengths of short sea shipping (SSS) and IWW, while offering lower freight rates to the shippers. Nonetheless, when it comes to emissions of NOx and SO_2 and PM, SSS is not environmentally friendly at all (Hjelle, 2012). This is changing now with the SECA (Sulfur Emission Controlled Area) rules for the Baltic Sea, which are incrementally introduced. These rules give stricter restrictions in certain areas for the emissions of sulfur (Kalli, 2009). For SSS in Europe there are five types of vessels operating and these are single-deck bulk carriers, container feeder vessels (150 – 500 TEUs (Twenty foot equivalent unit)), ferries, bulk carriers and tankers (< 3,000 dwt (deadweight ton)), and sea-river ships (Paixão, 2002). Still, Hjelle (2010) found in his study, that only under advantageous conditions towards SSS, SSS is more environmentally less damaging than road transport. Likewise, it depends on the type of vessel that is in use. For Ro/Ro-vessels there exists the problem of double-load factor, which means that the load factor of the vessel does not only depend on the percentage extent to which the vessel itself is filled but also depending on the load factor of the trucks, trailers or swap bodies on the ship. Only with slow-steaming, a long enough distance, and high enough load factors, SSS can utilize environmental advantages over road and rail.

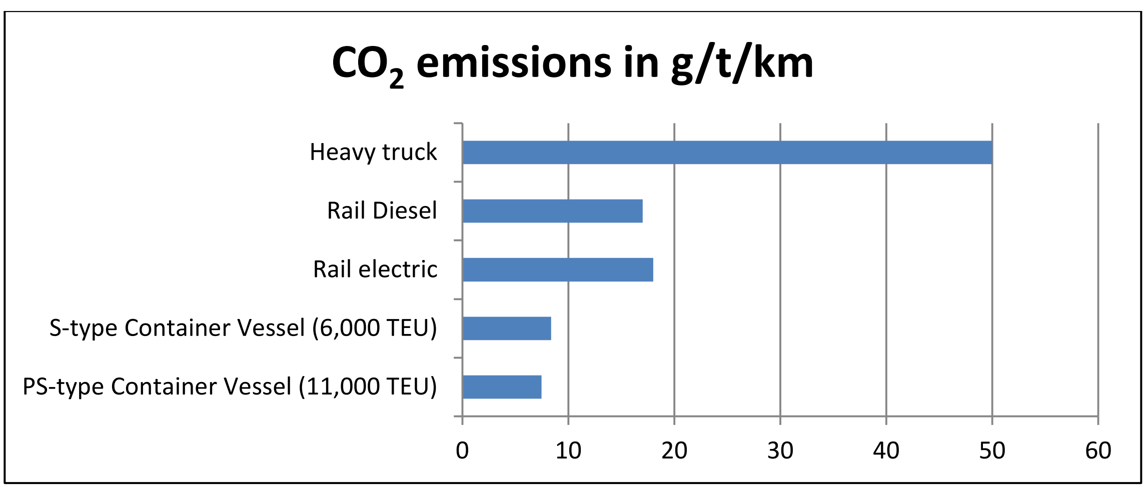
2.1.4 Terminals

For terminal operations there is way less literature available then for the concrete modes of transport and research upon their dedicated emissions. It appears as terminals do not seem to be of that much interest so far when it comes to measuring and capturing the emissions caused by their operations. Albeit, according to Dekker et al. (2012) terminal operations are the most inefficient operations in a transport chain. This is in accordance with Lumsden (2007), who states that terminal operations are rather expensive and often lead to delays in the transport chain. The location of the terminals can be determined with the point of gravity method. This method can also be used to find the best location for a terminal from an environmental point of view. Still, terminal location is not that much related to the emissions caused by the terminal but rather by optimizing the routes of the transport itself. Concrete numbers about the environmental impacts of different terminal types (rail, intermodal, road, port terminals) and sizes were not found.

2.1.5 Comparisons of transport modes

According to Dekker et al. (2012), there is no clear ranking between the different modes of transport as each has its advantages and drawbacks in regards to the environment. However, within the field of rail and inland navigation there have been very few technological developments in the last years. Thus, technologies in road vehicles are bridging the gap between the modes further. Contradicting to this, Ruzzenenti and Basosi (2009) state that the engines in road transport have become better, but the energy use did not improve. But, as can be seen in Figure 7, trucks are still causing the highest rate of CO_2 emissions per tkm.

Figure 7 CO_2 emissions from different modes



Source: Data taken from (Dekker, 2012)→ based on data by NTM

Moreover, not every mode that is available fits to all different products. Food transport should for example not be performed by inland waterways according to Woodburn and Whiteing (2012), as it takes too much time for perishable goods and it is more complicated to keep the chain temperature controlled. For that reason, companies cannot only decide based on environmental footprints or economic reasons about the transport mode. But also the type of product, time restrictions and customer requirements need to be taken into consideration. According to McKinnon (2007), that if specific modes are advertised as being especially "Green", it could be that the load factors are whitewashed in favor of the specifically promoted mode. According to the EEA (European Environment Agency (EEA) , 2010), the load factor of rail is around 50 per cent. And for road freight it is about the same level. Hjelle (2011) assumes a load factor of around 70 per cent for Ro/Ro and Ro/Pax vessels. However, according to Hjelle (Hjelle, 2011) information about load factors can rarely be found, as it is sensitive information.

2.2 Transport efficiency

Nowadays, when discussing innovations and technologies in transportation, solutions should be efficient. Indeed, the term efficiency needs to be clarified, as there are different definitions of efficiency. Performing efficient operations is often also connected to productive and effective operations. There are interdependencies between all of these three (productivity, efficiency and effectiveness). Yet, it needs to be clarified and differentiated what each of these mean. According to Berchtold (2002) productivity is a certain level of output and efficiency is this output level in relation to costs and resources. Nevertheless, according to Arvidsson (2011) productivity and efficiency are aiming towards the same goal; just from different points of view. Productivity is a constant level of output with savings in the input. Efficiency is the same level of input but with an increased output level. This definition of efficiency goes along with the definition by Black et al. (2008a) in the Dictionary of economics where efficiency is:

> *"Obtaining the maximum output for given inputs".*

Though, technical efficiency can be both (Black, 2008c):

> *"Those aspects of efficiency concerned with obtaining the largest possible level of output for a given quantity of inputs, or using the smallest possible quantity of inputs to obtain a given output"*

Whereas productivity is the

> *"amount of output per unit of input achieved"* (Black, 2008b).

Effective means, according to the Oxford Dictionary (Oxford University Press, 2013)

> "s*uccessful in producing a desired or intended result"*.

An efficient transport system would, in fact, be able to transport an increased amount of goods with the given input. Or with fewer resources the same amount of goods. This would lead to the fact that transport of goods should become environmentally better per tonkilometer (tkm) as the same level of transport is able to carry more goods. So the emissions caused by tkm should decrease. But this can only be concluded if the transport gets more efficient while all other factors are ceteris paribus. Still, in reality there are side effects caused by the new situation of better transport systems. These side effects can have direct, indirect or macroeconomic impacts as transport in general (Rodrigue, 2009). These effects are the so called rebound effects (Herring, 2006). That means that the emissions per tkm are still lower than before, yet, the total amount of emissions will be higher.

Efficiency in transports is nowadays also linked to be more energy efficient. This is especially the case when discussing the emissions of CO_2, as use of energy results in emitting CO_2 (Moriarty, 2012). As a result, transport efficiency from an environmental point of view is related to energy efficiency. However, Herring (2006) states that an increased energy efficiency can eventually lead to higher use of energy and, as a result, a constant or further growing level of emissions.

The arising question from the definitions is what are the goals of transport efficiency above in greening transports? Emissions caused by transport should be reduced on the one hand, and on the other hand operations should not become more expensive to logistics operators and transport buyers or at least there needs to be some benefits which they can achieve. Else, there is no incentive for companies to make use of more environmental sustainable transport solutions. According to Moriarty and Honnery (2012) these two goals can aim for the same direction and reducing one will lead to the reduction of the other. As a consequence, reducing the environmental impact of the transports system would also reduce the operating costs for a company. Transport efficiency is, for that reason, to be able to produce the same output, but with a decreased level of inputs or resources. Hence, efficiency in transport is transporting the same amount of freight with lower use of resources and energy and, as a result, decreased level of environmental impact per tkm, while sustaining economic benefits from more efficient operations.

To sum it up, transport efficiency is a rather complex topic and its definitions are varying strongly. Likewise, transport efficiency can be at the same time environmentally efficient, but according to some definitions it can be the other way around, too. Though, in this study, transport efficiency includes that it is better for the environment.

2.3 "Green" from a business perspective and the drivers for "Going Green"

To understand what "Green" is, it first needs to be clarified what the background and framework of "Green" is. "Green" is part of Corporate Social Responsibility (CSR). As Idowu (2009) states, businesses are not only rated by financial performances anymore, but also on social and environmental behavior. According to Gonzalez-Perez (2013), the development of CSR came along with globalization and the need for more social and environmental business performances. In the context of CSR, it is also often referred to the triple bottom line. The triple bottom line was developed in the thought of that companies should not only focus upon their profits, but also about people and the planet (Killian, 2012). Thus, the triple bottom line refers to the three sectors that CSR includes: economic, social and environmental (Esen, 2013; Brown, 2006). The economic role of CSR is the "traditional" business issues such as sales, profits and others. The social part of CSR deals with working conditions, human rights and impacts on the communities. And the environmental part refers to energy consumption, emissions and waste (Esen, 2013). Additionally, companies have realized that they can create value by having a well-developed CSR. For that reason, companies started to include CSR in their strategies (Idowu, 2009). "Green" refers in this context to the planet part of the triple bottom line and the word "Green" is, nowadays, used very often and in different situations. Each institution, company and customer seems to understand what is meant when referring to something as "Green". Nevertheless, defining what "Green" actually means to a company in order to have common understanding of it is rather seldom. Also, the different stakeholders have each a different viewpoint of what is "Green". According to Miller and Szekely (1995) the term "Green" is often used when operations are less damaging the environment than the common ones. Though, this is not a technical state of the art definition, as it does not include the business perspective. So they state that "Green" refers to what is best for the environment and the business at the same time (Miller, 1995). Kim and Min (2011) state that in the future "Green" should mean the same as "Lean", as companies want to reduce waste and non-value-adding actions from their performances. It can be said that “Green” cannot be defined as a status that can be reached, but rather an ongoing process. By applying the concept of “Green” companies can, amongst others, according to Miller and Szekely (1995)

> *“become sustainable […] improve business efficiency [and] become more competitive”.* (p. 404)

Whereas becoming sustainable only refers to environmental matters. Hence, “Green” includes actions and changes in a company that do harm the environment less than previous business behavior (Miller, 1995). Bansal and Roth (2000) mention four main drivers for “Going Green” and these are:

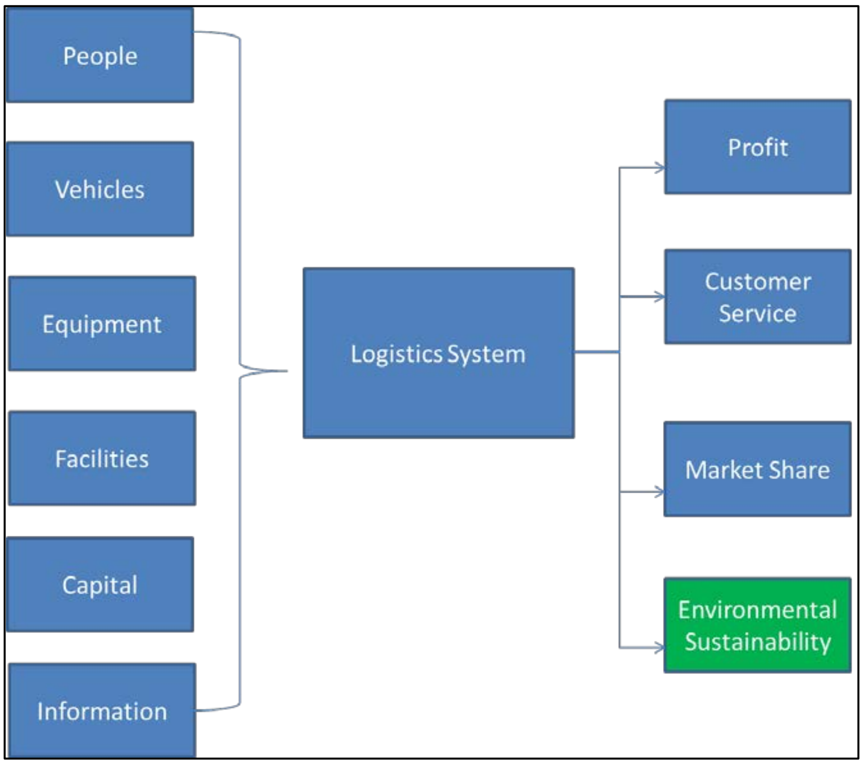
> *“legislation, stakeholder pressure, economic opportunities, and ethical motives.”* (p. 718)

Legislation compliance is of high importance as any violation will lead to some kind of penalty. Stakeholder pressure comes from shareholders, customers, authorities, environmental interest groups and the environment itself, as business interacts with the natural environment and changes in the environment can also affect the business’s performance (Bansal, 2000; Björklund, 2012; Pane Haden, 2009; Driscoll, 2004). Economic opportunities are again related to cutting costs in operations or improving market position through marketing. Ethical motives are depending on the firm and how strong the self-motivation of a company is to take over environmental responsibility without achieving economic benefits (Bansal, 2000). Thus, acting in a less environmentally harmful way, can potentially cut costs and satisfy stakeholders’ requirements leading to higher renown of a company. Lynes and Dredge (Lynes, 2006) summarized motives for “Going Green” from research as follows:

- Cost reductions and efficiency gains,
- Avoid legal enforcement,
- Competitive advantage,
- Positive company image,
- Stakeholder pressure,
- Increase employee productivity.

The whole concept of “Green” can also be narrowed down from a comprehensive business perspective to the field of logistics and, hence, transports. Chow et al. (1994) state that social responsibility and, consequently, environmental performance is one part of the logistics performance of a company. In 1991 Clarke and Gourdin (1991) showed a conceptual model of the in- and outputs of a logistics system (see Figure 8). According to Wu and Dunn (1995) environmental impact is a byproduct of logistics activities. In fact, it can be seen as an undesired, but additional output of a logistics system. So the model from Clarke and Gourdin (1991) can be nowadays supplemented with “environmental impact” as part of the output of the logistics system.

Figure 8 Inputs and outputs of logistics systems based



Source: Adapted from (Clarke, 1991)

Hence, the logistics systems need also to adapt to the “Going Green” processes and, therefore, stands the term “Green logistics”. Looking at each function of a logistics system, transportation is the most environmental damaging single activity within a logistics chain (Wu, 1995). According to Thiell et al. (2011) “Green logistics” means the use of advances technology to reduce environmental impacts and increase resource utilization. Activities coming along with “Green logistics” in transport are re-using of load units, fill rate optimization, use of new vehicles and selecting the carrier thoroughly (Thiell, 2011). For McKinnon (2010b) the five factors freight transport intensity, freight modal split, vehicle utilization, energy efficiency and carbon intensity of the energy source are activities within “Green logistics” with regards to transport. Sbihi and Eglese (2010) state that, additionally, measuring the environmental impact and waste reduction belong to “Green logistics”.

According to Reh (2011) what cannot be measured, can eventually not be improved. In order to keep track on set environmental goals, the performance needs to be measured by the companies. Furthermore, before implementing a new transport solution, different options need to be evaluated. For that reason, companies need to have tools, which enable them to track current performances and compare environmental impacts of different solutions. This leads to the next part of how to measure emissions in transport.

To recapitulate, “Green” is a continuous process of becoming environmentally efficient and there are several reasons for “Going Green” for companies; ranging from external pressure to simply improving the business performance. This development also includes logistics and transport operations and, especially, regarding the use of energy and fill rate optimization. But to make the process of “Going Green” “visible” it needs to be measured.

2.4 Measuring emissions of transport

In this section several methods of calculating emissions of transports will be presented. First a model of influencing factors by McKinnon is introduced and then other approaches, which are more holistic, thus, including more factors than just transport, are shown.
McKinnon (2010a) developed a model for green logistics, which shows how the external costs and, thus, including emissions caused by logistics are composed. The nine key parameters in the model are: modal split, average handling factor, average length of haul, average load on laden trips, average per cent empty running, energy efficiency, emissions per unit of energy, other externalities per vehicle-km, and per unit of throughput and monetary valuation of externalities. These parameters are the “adjusting screws” with which the environmental impact of a logistics solution can be varied. There are four different levels of decisions that are influencing those parameters: strategic, commercial, operational and functional decisions. Strategic decisions deal with location and amount of warehouses, distribution centers and terminals. Commercial decisions are about sourcing and suppliers and distributor networks. Operational decisions influence inventory in warehouses and freight flows to distributors. Functional decisions control the resources; it is about routing, loading and operating practices. Environmental sustainable decisions on a functional level are often overcome by strategic decisions, which have a much higher impact on the environmental effects of logistics.

According to Nocera et al. (2012) when planning transport infrastructure there are different origins of emissions that need to be taken into consideration and these are: designing, constructing, operating and decommissioning. These have to be compared to the change-nothing situation. If these thoughts of transport infrastructure planning are transferred to the transport planning of an individual company, they also need to take the different levels into consideration such as developing new transport system, introducing a new system, operating and ending the system. For example, sourcing new technology trucks would mean that these need to be manufactured and shipped to the destination and old trucks need to be scrapped. Thus, a life cycle assessment needs to be done to fully capture environmental effects of a transport system. Eriksson et al. (1996) found that the two most decisive factors in a life cycle assessment of road transport are the fuel consumption and the production of fuels. However, there should be a differentiation between a life cycle assessment and the well-to-wheel assessment. Well-to-wheel includes all factors relevant to the energy combustion of a vehicle and accordingly, the production of the fuel and energy provision (Klell, 2009; Foley, 2011). Well-to-wheel is, therefore, a life cycle analysis of the vehicle and its fuels. Thus, from the resources needed to production of fuel and delivery to the final usage (Edenhofer, 2011). The well-to-wheel approach consists of the two approaches well-to-tank and tank-to-wheel. Whereas, well-to-tank includes all steps from the resource to the point when the fuel is in the vehicle, but not the final use (Edenhofer, 2011), and tank-to-wheel covers only the combustion of fuel, while the vehicle is in use (Silva, 2006). Life cycle assessment is more holistic and includes production of the vehicle, maintenance and scrapping (Eriksson, 1996).

According to McKinnon (2007) there are two different approaches to measure CO_2 in general: the input-based method and the output-based method. The Input-based method is based on the sourced energy (e.g. fuels) of a company and the output-based method is based on estimates about the actual consumption, thus, the consumption of energy per output unit. The output-based measure reflects the more accurate numbers for additional services such as transport, as it is based on the actual performed work and not estimations from purchased energy in general.

Cullinane and Edwards (2010) state that it is crucial to be cautious when analyzing data for environmental impacts of transport as the performance of a mode can be influenced by assumptions of filling rate, transfer of data from one country to another, even though, there might be differences in the systems, for combined cargo and passenger transports, the allocation of the emissions, disregarding the life cycle and well-to-wheel emissions.

To sum it up, there are different points of view what needs to be taken into consideration to accurately measure the environmental impact of a transport solution. The existence of several different approaches and definitions shows the complexity of the topic of measuring environmental impacts of transports (Cullinane, 2010). Yet, not all of the approaches are suitable or feasible for companies to measure their external impacts. The tools, which are suitable on a business level, can be grouped in two categories: one group taking the well-to-wheel approach and the other is taking only tank-to-wheel approach into consideration. Furthermore, tools have in common that they rely on data from databases of environmental impacts of transport modes (Cullinane, 2010).

2.5 Measuring environmental performance of logistics

Performance indicators are non-financial values, which show the performance of a certain area in a company against a certain target or the norm, according to Parmenter (2010) and Fortuin (1988). Indicators reflect qualitative improvements in a quantitative way. Performance indicators should be compared to a given plan and comparison with the past makes improvements visible (Fortuin, 1988; Gunasekaran, 2007). Björklund and Forslund (2013 S. p.232) summarize the function of performance indicators as

> *"to see progress, understand and evaluate performance, identify problems, bottlenecks and possibilities of change, to form new goals and targets, to confirm priorities and determine future courses of action, to assist operational personnel and to report performance." (p. 232)*

Moreover, it must be differentiated between a performance indicator and a key performance indicator (KPI). The former indicates what should be done and the latter shows what needs to be done to have a significant performance increase. KPIs reflect the most relevant and crucial areas of a business (Parmenter, 2010).

Especially environmental indicators are there to fulfill demands from authorities and customers (Björklund, 2013). Caplice and Sheffi (1994) researched upon characteristics of metrics especially in the field of logistics. They defined eight different characteristics a logistics KPI should have in order to be of value as a measurement tool. Those are:

- validity
- robustness
- usefulness
- integration
- economy
- compatibility
- level of detail and

- behavioral soundness.

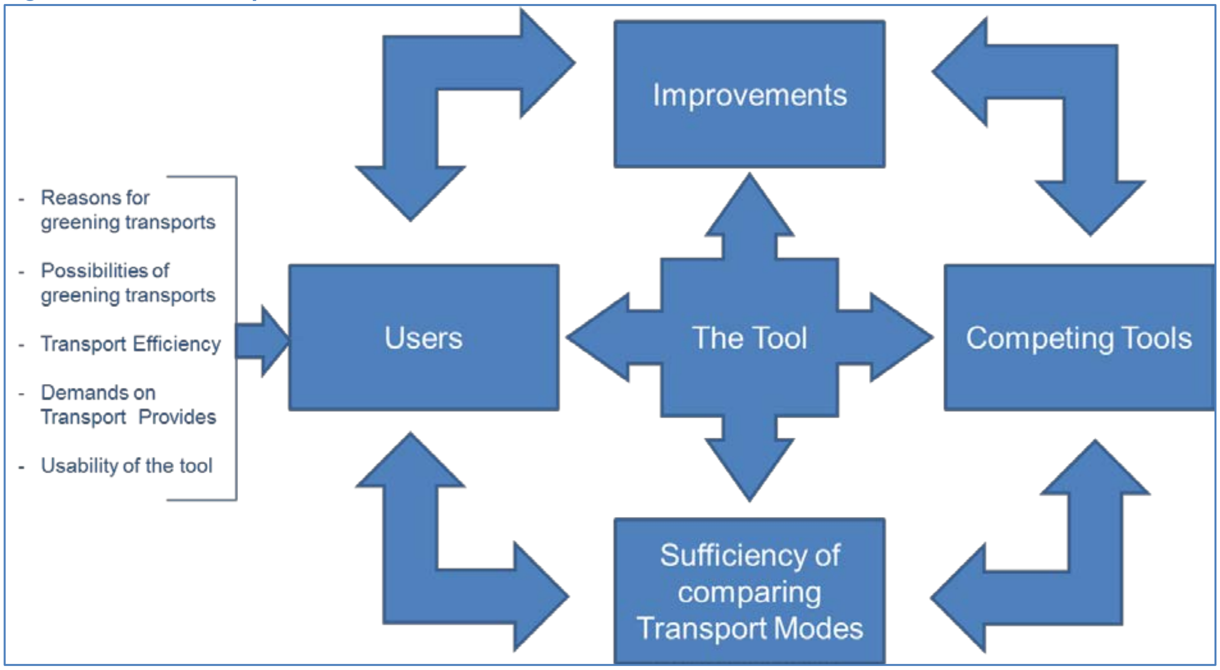
Validity means in this context that the activities in focus are measured accurately. Robustness makes it possible to have comparisons over time, location or organization and that the results are reliable. Reliable in this context means that the same results appear, if the measurement is repeated and, therefore, comparison over time is possible. The usefulness reflects the understandability of the results of the KPI in initiating measures to reduce impact. Integration ensures that all relevant factors are taken in consideration. If the KPI has the characteristic of economy, the costs of collecting data and analysis are compensated by the gained advantages. Compatibility of a metric makes it useful with the existing information. The level of detail deals with the sufficiency of the gained information. Hence, can decisions be made based on the provided information from a tool? And last the behavioral soundness of a metric keeps people away from counterproductive acting. Nevertheless, it is impossible to reach all eight of the characteristics as some of them are interconnected and the better one is the lower is another characteristic (Caplice, 1994). For example if a tool for measuring emissions is dedicated to a certain transport corridor, the level of detail can be very high, whereas the usefulness decreases as it could only be used for a limited number of dedicated transports.

In summary it can be said, that in order to see progress and improvements in changes made in the logistics structure, they need to be measured. For that reason, PIs and KPIs exist. But metrics in logistics should fulfill a number of characteristics, in order to ensure the quality of information such a metric provides.

2.6 Summary of the theoretical background and derived model for analysis

First the different transport modes were presented. Although several technologies have been developed for and regulations put on road transport, it remains the worst mode, when it comes to emissions of CO_2 per tkm. SSS and rail have advantages over road transport, when it comes to emission. However, it should not be neglected that some of the advantages of sea transport and railway is only when there are favorable conditions for them, e.g. assumptions of high fill rates and not too long detours. About terminals, there is not much research been done so far, upon the environmental impact and how it could be improved. Transport efficiency is the usage of less resources and energy and still keeping a certain performance level. The transport efficiency led to the topic of why do companies want to be more efficient, especially with regards to the environment. There CSR, the triple bottom line and “Going Green” was discussed. Several drivers were identified. The next sections presented different approaches, on what could be relevant for calculating emissions and how it could be used as KPI.

Figure 9 Model for empirical research



The model above can be derived from the literature review for what is of importance to a tool calculating emissions of transports. The most important factor for such a tool is the users. Why should the user make use of the tool? Therefore, also what drives the user is vital. In this case for the tool of the Swedish Transport Administration in the context of Green Corridors, it is, thus, relevant to know why shippers change their transports chains towards environmentally better solutions. Furthermore, what are the possibilities of doing so and what is, in this context, transport efficiency for the shippers. Also, do they put requirements on their transport providers with regards to the environmental performance and have, so, knowledge about the modes in use? Finally, the usability, as it is perceived by the target group of the tool is decisive for if the user uses the tool or not. The next factor for evaluating the tool is the different modes included in the tool and if they can be compared in a sufficient way. Also, it is of interest for the evaluation if there are other tools available, which fulfill the criteria of the different approaches towards measuring emissions better. And derived from these points, what are improvements that make the tool more valuable. The empirical research is built upon the model presented in this section, in order to capture a full picture to evaluate the tool provided by the Swedish Transport Administration.

3 Methodology and research methods

3.1 Methodological approach

The purpose is to evaluate the tool provided by the Swedish Transport Administration and the according research questions include the sufficiency of measuring emissions from transports, the possibility of comparing different transport solutions and the tool's usability. The research problem of this thesis consists of several parts, as shown in the derived model in chapter 2.6. Foremost it is important to get involved with the target group, thus, the potential users of the tool and what drives them, in order to evaluate, if the tool fits to their needs. For this reason, qualitative research fits the best to investigate upon the users intentions. Albeit, as the research problem is about the tool and its sufficiency of measuring emissions of transports, it is as well vital to have quantitative data from real logistics cases in place to see results from the tool. Those results can then be evaluated, so as to see, if the results are rather in accordance with theory or if there are major differences, which need to be scrutinized. To investigate about this research problem the approach of the research will be in-between interpretivist or as stated by Guthrie (2010) post-positivism, and positivism, as the research will not be adapted to any of these two paradigms, but with tendency towards an interpretivistic view. The research itself is of qualitative nature as the findings will not be derived from any statistical data (Golafshani, 2003). The study will, consequently, focus on both collecting qualitative and quantitative data. The qualitative data is used to evaluate the tool from the point of view of the target group, i.e. the shippers, which is crucial for determining if there is a usage potential for the.tool. The quantitative data is important, in order to see, if the tool shows reasonable results. As a result, collecting both kinds of data captures a complete picture of the tool in focus of the study. Hence, the chosen methodology for the research problem is a multiple case study, based on quantitative and qualitative data from the units of analysis.

3.1.1 Case study with qualitative and quantitative approach

The methodological choice is primarily case study, as some companies will be studied with regards to their logistics choices and their opinions on greening of transports and will be compared. In the end conclusions can be drawn (Dul, 2008). A case study focuses on one or a small number of instances in a real world environment, as factors around the case are not manipulated in opposition to an experiment, according to Dul and Hak (2008) and Blumberg et al. (2008). Furthermore, it will be as aforementioned a multiple case study, where more than one instance will be analyzed in order to be able to answer the research questions, because investigations upon the tool should be based on more than one single case to make them more reliable and strong (Blumberg, 2008). The research will be both, qualitative and quantitative, and applied as the data will have qualitative and quantitative nature and the research problem is taken from the real life (Adams, 2007). Therefore, a case study was chosen as the most suitable methodological approach to the research problem.

3.2 Interview study

3.2.1 Sample

The unit of analysis is an aggregate of different stakeholders. As a consequence thereof, interviews were held with a judgmental chosen sample of stakeholders to investigate upon their potential savings in relation to the transport of goods and environmental aspects of GHG emissions. As the tool is provided by the Swedish Transport Administration the three companies which are studied are based in Sweden. To answer the research questions, it was crucial to get numbers and data from the selected companies in the sample. Shippers and no carriers were chosen for the sample, as they are the main target group for the tool. The companies are rather big and all have high amounts of goods flows through Europe, because bigger companies tend to have more interests in environmental issues than smaller ones (Constantinos, 2010), at least most research also focuses upon the bigger ones (Moura-Leite, 2011). The sample was chosen based on replication logic (Blumberg, 2008), in order to provide theoretical propositions. Thus, the conclusions drawn in the end, are theoretically applying for companies in the same category as the chosen ones. The case study allows generating data from two different sources: the interviews and data provided by the companies about some transport cases. In Table 4 the characteristics of the companies can be found. The companies will not be named, as this is not of further interest to the study.

Table 4 Characteristics of Companies from the Case Study

Characteristics	Company A	Company B	Company C
Industry	Furnishing industry	Paper and packaging/ Forest industry	Automotive Industry
Environmental Image	Neutral	“Green company”	Neutral
No. of employees	> 10 000	> 10 000	> 10 000
Corporate form	Limited liability	Stock market	Stock market

3.2.2 Interview setting

The chosen method to collect the qualitative data is an in-depth research (Adams, 2007) semi-structured (Collis, 2009) interview. In interviews the interviewees are asked several questions to find out what they think and feel about the topic investigated. Interviews can be conducted personally but also through different modes of communication such as telephone. Although personal interviews are the best option, as it allows for more human interaction, two out of the three interviews were conducted by telephone and only one was a personal face-to-face interview. This is due to the fact as it was at the convenience of the interviewees, as they did not have enough time for personal meetings. Additionally, there are three different types of interviews that can be distinguished: structured, semi-structured and unstructured ones. In the structured interview all questions are the same for each interviewee, and no additional questions are asked. Whereas in the semi-structured interview an interview guide is the starting point, but if it is of interest to the research more in depth questions can be asked. The unstructured interview has no given set of questions before the interview starts and questions are asked according to how the interview develops (Collis, 2009).

The semi-structured interview was selected as the best option for this research problem, as all interviewees got a pre-defined set of questions and, thus, it is easier in the analysis part to compare different companies and their answers. But, as it was only semi-structured it left space for additional, more in detail questions, if it turned out to be necessary and of interest for the research problem.

The data from the interviews were analyzed along some themes which were identified as important topics throughout the process of interviews and reviewing the literature (see derived model in chapter 2.6). Then the statement of each unit of analysis was grouped under such themes, according to Crowthers description (2008).

3.3 Data for testing the calculation tool

3.3.1 Sample

The quantitative data was gained separately to the qualitative data, as it took the companies some time to prepare the data. Still, the same sample companies were used as for the interviews. All three companies under the study provided the author with some real logistical cases which are relevant to test the tool. The units of analysis were asked for specific data they have available for dedicated transports: the origin and destination, the average weight of a shipment, the type of vehicle (train, vessel) in use, the distance of each leg of the transport and information about the terminals.

In order to evaluate the tool quantitatively there were different scenarios with data given by the companies.

These different scenarios were:

1. Direct shipment
2. Inter- or multimodal shipment
3. Shipment with terminal transshipment
4. Shipment with distance between 250- 500km
5. Shipment with distance above 500km
6. Shipment from/to Sweden from/to a non-Scandinavian country

3.3.2 Use of quantitative data

The data from the companies differed somehow. Whereas Company A provided data according to the list above, Company C provided several transport solutions they have in place for a dedicated shipment from 1 to 2. Likewise, the different companies have different levels of information available about the transports, thus, it was necessary to the author to make assumptions to make up for the missing information. But, these assumptions are explained in detail in 5.1. The information received (see Appendix 4) from the companies varied quite a bit. Assuming that the provided information of each company is correct, for some it is rather hard to use the tool, as information is missing and assumptions need to be made. Company A does not have information about the size of the terminals and also they know more about the loading unit (trailer, container) and how many loading meters are available, rather than the type of vehicle. Also, for all companies, information about the type of train in use for a transport is limited. They did not know the train size and if it is electrified or running on Diesel, because according to Company B that can also change during a transport, when there is for some parts no electrified rail track available. Furthermore, in the real logistics case it turned out, that it is confusing in the tool, which one of the terminal types counts as intermodal terminal, as it only lists ports, rail and truck terminals. Although, for transports it might be of importance to know the type of goods, this information was not required from the companies, as this variable does not exist in the tool. This is a drawback, as different goods require different handling and shipment equipment.

The results are not compared between different companies, or transports from different destinations. The only interest in the results is to compare these within one case, to see if the numbers reflect what was to expect and if they appear realistic, from what has been evaluated in the paper so far, or if the results from the cases might indicate errors in the tool. The quantitative data was not statistically analyzed, but only used to show results of the tool from real logistics cases and compared to alternative solutions.

3.4 Literature review

A literature review is important to conduct in order to find out what has already been researched about the topic in detail. Also, for the study a conceptual framework from theory needed to be set up. This framework is necessary to make use of the gathered data in the study. Without a proper theory background an interpretation of the data in an appropriate way is not possible (Adams, 2007). So in the second chapter first the different modes and their specifics were discussed and transport efficiency, as it is an important topic in the current transport discussions. "Going Green" was set in the context of CSR and the drivers for companies of doing so were worked out. Then the need for measuring emissions was set in a research framework and different current approaches and research on how to assess the topic of measuring emissions was evaluated. For the literature search the snowballing method was used. Therefore, the starting point for each topic was one recent relevant article and then the reference list of this article was checked for more relevant readings (Lecy, 2012).

3.5 Validity and reliability

Reliability and validity are two crucial factors that need to be discussed in order to evaluate and rate the quality of the study conducted (Adams, 2007 S. 235 ff). Reliability means that the same results will be gained, if the study is repeated under the same conditions (Golafshani, 2003). Therefore, it measures how consistent the method is in a specific case (Adams, 2007). As the study is exploratory and there was no research upon this topic beforehand, the reliability is difficult to ensure as there are no previous studies upon it. Even though, Golafshani (2003) states that reliability might not have the same importance in qualitative research as in purely quantitative research, reliability is ensured through the thoroughly studied data. However, for the calculations of real and hypothetical cases the reliability of the output of the quantitative data is given as the same tool is used for all cases. Nonetheless, reliability is not a sufficient criterion itself to evaluate the value of a study. As in the study and its repetitions, a factor could be measured consistently, but consistently wrong. In fact, validity has higher value in research than reliability (Adams, 2007). Validity represents the rate on which a study actually measures what it is meant to measure (Collis, 2009). As the used paradigm is more of an interpretivists nature, usually validity is high (Guthrie, 2010), because the data that are collected are very detailed and the researcher tries to access the knowledge of the ones involved in the study (Collis, 2009). Also, the researcher is aware of the fact that by investigating upon the topic and approaching different stakeholders that are concerned with the topic of transport and greening of transports, the reality and thereby, the results of the study could be influenced by the investigation itself. This is because the unit of analysis will be aware of the fact that it is observed by the researcher (Collis, 2009). According to Musch et al. (2002), this can happen willingly from the interviewee side or unintended. This is also referred to delusion and self-delusion in order to act social desirable. Thus, the unit of analysis could provide other data than the actual reality or its concrete plans of using greener transport solutions, in order to appear eager towards gaining positive change. Though, this does not affect the evaluation of the tool, as it is of none importance. Moreover, the researcher kept an objective and critical position while screening and reviewing the respondents' statements. Accordingly it can be ensured that what is intended to be measured is actually measured; hence, the validity is given. According to Stenbacka (2001), validity is rather simple to ensure in qualitative research, as the interviewee only needs to be part of the problem and needs to be given the chance to speak freely about it. To sum it up, validity will not be difficult to discuss for the qualitative part of the study, as it can be seen as "given" in an interpretivists study or at least it is highly distinctive. To ensure validity for the quantitative part of the research is harder, as it usually aims more towards reliability rather than validity. Yet, through thoroughly analyzing the tool and its underlying assumptions, validity and reliability are also given. Likewise, the reliability and validity are given for the theoretical analysis of the tool, as a well-diversified basis of literature is used and different aspects are mentioned. Furthermore, the awareness that the field of measuring emissions of transport is not well studied so far and there is no right or wrong existing. Yet, more important than reliability is credibility in qualitative research (Collis, 2009). Credibility is ensured for this study through the multivariate base of literature, which does not support any specific direction, but critically assesses different points of view. Besides, the tool and its assumptions are described and the reader can access the tool online. This ensures that readers can get their own opinion about the tool and work with it themselves.

4 The calculation tool for measuring carbon footprints of transports

In this chapter the tool will be explained in detail and it will be very roughly compared to the NTMcalc tool. Then the tool is connected and evaluated with the theory.

4.1 Background and description of the tool

4.1.1 Background

In the context of the concept of Green Corridors the calculation tool was developed, in order to measure the environmental efficiency of a transport solution and to see improvements in newer transport solutions with regards to the environment. The tool was developed from the project working group of Green Corridors together with a transport provider. (Trafikverket, 2012a). The defined target group for the tool is shippers and logistics providers which can calculate their emissions for current transports and how changes in their logistical choices would affect it. The results from the tool are proposed as KPIs for companies, according to the handbook Green Corridors Criteria (Trafikverket, 2012b).

4.1.2 Description

The Swedish Calculation tool[2] from the Swedish Transport Administration is available online and for free and it is based on Microsoft Office Excel. The tool is based on figures from NTM and only available in Swedish. The tool is kept simple and the user only needs to enter the weight of the shipment, the traveling distance, the used mode and the terminals. These three data can be entered for each leg of the dedicated transport. The weight is entered in tons and can also change for different legs of a transport chain. The distance needs to be entered for each leg of the transport. For the used mode and terminals there is a predefined list of different vehicle and terminal types, from which the user can choose. For terminals it is differentiated between small, middle and big terminals and sea ports, rail and road terminals. For road transport there are eight different vehicle types available, depending on where the transport takes place (e.g. city vehicles). For rail, there are different sized available, but also if it is electrified or Diesel based. Besides, there is an option of choosing SE (for Sweden) or EU for electrified rail. A transport solution can be entered with maximum ten legs and nodes. The tool then calculates the transport work in tkm. The emissions, which are calculated by the tool are divided into global, regional and local, according to their effects, as described in the introduction. For the global level CO_2e is shown, for the regional level NO_x and SO_2 and locally

[2] Tool available at: www.trafikverket.se/PageFiles/42686/kalkylverktyg_grona_korridorer.xls

PM and NMHC (Non Methane Hydrocarbons). Additionally, the energy use is stated. All results are shown in absolute figures and per tkm. Also, all the results are provided for each leg of the transport chain and for the total transport. Energy and CO_2e are stated as well-to-wheel and the rest tank-to-wheel. Likewise, there are assumptions made for the filling rate of each transport mode and that the bigger a terminal is the more energy efficient it is. Similarly, assumptions about the topography and type of road are made. The capacity of each vehicle type is provided and also how the energy is calculated for the terminals.

4.1.3 Comparison to NTM tool

Compared to the NTM tool[3], the tool from the Swedish Transport Administration is a lot simpler. It does not require as much input as the NTMcalc. The NTMcalc includes also "air" as mode of transport and the tool offers a lot more options on different vehicle types. Typography can be adjusted, carrier capacities, load factors, the average fuel consumption, fuel type and other variables. It shows how many vehicles need to be used for the entered shipment (e.g. 1.58 vehicles). The results provided are then CO_2, CO_2e, SO_2, CO, HC, CH_4, NO_x, N_2O, PM, energy and fuel consumption. And all of them are provided from well-to-wheel and tank-to-wheel. In the NTMcalc the real destinations can be entered (e.g. Gothenburg) to see the distance and an estimation about the topography. Besides, the tool from NTM is available in English and a very simple version of this tool is also available, where similar data to the tool of the Swedish Transport Administration is needed.

[3] Tool available at (but only with Login data): www.ntmcalc.org

Table 5 Comparison to NTMcalc

Input data	NTMcalc	Swedish Transport Administration tool
Distance	X	X
Weight of Shipment	X	X
Volume of Shipment	X	-
Fuel type	X	-
Road type	X	-
EURO standard	X	-
Gradient / Topography	X	-
Cargo Carrier Capacity	X	-
Fuel consumption	X	-
Well-to-wheel	X	partly
Tank-to-wheel	X	partly
Vehicle type	X	X
Load factor	X	-
Cargo Type	X	-
Electricity Mix	X (EU/ SE/ Green)	X (EU/SE)

4.2 Connection to theory

4.2.1 Overview of the approach of the tool in theoretical background

The tool does not take the whole life cycle or well-to-wheel approach into consideration, but for regional and local emissions solely calculates for the tank-to-wheel part and only for energy and CO_2e well-to-wheel. Moreover, the user cannot choose between the approaches, but has to take the well-to-wheel for CO_2e and energy and the tank-to-wheel for the others. Thus, it does not reflect the emissions caused just by the performed transport, but also not totally for the whole well-to-wheel approach. But for choices of changing a whole logistics or transport structure this could be of importance. As to see how much time it takes to actually gain benefits regarding the environmental performance out of a new structure, the additional emissions caused by the whole product life cycle are important to take into consideration. The approach to calculate the emission is output-based in the tool, as it calculates based on what is actually transported. This goes along with McKinnon's (2007) claim that for transport this approach is advantageous for such calculations.

The tool assumes filling rates, which seem to be fairly realistic, and not a specific mode is whitewashed from that point. Indeed, the tool is missing IWW – ships totally. Moreover, IWW is not an option in the tool.

4.2.2 The tool connected to McKinnon's model of Green Logistics

Now it will be analyzed, if the nine adjusting screws for green logistics (modal split, average handling factor, average length of haul, average load on laden trips, average per cent empty running, energy efficiency, emissions per unit of energy, other externalities per vehicle-km and per unit of throughput, and monetary valuation of externalities) are taken into consideration for the tool, as these are the decisive factors with which the impact of transports can be accustomed.

First of all, the modal split is relevant. The tool does fulfill the requirements of modal split, as it shows a variety of different types of vehicles even within a specific mode. Moreover, one transport can be split up, if there is more than one mode used. Nonetheless, the mode of aircraft is left out in the tool, which indeed accounts for the smallest part of transports within Europe. However, as it is still a possibility and it might be used from some companies, it could also be included as an alternative in the tool. The average handling factor is incorporated in the tool, as terminals as such are part of the tool and each time a consignment is transshipped additional energy is used and exhaust fumes are emitted. Given in the tool is also the average length of haul. For each leg of a transport chain, the length of the leg can be entered. As a result, the user can see immediately the effects of shortening or lengthening a route by route optimization, or also the effects of consolidation and, thus, extending length of haul and the average handling factor. For the average load on laden trips goes the same as for the average length of haul. The user can enter these data and the tool itself then "decides" upon how many vehicles are needed for that weight. But, it is assumed that each vehicle has only a certain filling rate, which is fixed. Based on this filling rate the emissions are then calculated. The average per cent of empty running is not included in the calculations of the tool. This is a drawback as this is a large field of potential optimizations in transports. Though, for shippers with rather small consignments, which are using third party logistics providers to carry the goods it is out of their scope and optimization along load factor can then only be carried out by the carrier. This is a part which would in fact be hardly or impossible to include in such a tool, as it would surpass the feasibility and capacities of such a tool.

Energy efficiency is shown as one of the results of the tool. Not in the way as it is defined by McKinnon (2010a), therefore, as the ratio of travelled distance and consumed energy, but as consumed energy per tkm. The emissions per unit of energy are not shown specifically in the tool. As well, this cannot be carried out by the tool, as this variable differs with the type of fuel or energy source that is in use. And the tool does not offer the option of entering the source of energy or fuel, as this is already included in the default data. But these are fixed numbers in the tool and also not in the range of influence of a shipper. Other externalities per vehicle-km and per unit of throughput are not included in the tool. Still, the main focus is about measuring CO_2e and the emissions and not about general societal externalities. Besides, societal impacts of transport such as noise and vibration are not to be reported from companies and measuring those is even harder than emissions. Thus, methods for doing so do not exist especially not in rather simple calculation tools such as the one in scope of this study. Monetary valuation of externalities is not given in the tool. Though, this is also not the focus for a company as so far the measurements of transport emissions are not included in payments of externalities of companies. Similarly, this adjusting screw is more in the scope of authorities as authorities need to develop systems, on how to monetize the external effects of transports and how to divert these costs to the polluter.

Table 6 Parameters integrated in the tool

Parameters	High	Sufficient	None
Modal split		X	
Average handling factor	X		
Average length of haul	X		
Average load on laden trips		X	
Average per cent empty running			X
Energy efficiency		X	
Emissions per unit of energy			X
Other externalities per vehicle-km and per unit of throughput			X
Monetary valuation of externalities			X

4.2.3 The tools usability as Key performance indicator

Now the tool is analyzed along the characteristics of logistics metrics, which were identified by Caplice and Sheffi (1994) and that a metric should have (with varying degrees of the characteristics) in order to be useful within a company. Validity, as defined by Caplice and Sheffi (1994), is given in the tool, in the sense that there is no 100 per cent accurate measurement existing for transport and its emissions as it is very complex. So, the tool works with average data given by NTM. Nevertheless, users must be aware that the tool is simplified and only measures based on average values and emissions only directly caused by transport. The robustness is restricted as to compare results over a longer period of time it takes a lot of manual work to enter all the values. Furthermore, comparison would need to take place in an outdated way of comparing excel sheets. The results of the tool are easy to understand, so, usefulness in the sense of Caplice and Sheffi (1994) is given. The integration is hard to rate, as it depends on the point of view, what are the actual relevant factors for measuring emissions of transport. Still, the tool is very simple and there are not many user-individual factors that can be entered. The characteristic of economy is not given by the tool, as is takes a lot of time to enter every single transport and then to save every excel sheet separately. Which makes also, as stated above, comparisons between different solutions and comparisons over time rather time consuming. Compatibility is given, as information that is needed for the calculation should mostly be available in the company. Or at least realistic assumptions can be made. For reasons of simplicity, the level of detail is not that sufficient. Results are detailed as different emissions and CO_2e are stated. But the calculations are mostly based on average values (topography, filling rate and others). However, this is information that is too complicated to be accessed and available to a shipper. Behavioral soundness is not a big problem with the tool, as emissions from transport are rather complex to calculate and are never accurate (due to average value based calculations and other factors which cannot be taken into consideration such as driver's behavior, fuel in use, etc.) people have no incentive for counterproductive acting. Still, when assumptions are made for vehicle types, this can be done in advantage of the company, so if numbers are published they look better as they might be. Especially, because there are no regulations regarding measuring emissions of transports. But on the other side the vehicle types in the tool are all weighted with an average of EURO I to V engines.

Regarding the function of KPIs, especially environmental KPIs, so far there is no requirement from the governmental side to report emissions caused by transports. Also, the government does not put any obligations on companies on how to measure or calculate the emissions. The only stakeholder requiring figures for emissions are the customers of companies. They are interested in these numbers, because often companies put requirements on their suppliers regarding environmental topics and, for that reason, they need to know these numbers.

Table 7 Characteristics integrated in the tool

Characteristics	High	Sufficient	None
Validity	X		
Robustness		X	
Usefulness	X		
Integration		X	
Economy			X
Compatibility	X		
Level of detail			X
Behavioral soundness		X	

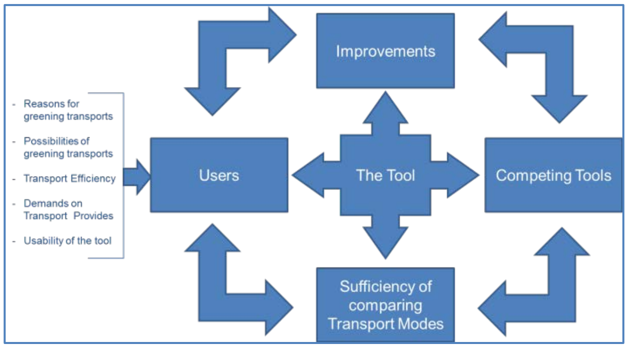
4.3 Conclusions of the tool

The tool from the Swedish Transport Administration is kept simple and does not allow the user to enter many data. At the same time, it does not require the user to have a too in-depth knowledge about all the different factors of a transport solution, because the tool has valid default data, taken from NTM. When the tool is connected to the theory from chapter two, it can be concluded that the tool has a good approach (output-based) and the assumptions are rather realistic. However, the tool is missing IWW ships and air as transport mode. The most variables from McKinnon's model of Green Logistics (2010a) are not fulfilled by the tool, which is a major drawback from a theoretical point of view. Also, the tool turned out to only fulfill three characteristics of logistics KPIs to a high degree, three to a sufficient degree and two are not fulfilled. Although, not all characteristics can be fulfilled 100 percent by a KPI, the usage of the tool in this context is questionable.

5 Results of the empirical research

In this chapter the empirical findings from the data provided by the companies of some real cases and the interviews are presented according to the model from chapter two.

Figure 10 Model for empirical research



The real logistics cases are referring to the sufficiency of comparing the modes and improvements and usability of the tool. The other points will be covered by the interview results.

5.1 The real logistics cases provided by the companies

5.1.1 Assumptions

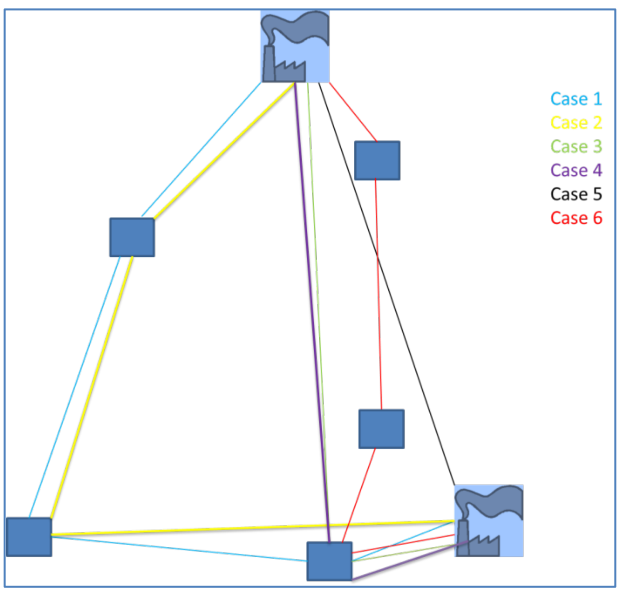
Assumptions were made by the author, if corresponding information was not provided from the companies. Those assumptions are:

- Trains are always “middle” sized, because then the results are not extreme in one direction.
- Trains are “SE”, if they only run in Sweden, because then the energy only comes from Sweden.
- Trains are “EU”, if they cross borders or not in use in Sweden, as then the EU energy mix, needs to be used.
- Road is “internationell dragbil med trailer” as this is the common truck with one normal sized trailer
- “Ro/Ro” has 2000 lm, because Company B stated it as typical size.
- Terminals are “middle” sized, because then the results are not extreme in one direction.

5.1.2 Description of the cases

In this section a short description of the different cases from the companies will be given, in order to understand the results better. As aforementioned, Company A and C provided cases for the six different scenarios as introduced in chapter three. Therefore, the distances, point of origins and destinations, and terminals location varied in each scenario. Company B provided data for six different transport solutions, but from one point of origin to one point of destination. Figure 11 illustrates the different solutions for one dedicated transport from Company B, to make it more conceivable. Furthermore, Appendix 4 includes the original data, as provided by the companies, in order to see the differences between the available data for the researcher. The alternative solutions for Company A and C come from the researcher, and were not provided by the companies.

Figure 11 Logistics Cases from Company B - 6 ways of delivering from A to B



5.1.3 Results from the cases

In Table 7Table 8, Table 9 andTable 8Table 10 are the results shown from the tool, to keep it lucid, only energy use and CO_2e are shown in the table. Alternative solutions are always with electrified rail, as it is supposed to be cleaner. For routes on land Google Maps[4] (Google, 2013) was used, for sea Sea distances[5] (sea-distances.com, 2013) was used. To see if terminals are available general knowledge and different sources such as Port of Gothenburg[6]

[4] http://maps.google.se/
[5] http://sea-distances.com/
[6] http://www.portofgothenburg.com/Line-selection/

(Port of Gothenburg, 2013) and DB Schenker[7] (Deutsche Bahn AG, 2011) were in use. The proposed routes are not checked on their feasibility, thus, for example is there a rail solution in place from A to B. Also, as distances are taken from Google Maps, the distances for Rail could differ, however, there is not data available for such an inquiry online. In fact, rail solutions could just not be in place for the proposed alternative solutions or no direct connections are available, which would increase the distance to travel and, therefore, the emissions. The solutions are also no proposal to the companies, but rather just different scenarios to make an evaluation of the tool more in depth.

Results Company A

Table 8 Results Cases from Company A

	Modes	Destinations	Distance (km)	Energy (kWh)	CO_2e (kg)	CO_2e (g/tkm)
Case 1	Road	TI-TV	82	499	125	51
Case 1 alternative	too short, no alternative provided					
Case 2	Road - Rail - Road	KT-NS-DB-SG	1,478	4,115	1,074	30
Case 2	Road - Rail (Diesel) - Road	KT-NS-DB-SG	1,478	6,205	856	24
Case 2 alternative	Road - Sea - Road	KT-MM-TM-SG	877	4,939	1,135	53
Case 3	Road - Rail - Road	AH-HB-DB-DO	976	2,892	725	27
Case 3	Road - Rail (Diesel) - Road	AH-HB-DB-DO	976	4,731	532	19
Case 3 alternative	Road - Sea - Road	AH-MM-TM -DO	807	5,264	1,200	53
Case 4	Road	MB-SG	331	1,732	437	55
Case 4 alternative	Road - Rail	MB-SC-SG	391	1,470	289	31
Case 5	Road	ZB-ME	955	3,228	814	55
Case 5 alternative	Road-Rail-Road	ZB-RB-SB-ME	1009	1881	466	30
Case 6	Road	BM-AH	1,895	2,190	552	55
Case 6 alternative	Road-Rail-Sea-Road	BM-BD-LB-TM-MM-AH	1980	986	247	29

[7] http://gueterfahrplan.hacon.de/bin/db/stboard.exe/dn?

Results Company B

Table 9 Results Cases from Company B

	Modes	Destinations	Distance (km)	Energy (kWh)	CO_2e (kg)	CO_2e (g/tkm)
Case 1a	Rail - Sea - Rail - Road	KV-GB-ZE-DD	1,848	12,994	2,874	27
Case 1b	Rail (Diesel) - Sea - Rail (Diesel) - Road	KV-GB-ZE-DD	1,848	17,077	2,940	27
Case 2a	Rail - Sea - Road	KV-GB-ZE-DD	1,806	15,331	3,480	33
Case 2b	Rail (Diesel) - Sea - Road	KV-GB-ZE-DD	1,806	17,729	3,723	35
Case 3a	Rail - Road	KV-DD	1,593	4,963	1,722	18
Case 3b	Rail (Diesel) - Road	KV-DD	1,593	12,644	918	10
Case 4	Road - Road	KV-DD	1,431	19,210	4,691	56
Case 5	Road	KV-DD	1,412	18,165	4,582	55
Case 6a	Road - Rail - Road - Road	KV-NK-HE-DD	1,685	10,403	2,669	27
Case 6b	Road - Rail (Diesel) - Road - Road	KV-NK-HE-DD	1,685	16,842	1,994	20

Results Company C

Table 10 Results Cases from Company B

	Modes	Destinations	Distance (km)	Energy (kWh)	CO_2e (kg)	CO_2e (g/tkm)
Case 1	Road	KO-ST	467	1324	334	55
Case 1 alternative	Road - Rail - Road	KO-GB-ST	474	730	56	9
Case 2a	Road - Rail - Sea - Road	LL-GB-GE-AN	2,921	6035	1,115	20
Case 2b	Road - Rail (Diesel) - Sea - Road	LL-GB-GE-AN	2,921	8510	1,366	24
Case 2 alternative	Road - Sea - Road	LL-GB-GE–AN	2,917	1,4016	3,503	50
Case 3 Carrier A	Road - Sea - Road	VN-TB-TM-ZW	900	210	48	54
Case 3 Carrier B	Road - Sea - Road	VN-MM-TM-ZW	895	207	48	53
Case 3 alternative	Road - Rail - Sea - Road	VN-NS-TB-TM-ZW	1,062	112	17	27
Case 4	Road	VN-ST	362	79	20	55
Case 4 alternative	Road - Rail - Road	VN-NS-ST	382	63	7	20
Case 5	Road - Sea - Road	SH-GB-GE-AW	1,372	4,448	1,098	44
Case 5 alternative	No alternative provided					
Case 6	Road - Sea - Road	AB-TM-TB-ST	1,717	9,715	2,334	54
Case 6 alternative	Road - Rail - Sea -Rail - Road	AB-MN-LB-TM-TB-ST	1,844	2,997	690	27

Road is of course part of every solution as it at least serves the final leg of a transport. As can be seen in the table, the environmentally better solution is to use rail. As there the distances are shorter than by sea transport and emissions are significantly lower. The results reflect what was partly to expect, as the more rail and sea (“the green modes” see chapter 2) are in use, the more the emissions decrease. Furthermore, the distance is not long enough that SSS would surpass the performance of rail (see chapter 2). However, it also becomes obvious in the results that when more different modes are in use, the longer the distance to travel gets. And mostly using rail results in the longest distance to travel, compared to other solutions. But also, already on a total stretch of around 1,400 km for road transport additional 400 km with rail transport are still much better when it comes to emission reduction, as can be seen when comparing Case 1 and 5 with regards to distance and emissions. Interesting is the fact that if Diesel-based trains are in uses, the consumption of energy increases but emissions of CO_2e decrease. This goes for all train solutions, where the train is running on EU electricity. When a train is running on Swedish electricity, the case is different: electrified train is environmentally more efficient than Diesel then. Another finding here is, if cases four and five of Company B are compared, it can be seen that there is only a difference of around 20 km, but the CO2e g/tkm is already one g/tkm higher. This is probably not due to the 20 km extra travel, but rather to the transshipment taking place in the terminal. Therefore, the tool proofs that the average handling factor of goods have an impact on the environment.

5.2 Results from interviews

The covered topic areas of the interviews were:

- Possibilities of greening transports
- Reasons for greening transports
- Purchasing demands on transport providers
- Transport efficiency
- Measuring emissions from transport
- Tools in use of the companies
- Tool from the Swedish Transport Administration
- Usability of the tool
- Sufficiency of comparing different modes
- Improvements for the tool

Even if the tool from the Swedish Transport Administration is not in use, benefits and drawbacks that the companies mention with their own tools can be partly transferred to the tool from the Swedish Transport Administration. These topic areas will now be discussed based on the results of the interviews. In Appendix 5 is additional information provided of the interviewed persons.

5.2.1 Users

Possibilities of greening transports

All three companies within the study are looking for ways of greening their transports and all of them are aware of the initiative of Green Corridors. However, there are different approaches from the companies for greening transports. Nonetheless, one common solution was intermodal solutions (Company A and B) and improving filling rates (Company B and C, Company A did not mention the filling rate in the interview, but shows improvements in this field in their sustainability report) are important factors of becoming more less damaging to the environment with transport solutions. Furthermore, each company puts requirements on its transport providers to at least ensure that vehicles with a high environmental impact are not in use for their transports. So, for example, company A does not allow trucks older than ten years (which would be between EURO III and IV standard (see Appendix 2) and Company B requires also at least EURO III and for new investments EURO V. Additional options that came up and that are utilized to reduce the environmental impact of the transport are for company C to choose the "right" mode for dedicated transports, which means, evaluating the environmental impact before implementing a transport solution, the routing of vehicles, choice of equipment, and research upon, how to reduce fuel consumption. Moreover, for company C supply chain integrating factors can become crucial such as predictability towards the carrier and supplier, thus, good information flows, to ensure better planning. This facilitates higher utilization of the vehicles. Company B is already taking environmental impacts in consideration when setting up loading systems to be more efficient during transshipments in order to then be able to slow steam, which means to slow down the speed of a vessel and so reducing bunker fuel consumption and emissions, and increased use of short sea shipping.

To sum it up, there are several ways of making transports better with regards to the environment. Still, the two most important ones are for the companies' intermodal solutions and improvements of the load factors.

Reasons for greening transports

The reasons why companies are looking for new transport solutions vary a bit. Whereas, two companies have the same direction of reasons, the third one differs from that. Company C's main focus is to eliminate waste in all processes and through waste elimination creating more efficient solutions. More efficient solutions are then leading to cost reductions and are lowering the environmental footprint of the company. For Company B cost and services towards the customer are the main drivers for new logistics and transport solutions, hence, green logistics. But according to them, this can only be gained through more efficiency in the solutions, which for them goes hand in hand with a reduction of the environmental impact. As a consequence, cutting costs through more efficient solutions in transports nowadays means to reduce also the environmental impact of the transports. However, they are evaluating how a new solution does effect the environment, and if the solution would be more efficient and more cost effective, but worse for the environment, they would not take this solution but rather check for others. The environmental aspect is, in fact, important but not decisive. For

Company A the case is different, as their main driver is the environmental footprint and they accept to have higher costs related to intermodal solutions. Moreover, they can increase their capacity with intermodal solutions and, therefore, reduce the number of trucks running on the roads.

All in all, reasons for improving the environmental performance of transports are economical and efficiency reasons, but also ethical motives.

Purchasing demands on transport providers

All three companies have requirements regarding environmental aspects on their carriers. Company A has very strict requirements on their transport providers and they are incorporated in the contracts. If a supplier does not fulfill those, the contract is cancelled. Company B puts pressure on the suppliers to make them improving their environmental performance and Company B tries to control as much as they can upon which modes and vehicles are in use. Company C has a yearly follow-up with its carriers and they are also discussing topics such as the engine types but also eco-friendly driving and trainings for the drivers.

In summary, all companies have purchasing demands on the carriers regarding the environmental performance.

Transport efficiency

Efficiency in transport is for Company B related to the use of fewer resources, which means less environmental impact of a solution. However, if third party logistics providers are engaged it is not 100 per cent in the hand of the shipper what type of vehicle is used and how efficient a transport is performed in total. But efficiency in transport means also reduction in environmental damages. For Company C efficiency in transport means to satisfy the demand for transport work in the most efficient way. Thereby, reducing waste in all processes of a transport, therefore, for example run only full trucks and no empty backhauls.

To sum it up, transport efficiency goes for the companies hand in hand with reducing the environmental impact of transports.

Measuring emissions from transport

All companies in the study are only measuring their carbon footprint from their transports. Other emissions are either not calculated at all (Company A and C) or only in special circumstances (Company B), such as customer request or in the process of evaluating new transport solutions. Main driver for the calculation is reporting to the management and publishing figures in the annual or sustainability reports, this applies for all three companies. Company C only takes the tank-to-wheel emissions into account, but other approaches such as well-to-wheel are in discussion for the future. As an internal KPI it is only used by Company C. But in general Company B stated that it is rather complex to measure the emissions caused by a shipper, as a shipment can also only be part of a bigger transport from a carrier and, consequently, the accuracy of calculation from the shipper goes down.

It can be concluded that companies are measuring the carbon footprint, but in addition to it, other emissions are more or less neglected.

Usability of the tool from the Swedish Transport Administration

Company A stated that the tool from the Swedish Transport Administration might be useful to those who do not have any other tool. Company B stated about the usability of the NTM tool, which can be also said for the tool in focus then, that it is user-friendly as only limited data input is required (even less for the tool in focus). This could be more advanced and, thus, representing more accurate results. Though, for Company B there is a trade-off between accuracy of calculations and user-friendliness. People would not use tools that are rather complex and require too much input data. This is also in accordance with a statement from Company C, that the biggest problem, when calculating emissions is that a lot of data are not available and connected to uncertainties. Therefore, the tool from the Swedish Transport Administration already offers a lot of default data, about which the user does not need to be concerned. Nevertheless, both companies (B + C) agree that it is hard to handle a lot of data, and it is easy to compare one single flow with two different options, but for more it is rather time consuming as it requires a lot of manual work.

Recapitulating, the tool from the Swedish Transport Administration is rated as user-friendly, and the default data is good. But it is not possible to handle a lot of data.

5.2.2 Competing tools

Tools in use of the companies

Company A is using their own tool for calculating CO_2 emissions. Further information was not provided on their tool. Company B stated that they use the tool “as everyone else” and that is the tool provided by NTM. This tool is in use because Company B uses it for several years now and even if the measurement of the emission would not be 100 per cent correct, at least the internal comparison over the years would be right. So at the moment, they do not want to switch to another tool, as it is a rather big step to switch the tools. Furthermore, the NTM tool is well recognized in Europe and has according to Respondent from Company B (see Appendix 5); the acceptance by the EU and the tool is in English and can, as a result, be used at any location. Moreover, the NTM tool offers options to change the load factor and other settings. Company C created some years ago its own database, which suits their requirements and needs the best. Additionally, there was not really a tool available, when they created their own. However, the calculations in their database are also based on NTM data and methodology. Company B's tool reduces their manual work and is integrated in their IT-system, which reduces work load.

Essentially, all companies have tools in place and they are satisfied with those and switching the tool would be connected to high efforts.

Tool from the Swedish Transport Administration

Company A is aware that there is a tool provided by the Swedish Transport Administration. But no further information is available, neither about the tool in focus or the tool Company A uses for its calculations. Company B is not using the tool from the Swedish Transport Administration as they are using the tool from NTM. They also have not looked into the tool from the Swedish Transport Administration, but according to them, most tools nowadays are very similar, and have only smaller variations in the assumptions. Even if Company C is not using the tool from the Swedish Transport Administration, they grappled with the tool and came up with some conclusions. According to Company C, the tool in focus of the study is good for two reasons: First of all it is easy to use, because only limited data is needed and secondly the effects of changes in modality are easily available and good to see.

To sum it up, no company, which was interviewed, uses the tool from the Swedish Transport Administration.

5.2.3 Sufficiency of comparing transport modes

Sufficiency of comparing different modes

Company B elucidated that the figures which are provided by NTM are accurate and as mentioned before, there are no significant differences to others, in their opinion. However, measuring transport emissions is not an exact science with one ultimate truth. All assumptions behind tools are average based, but based on these averages it is possible to compare different mode solutions in a good way and to see the effects of specific changes. This goes along with Company C's opinion about the tool of the Swedish Transport Administration.

So, the tool is good to compare different solutions and it is easy assessable how a change in modality effects the environment.

5.2.4 Improvements

Improvements for the tool of the Swedish Transport Administration

In the future authority will most likely, according to Company B, require the companies to publish data upon their transports and the associated emissions. Therefore, the possibility of integration into the ERP system would be of great use. As a result, integration in the IT-system would facilitate the work, which would obligatory to do, if it is legally required. But for a rather simple and free of charge tool, this is a too high expectation. Also while looking at the tool from the Swedish Transport Administration during the interview it turned out, that the vessel Company B is using, is not available as an option. This could be a point of improvement for them, according to the respondent, since most short sea ships in the Baltic Sea and also in the EU are pure Ro/Ro vessels. These are not included in the evaluated tool. Company C sees it as potential improvement for the tool to be able to change the filling rate, as this is one of the more common solutions for shippers to green transports. The vehicle type is in the responsibility of the carrier and then not in the influencing field for the shipper. In the tool from the Swedish Transport Administration the basic assumption is that the shipment is always a part of a bigger shipment, which should be an option to choose.

To sum it up, changing fill rates would be a major improvement to the tool.

Below (Table 11) is a summarizing overview of which company provided information to which field of the study. If one box is not ticked, the company did not provide any or no sufficient information about the dedicated topic area.

Table 11 Contribution of the companies to different topic areas

	Company A	Company B	Company C
Possibilities of greening transports	X	X	X
Reasons for greening transports	X	X	X
Purchasing demands on transport providers	X	X	X
Transport efficiency		X	X
Measuring emissions from transport	X	X	X
Tools in use of the companies		X	X
Tool from the Swedish Transport Administration	X	X	X
Usability of the tool		X	X
Sufficiency of comparing different modes		X	X
Improvements for the tool of the Swedish Transport Administration		X	X

6 Analysis of the findings

In this chapter the theoretical and empirical findings will be analyzed along the research questions. Also drawbacks of the tool are stated and a summary of the criteria that the tool fulfills is given.

6.1 Sufficiency of the tool in measuring the emissions of shippers' transport solutions

Research question one asked for the sufficiency of measuring the emissions of a company's transports with the tool provided by the Swedish Transport Administration. From theory it can be concluded that there are several different options on how to approach the calculation of the emissions caused by a dedicated transport. The tool provided by the Swedish Transport Administration does only provide the CO_2e emissions in the well-to-wheel approach and the others emissions only for the tank-to-wheel. It does not allow for the option to choose or see both levels. Hence, it shows some emissions caused just by a specific transport and not the whole chain of events caused by new transport solution implementation is taken into consideration. This does not mean that it makes the tool worse or superior over other tools, which are taking those things into consideration. The user, however, needs to be aware of that fact, as it could influence at least short term decisions. Besides, the numbers on which the tool is based upon are taken from NTM. And NTM seems to be well recognized not only amongst the companies, but also researchers seem to find NTM a reliable and fairly accurate source when it comes to figures related to transports and emissions (Dekker, 2012). In fact, it can be said, that the tool is not calculating the emissions 100 per cent accurate, but for today's knowledge it bases on fairly accurate numbers and average assumptions of today's transports. Therefore, getting as close as it is possible within a certain frame to precise results. Similarly, for the industry it seems to be of lower importance to see the exact numbers, but rather to get approximate numbers of average transports and compare those to each other. Likewise, if it is looked at the reasons why companies measure their emissions and why they want to have more environmental ways of transporting their goods, cost and efficiency seem to play the most important roles. Even though, Company A answered that it is just for the environment, compared to Company B with the very green image, which stated that economic reasons are also important, it could be questioned if this answer is related to social desirability. According to the findings from theory, it can be outlined, that Company A and B are driven by ethical motives (Bansal, 2000). Yet, from Company A this could be as mentioned in the methodology a social desirable answer (Musch, 2002) and, consequently, been given for image reasons, which is also a driver for “Going Green” (Lynes, 2006). Company B and C are, moreover, driven by economic reasons, hence, reducing costs and increasing efficiency. Not specifically mentioned drivers from the companies were stakeholder pressure, competitive advantages, avoiding legislative enforcement, and increased employee productivity (Lynes, 2006; Bansal, 2000). Nonetheless, the tool does not state anything about these two decisive points for companies. Even if comparing two solutions, a company still needs to calculate the actual saving in energy (which refers to efficiency and costs) manually themselves. But an advantage of the tool is that it is stating results for emissions other than CO_2. This might not be of such a big interest of companies at the present, but the trend seems to be towards customers requiring such information and companies working on solutions for other emissions. For that reason, it is also beneficial in the tool that the indirect GHG emissions are directly converted into CO_2e. But the tool calculates only well-to-wheel for CO_2e, which might not fit to companies’ approaches, as they might only be interested in the tank-to-wheel carbon emissions and the tool does not allow for switching the approaches. Nonetheless, stating the pure CO_2 emissions and not just CO_2e, would give even more value to companies, as often they are required to state CO_2 emissions. Also, the answers from the companies are contradicting the statements for greening of transports, as all companies are eager to do so, but when it comes to measuring those changes and impacts on different emissions and taking CO_2e into consideration, the companies are lacking this kind of benchmarking.

Summarizing, the sufficiency to measure emissions are given in the tool, provided that there is no 100 per cent correct measurement and that the user knows about this.

6.2 Possibility to compare different transport solutions in an efficient way

This leads directly to the second research question about the extent to which it is possible to compare the different transport solutions and modes of transport. In the theoretical part of the paper were the different modes described and how they affect the environment. For road transport it was stated, that there have been some technologies being developed within the last decades and that also the introduction of the different European emission standards caused the commercial vehicles to emit less exhaust fumes and, therefore, also less CO_2e (Piecyk, 2012). The tool does take a weighted mixture of the different EURO standard engines from I to V. But it can be assumed that nowadays few EURO I trucks are running. Also, from the empirical findings it became apparent that at least all the companies, which are part of the study, require their suppliers to use at least around EURO III or IV standard vehicles.

As a result, in the tool, the road mode is classified worse than it might actually be in reality nowadays. This is a point that needs to be taken into consideration when changing the logistics structure, as certain flows might be close to a “trade-off-point”, where it could be better to use the more emitting mode but, as a result, having a shorter distance resulting in lower absolute CO_2e emissions, which goes also along with the findings from the IFEU and SGKV study (2002). But this applies probably only for rather short distances. Also, that rail is always referred to as the green transport mode, but that there are situations when this is not true, especially in countries where there is a lot of energy produced by coal power plants. In the tool there is an assumption made about energy mix, but not stated how this is built up. But as shown before, the main part of energy in Europe is bad when it comes to exhaust fumes (eurostat - European Commission, 2012). Likewise, with the cases from the companies, it can be seen, that rail is still producing less emission then road, even when powered by combustible energy sources. This might be true in most cases, but in the tool it is true for all tested cases. Here the tool provides a good way of comparing modes on their average values, but not specifically. But then the tool is constructed for long distance freight flows. For those rail and sea transportation are often beneficial over road transport. Furthermore, the results from the real cases showed that Diesel trains are better for the environment then electrified trains in the tool. This is interesting as the result contradicts McKinnon’s (2007) statement about rail in Europe, as he states that electric traction is causing only half of the emissions. Correspondingly, Dekker (2012) who based his data on NTM, as the tool does, shows different results for emissions of electrified and Diesel traction rail. This could be an error in the tool. Or the energy mix, based on which the emissions of electric trains are calculated, are heavily weighted with combustible energy sources, such as coal. However, it needs to be differentiated between trains running in Sweden: here the results from test calculation show better environmental impacts then Diesel run trains. Although, still the energy generation from combustible fuels makes up for more than 50 per cent of the total energy generation (eurostat - European Commission, 2012) in the EU average, the questions is, if it worsens the performance of electrified rail like in the examples from the empirical real logistical cases. Still, theory shows another direction, also based on EU average. A positive feature of the tool is the differentiation between EU trains and Swedish trains, as from the results can be assumed, that Swedish trains run on much cleaner energy than EU average, which is true according to the findings in chapter one numbers from Statistics Sweden (Statistics Sweden, 2013).

The empirical findings from the interview show that for the companies the comparison of different modes seems to be sufficient in the tool provided by the Swedish Transport Administration. As they usually do not have that specific information available about which power origin is used and on which engine a vehicle is running. However, the problem with the tool here is that any shipment is just rated as part of a bigger shipment and with a higher utilization rate road could become more competitive to rail when it comes to environmental impacts. This is what is not taken into consideration in the tool. For that reason, the tool offers a good solution to compare different transport solutions quickly and to get impressions about the environmental footprint they cause. But when going more into detail and comparing along load factors and the possibility to improve those, the tool cannot provide sufficient information and deliver comparable results for different solutions. Furthermore, the tool does only provide limited information about the efficiency of a transport solution, but efficiency seems to be of high importance to the companies. For example, Company C is reducing waste in all processes of a transport, therefore, for example run only full trucks and no empty backhauls, which goes along with Kim and Min's (Kim, 2011) statement about "Green". But as stated in the theoretical background, efficiency is a rather complex topic and the rebound effect can lead to even higher environmental impacts, which cannot be measured (Herring, 2006).

Recapitulating the results of the tool to compare different modes of transport might be sufficient in practice, but from a theoretical point of view the results are too contradictory to previous findings and also road as mode is rated too bad.

6.3 Usability of the tool

The third research question is only answered from empirical data. Yet, it turned out, that from the chosen sample no company does use the tool in their daily business. But from the answers they gave about their tools and also how they grade the tool in the scope of this study, some conclusions can be drawn for the usability of the tool in daily business. Positively rated is the simplicity of the tool as it does only require three different types of data input and for the rest there are default data in the tool. Besides, this default data is of good quality as it is based on the NTM data. Nevertheless, the companies that were studied have only limited knowledge about the type of vehicle that is in use, for example there is no specific knowledge about the fact if a train is electrified or running on Diesel. Contradictory is the statement one hand that the tool is good, because not much input data is required and on the other hand that the vehicle type is at present information that could not be provided by the companies in all cases. So in general, shippers might only have the knowledge about what mode is in use and put minimum requirements on the carrier regarding the engines or the age of the vehicle, but which type is specifically used is not known. The transport itself is still performed by the carrier and, hence, within its responsibility. A major drawback of the tool is that shippers try to green transports by optimizing the filling rates of the vehicles; this is a fixed value in the tool and, therefore, one of the major points for companies to optimize transports and reduce the environmental footprint is neglected in the tool. However, the average filling rates of the different modes seem to be reasonable, except for the ships, which seem to have a rather high load factor with 80 per cent. Nonetheless, the tool does not work in favor of a particular transport mode.

6.4 Drawbacks on the tool

Additionally, it takes a lot of manual work to get results from the tool, as it is Microsoft Office Excel based and all the data need to be typed in manually and cannot be generated from the ERP system or the tool cannot be integrated into a company's IT-system. Moreover, companies might be reluctant to use the tool, as it is too time consuming. Also, the tool is only available in Swedish; in consequence, it is inconvenient to use it for people which are not Swedish speaking. As a result, for an international company, it is more unlikely to use the tool, as it is preferred to have one tool in use across all countries, where it is operating. Similarly, the preset list of modes and specific types within those modes is rather inconvenient for the companies, as some of the types are not available or the information about it is not available to the company. Besides, there are a broad vary of different types of terminals available in the tool, but, only one of the companies was able to provide information about the terminals. So it seems that this is too detailed in the tool. But in general it is good that terminals are included, as they contribute to the environmental impact of a transport chain. Still, research seems to have not dealt with this topic in detail so far.

6.5 Summarizing the tools performance

In Table 12 are the main criteria for the tool summarized. A tick indicates that the tool fulfills the item, a lightning that it does not. Both point out that there are good points, but, also, disadvantages. A hyphen displays that it is not answered.

Table 12 Indicators fulfilled by the tool derived from empirical findings and link to theory

	Data testing	Interview findings	Link to the Theory
User-friendliness	–	✔	-
Default data	✔	✔	strong
Valid assumptions	✔	✔	strong
Options for input data	ϟ	ϟ	weak
List of available vehicle/vessel types	ϟ	ϟ	weak
Integration of the tool	-	ϟ	-
Language	-	ϟ	-
Usability in daily work	ϟ	ϟ	-
Usability as KPI	-	ϟ	strong
Comparing different solutions	✔	✔	normal
Showing transport efficiency	ϟ and ✔	-	normal

The fulfilled points from empirical findings are the user-friendliness that only requires three different types of data. The given default data, using mixtures of energy source, topography, road types and load factors. The provided data by NTM makes the tool more recognized as the industry acknowledges the data from NTM as reliable and valid. However, there are quite some drawbacks to the tool, which make it less usable for at least the companies subject to this study. Most important the non-changeable load factor and the time it takes to enter and compare solutions in the tool. Therefore, its usability in daily work and the usability as KPI are limited. And a minor drawback, but for international companies not negligible: it is only available in Swedish. For big companies, as such in the study, the tool seems not to deliver the desired features and usability for daily work. As a result, the tool seems to be more suitable for small and medium sized companies. Also, because the tool is for free and small and medium sized companies do not make high investments in environmental tools according to Constantinos et al. (2010). But small and medium sized companies with high impacts on the environment are willing to work on improvements (Constantinos, 2010). As well, for carriers themselves it seems to be not of such great use, as they should have more information in place about transports then the shippers. In fact, a tool should offer carriers more features, such as type of engine, fuel types, and such.

7 Conclusion and outlook on future research

7.1 Conclusion of the study

This study focused upon the evaluation of a tool provided by the Swedish Transport Administration for calculating emissions of transports. The tool was developed in the course of the EU concept of Green Corridors and should enable companies to calculate their emissions and to compare other transport solutions with current ones, to see how it effects the emissions. Still, the tool is not widely used and this study provides information and conclusions of the reasons for that.

The first step was to describe the need for such tools and also put it in a theoretical context. The need to measure emissions is strongly related to stakeholder pressure, which is also confirmed by the empirical findings. However, companies seem not yet to use environmental impacts as benchmarking internally. Therefore, emissions might be a performance indicator, but not a KPI. Moreover, it seems not yet relevant that in this study the tool was evaluated as tool for measuring KPIs. But this might become relevant in the future, when the current trends of transport growth continue.

To what extent is the tool sufficient in measuring the emissions of shippers' transport solutions?

The tool showed surprising results with the real logistical case from Company B, when instead of electrified locomotives Diesel trains are inserted. Else the tool showed strength and weaknesses both from theoretical and empirical side. It seems to be not widely used because at least for the companies subject to the study, it was published too late. They had already put up their own tools, tailored to their own needs or they use the more advanced tool provided by NTM.

To what extent is it possible to compare different transport solutions in an efficient way?

As a major drawback of the tool was the fixed load factor identified as big companies are optimizing along this factor their environmental performance. The tool seems to be more suitable for smaller and medium sized companies, as the results are fairly accurate and the tool is free of charge. In fact, it could be a good starting point for small and medium sized companies that do not have a tool in place yet. As the tool is sufficient for measuring emissions and energy consumption and to get an idea of what could be potential savings of new transport solutions, as long as the amount of data is reasonable.

How is the usability of the tool rated by the target group (i.e. shippers)?

However, the tool needs modifications regarding the usability in daily work, in order to reduce the manual work that needs to be put in to get results. Again, it is more suitable for smaller and medium sized companies, as they do not deal with the same amount of data, as the bigger companies do. Still, it can be assumed that they are not willing to spend too much time on evaluating and measuring transport solutions from an environmental point of view.

7.2 Suggestions for the future use of the tool

In general the Swedish Transport Administration can approach two different strategies in the future: one strategy is to abandon the tool and shift the focus, for example, on the NTM tool. Or the tool is kept, but then some modifications should be done, which are: reduce the amount of choices for type of vehicle/ train type as companies do not have very specific knowledge about this. Likewise, specify which of the terminals an intermodal terminal (Järnvägsterminal or Bilterminal) is and define the size of terminals. Similarly, an English version of the tool could be published. Beyond those modifications, also the target group should be re-defined and appropriate marketing and promotion activities should be thought through. For future research it should be taken into consideration, to find out who are the actual users of the tool and it should be investigated if small and medium sized companies have an interest and need for the tool. Together with the potential users of the tool, should then be developed what they need to know and which information they can provide for the tool, in order to modify the tool accordingly.

7.3 Future research

Research beyond the tool provided by the Swedish Transport Administration should aim at possibilities how to integrate such calculation tools into the IT-systems of companies in order to reduce the manual work and, consequently, increase the usage of the tools. Moreover, integration into the IT-system could increase the level of detail and, as a result, the accuracy of calculations while at the same time not increasing the complexity drastically for the user. Also, it could be investigated upon the possibility of harmonizing the measurements of emissions caused by transports across the industry, in order to get comparable results and to be able to benchmark them. Allocation of emissions from carriers to shippers seems still to be an undiscovered field. Questions such as what is the emission dedicated to a shipper when the shipper has only one wagon of a whole train? And who is to be assigned responsible for empty running?

The field of the transport sector and emissions caused by it is already occupying the attention of the EU for more than 20 years since the first white paper was published mentioning transports and the problems coming along with it. Although, the EU is promoting navigation and rail as future modes, also, the possibilities and technologies that road transport offers should not be neglected, and that it is not necessarily the worst mode to use. At some point in the future probably a harmonized system should be introduced to measure emissions, in order that each firm reports based on the same assumptions. But until this will be realized further research in the whole field of transport emissions and its calculations is needed.

Additionally, more research in the field of Green Corridors is needed. What are the actual benefits of promoting and implementing those? Are they are used in the desired way? And are there ways of calculating the benefits of using a dedicated Green Corridor in comparison to other corridors for companies? These are all questions that should be researched upon in the nearer future.

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Appendices

Appendix 1

Ammonia (NH_3): *“The major use of ammonia is as a fertilizer“* (Encyclopædia Britannica Inc., 2013g).It has effects on the human health such as respiratory ailments (IFA - Institut für Arbeitsschutz der Deutschen Gesetzlichen Unfallversicherung, 2013).

Carbon Dioxide (CO_2): *“Released when fossil fuels are burned. The emissions of carbon dioxide and other gases lead to an increase in the atmosphere of greenhouse gases. The gases allow solar radiation to pass through to the earth but prevent it from radiating back into space. More heat is captured and the earth’s average temperature increases. This is usually called the greenhouse effect”* (Swedish Institute for Transport and Communication Analysis (SIKA), 2005 p. 126).

Carbon Monoxide (CO): *“It is [...] present in the exhaust gases of internal-combustion engines and furnaces as a result of incomplete* conversion *of carbon or carbon-containing fuels to carbon dioxide.“* It is toxic and damaging the health such as the respiratory system (Encyclopædia Britannica Inc., 2013d).

Fluorinated gases: *“Unlike many other greenhouse gases, fluorinated gases have no natural sources and only come from human-related activities. They are emitted through a variety of industrial processes such as aluminum and semiconductor manufacturing. Many fluorinated gases have very high global warming potentials (GWPs) relative to other greenhouse gases, so small atmospheric concentrations can have large effects on global temperatures. They can also have long atmospheric lifetimes--in some cases, lasting thousands of years. Like other long-lived greenhouse gases, fluorinated gases are well-mixed in the atmosphere, spreading around the world after they're emitted. Fluorinated gases are removed from the atmosphere only when they are destroyed by sunlight in the far upper atmosphere. In general, fluorinated gases are the most potent and longest lasting type of greenhouse gases emitted by human activities.”* (EPA - United States Environmental Protection Agency, 2013)

Global Warming Potential (GWP) and CO_2e: *„GWP is an index, based upon radiative properties of well-mixed greenhouse gases, measuring the radiative forcing of a unit mass of a given well-mixed greenhouse gas in today’s atmosphere integrated over a chosen time horizon, relative to that of CO2. The GWP represents the combined effect of the differing lengths of time that these gases remain in the atmosphere and their relative effectiveness in absorbing outgoing infrared radiation. The Kyoto Protocol ranks greenhouse gases on the basis of GWPs from single pulse emissions over subsequent 100-year time frames.“* (Edenhofer, 2011 pp. 959 - 960)

Greenhouse Gas	GWP
CO_2	1
CH_4	21
N_2O	310
HFCs	140 - 11,700
PFCs	6,500 - 9,200
SF_6	23, 900

Source: (Piecyk, 2012 p. 36)

„The amount of CO2 emission that would cause the same radiative forcing as an emitted amount of a greenhouse gas or of a mixture of greenhouse gases, all multiplied by their respective global warming potentials, which take into account the differing times they remain in the atmosphere." (Edenhofer, 2011 p. 956)

CO_2e is calculated by multiplying the specific GHG with its GWP and then divided by 3.67 (Piecyk, 2012).

Greenhouse gases: *"The greenhouse gases covered by the Kyoto Protocol are carbon dioxide, methane, nitrous oxide, hydrofluorcarbons, perfluorcarbons and sulphur hexafluoride. The climate effect of a greenhouse gas is due to the ability of gas to absorb heat radiation, the time of retention in the atmosphere and the quantity of emissions"* (Swedish Institute for Transport and Communication Analysis (SIKA), 2005 p. 126).

Heavy Metals (HM): *„Heavy metals (such as cadmium, mercury and lead) are recognised as being directly toxic to biota. All have the quality of being progressively accumulated higher up the food chain, such that chronic exposure of lower organisms to much lower concentrations can expose predatory organisms, including humans, to potentially harmful concentrations. In humans they are also of concern for human health because of their toxicity, their potential to cause cancer and their ability to cause harmful effects at low concentrations"* (European Environment Agency (EEA) , 2010)

Hydrocarbons: *"Compounds consisting of carbon and hydrogen only"*(Moss, 1995 p. 1341). Such as Methane and Carbon Monoxide.

Hydrofluorocarbons (HFCs): *"Any of several organic compounds composed of hydrogen, fluorine, and carbon. […]Because they are anthropogenic (human-generated) sources of positive radiative forcing, HFC emissions have been targeted for reduction by the Kyoto Protocol"* (Encyclopædia Britannica Inc., 2013h). See Fluorinated gases.

Methane (CH_4): see Volatile organic compounds.

Nitrogen Oxide and Dioxide (NO_x): *"Created when fossil fuels are burnt and lead to a precipitation of acidic substances, contributing to overfertilisation of ground and water. Precipitation crosses national borders and thus also comes from other countries."* (Swedish Institute for Transport and Communication Analysis (SIKA), 2005 p. 127).

Nitrous Oxide (N_2O): Also called laughing gas. Causes death, if too much is inhaled by a human. Also contributes to GHG emissions (Encyclopædia Britannica Inc., 2013e).

Non-methane compounds (NMVOC): see Volatile organic compounds.

Ozone (O_3): *"The ozone, which is useful as an UV filter in the atmosphere is harmful for people, animal and plants in layers of air close to the ground"* (Swedish Institute for Transport and Communication Analysis (SIKA), 2005 p. 127).

Particulates (PM): *"Very small fragments of solid materials or liquid droplets suspended in air […]. The particulates of most concern with regard to their effects on human health are solids less than 10 µm in diameter, because they can be inhaled deep into the lungs and become trapped in the lower respiratory system. […] Major sources of particulate emissions include fossil-fuel power plants, manufacturing processes, fossil-fuel residential heating systems, and gasoline-powered vehicles"* (Encyclopædia Britannica Inc., 2013f).

Perfluorocarbons (PFCs): *"Perfluorocarbons are compounds produced as a by-product of various industrial processes associated with aluminum production and the manufacturing of semiconductors. Like HFCs, PFCs generally have long atmospheric lifetimes and high GWPs"* (EPA - United States Environmental Protection Agency, 2013).See Fluorinated gases.

Sulfur Dioxide (SO_2): *"Created when fossil fuels are burnt and lead to a precipitation of acidic substances. Precipitation crosses national borders and thus also comes from other countries."* (Swedish Institute for Transport and Communication Analysis (SIKA), 2005 p. 127).

Sulfur hexafluoride (SF6):*"Sulfur hexafluoride is used in electrical transmission equipment, including circuit breakers. The GWP of SF6 is 23,900, making it the most potent greenhouse gas […]"* (EPA - United States Environmental Protection Agency, 2013).See Fluorinated gases.

Volatile organic compounds (VOC): *"Organic substances that are created when fossil fuels are burnt and which contribute to the accumulation of ozone in the lower atmospheric layers. The ozone, which is useful as an UV filter in the atmosphere is harmful for people, animal and plants in layers of air close to the ground"* (Swedish Institute for Transport and Communication Analysis (SIKA), 2005 p. 127)

EURO Emission Standards Enforcement Dates

	LCV < 1.305t	1.305t < LCV < 1.76t	LCV > 1.76t, max.3.5t	Heavy Duty
Diesel				
EURO I	Oct-94	Oct-94	Oct-94	1992
EURO II	Jan-98	Jan-98	Jan-98	Oct-96
EURO III	Jan-00	Jan-01	Jan-01	Oct-00
EURO IV	Jan-05	Jan-06	Jan-06	Oct-05
EURO V	Sep-09	Sep-10	Sep-10	Oct-08
EURO VI	Sep-14	Sep-15	Sep-15	
Petrol				
EURO I	Oct-94	Oct-94	Oct-94	
EURO II	Jan-98	Jan-98	Jan-98	
EURO III	Jan-00	Jan-01	Jan-01	
EURO IV	Jan-05	Jan-06	Jan-06	
EURO V	Sep-09	Sep-10	Sep-10	
EURO VI	Sep-14	Sep-15	Sep-15	

Source: (eurostat - European Commission, 2009 S. p. 174)

	CO	HC	NO_x	PM
EURO I	4.5	1.1	8.0	0.36
EURO II	4.0	1.1	7.0	0.15
EURO III	2.1	0.66	5.0	0.10
EURO IV	1.5	0.46	3.5	0.02
EURO V	1.5	0.46	2.0	0.02
EURO VI	1.5	0.13	0.4	0.01

Source: (Piecyk, 2012 p. 44)

Appendix 3

AB = Aldersbach	KO = Kode	SC = Schwerin
AH = Älmhult	KT = Kättilstorp	SG = Salzgitter
AN = Angers	KV = Kvarnsveden	SH = Sibbhult
AW = Antwerp	LB = Lubeck	ST = Södertälje
BD = Budapest	LL = Lulea	TB = Trelleborg
BM = Baia Mare	MB = Meyenburg	TI = Tibro
DB = Duisburg	ME = Metz	TM = Travemünde
DD = Düsseldorf	MM = Malmö	TV = Torsvik
DO = Dortmund	MN = Munich	VN = Värnamo
GB = Gothenburg	NK = Norrköping	ZB = Zbaszynek
GE = Gent	NS = Nässjö	ZE = Zeebrugge
HB = Helsingborg	RB = Berlin Rummels-burg	ZW = Zwolle
HE = Herne	SB= Saarbrücken	

Appendix 4

Data has been „cleaned“, where necessary, to keep anonymity of the shipper and not publishing confidential data.

Data Company A

Case	From city	From cty	To city	To cty	Weight (ton)	KM	Loadingunit	From terminal	To terminal
1	Tibro	Sweden	Torsvik	Sweden	30,4	82	TT122		
2	Kättilstorp	Sweden	Salzgitter	Germany	24,3	850	C45HPW	Nässjö	Duisburg
3	Älmhult	Sweden	Dortmund	Germany	28	825	C45HPW	Helsingborg	Duisburg
4	Meyenburg	Germany	Salzgitter	Germany	24	331	T90L		
5	Zbaszynek	Poland	Metz	France	15,5	955	T90L		
6	Baia Mare	Romaina	Älmhult	Sweden	5,3	1895	T90L		

TT122	Swedish bil och släp 21 loadingmeter
C45HPW	Container 13,6 loadningmeter
T90L	Trailer 13,6 loadingmeter

Case	INFO
1	
2	Kättilstorp to Nässjö by road, Nässjö to Duisburg intermodal, Duisburg to Salzgitter by road
3	Älmhult to Helsingborg by road, Helsinborg to Duisburg intemodal, Duisburg to Dortmund by road.
4	
5	
6	

Data Company B

CASE 1				
Origin	**Destination**	**Distance (km)**	**Mode**	**Terminal**
Kvarnsveden	Göteborg	494	train (SECU)	
Göteborg			terminal	Port, big
Göteborg	Zeebrugge	538 nm	Ro/Ro	
Zeebrugge			terminal	Port, big
Zeebrugge	DEDUS	347	train	
DEDUS			terminal	Rail/road, big
DEDUS	DE4054	11	truck	

Capacity	
Train	58 tons/railcar
Train (SECU)	59 tons/SECU
Road truck(EUR4)	24 tons

CASE 2				
Origin	**Destination**	**Distance (km)**	**Mode**	**Terminal**
Kvarnsveden	Göteborg	494	train	
Göteborg			terminal	Port, big
Göteborg	Zeebrugge	538 nm	Ro/Ro	
Zeebrugge			terminal	Port, big
Zeebrugge	DE4054	316	truck	

CASE 3				
Origin	**Destination**	**Distance (km)**	**Mode**	**Terminal**
Kvarnsveden	DEDUS	1582	train	
DEDUS			terminal	Rail/road, big
DEDUS	DE4054	11	truck	

CASE 4				
Origin	**Destination**	**Distance (km)**	**Mode**	**Terminal**
Kvarnsveden	DEDUS	1420	truck	
DEDUS			terminal	Rail/road, big
DEDUS	DE4054	11	truck	

CASE 5				
Origin	**Destination**	**Distance (km)**	**Mode**	**Terminal**
Kvarnsveden	DE4054	1412	truck	

CASE 6				
Origin	**Destination**	**Distance (km)**	**Mode**	**Terminal**
Kvarnsveden	Norrköping	278	truck	
Norrköping			terminal	Rail/road, middle
Norrköping	Herne	1326	train (intermodal	
Herne			terminal	Rail/road, middle
Herne	DEDUS	70	truck	
DEDUS			terminal	Rail/road, big
DEDUS	DE4054	11	truck	

Direct Shipment

- Supplier in Kode, SE, to factory in Södertälje
- Equipment – Bil och Släp
- Direct shipment, not via terminal

TRANSPORT_TYI	FILE_TOWN_COLLECTIO	FILE_TOWN_DELIVEF	VOLUM	GROSS_WEIGH
FTL-LTL	KODE	SOEDERTAELJE	21,76	12576

Shipment with terminal transshipment

- Flow from consolidating point (dedicated terminal) in Värnamo to factory in Zwolle
- Operated by two different carriers, carrier A and B
- Carrier A routing: Värnamo to Trelleborg (Road, Standard trailer)
  Trelleborg to Travemünde (Sea, RO-PAX)
  Travemünde to Zwolle (Road, Standard trailer)
- Carrier B routing: Värnamo to Malmö (Road, Standard trailer)
  Malmö to Travemünde (Sea, RO-RO)
  Travemünde to Zwolle (Road, Standard trailer)

TRANSPORT_TYPE	MAIN_CARRIER	FILE_TOWN_COLLECTION	FILE_TOWN_DELIVERY	VOLUME	GROSS_WEIGHT
TL	CARRIER B	VAERNAMO	ZWOLLE	0,76	71
TL	CARRIER A	VAERNAMO	ZWOLLE	1,39	577

Inter- or multimodal transshipment

- Component flow from factory in Luleå to final assembly production in Angers, FR.
- Current Routing:
  - Road transport from Luleå factory to train station in Luleå (no info on vehicle type)
  - Train transport from Luleå to Göteborg. (No operational information)
  - Sea transport from Göteborg harbour to Gent harbour
  - Road transport from Gent to Angers.

TRANSPORT_TYPE	FILE_TOWN_COLLECTION	FILE_TOWN_DELIVERY	VOLUME	GROSS_WEIGHT
FTL-LTL	LULEA	ANGERS	85	24000

Shipment with a distance between 250- 500 km

- From terminal in Värnamo to Factory in Södertälje
- Equipment: Bil och Släp
- Dedicated transports no handling

TRANSPORT_TYI	FILE_TOWN_COLLECTIO	FILE_TOWN_DELIVEF	VOLUN	GROSS_WEIGH
TL	VAERNAMO	SOEDERTAELJE	0,36	32

Shipment with distance above 500km

- From supplier in Sibbhult, SE, to consolidation point in Antwerp,BE
- Routing:
  - From Sibbhult to Harbour in Gothenburg (Standard trailer is used)
  - Sea transport from Gothenburg to Gent (RoRo)
  - From Gent to Antwerp, BE (standard trailer)

TRANSPORT_TYPE	FILE_TOWN_COLLECTION	FILE_TOWN_DELIVERY	VOLUME	GROSS_WEIGHT
FTL-LTL	SIBBHULT	ANTWERPEN	77,44	17576

Shipment from/to Sweden from/to a non-Scandinavian country

- From supplier in Aldersbach to factory in Södertälje
- Direct transports, high fill-rate
- Routing:
  - Aldersbach to Travemünde harbour (standard trailer)
  - Sea transport Travemünde to Trelleborg (RoPax)
  - Trelleborg to Södertälje (standard trailer)

TRANSPORT_TYI	FILE_TOWN_COLLECTIO	FILE_TOWN_DELIVEF	VOLUN	GROSS_WEIGH
FTL-LTL	ALDERSBACH	SOEDERTAELJE	35,85	24960

The interviews

Covered topics in the interviews

1. Possibilities of greening transports
2. Reasons for greening transports
3. Purchasing demands on transport providers
4. Transport efficiency
5. Measuring emissions from transport
6. Tools in use of the companies
7. Tool from the Swedish Transport Administration
8. Usability of the tool
9. Sufficiency of comparing different modes
10. Improvements for the tool

Information about interviewed persons

Company A: Transport Department working with strategic carriers (purchasing and operational)

Company B: Person A: Senior Advisor in Logistics / Sustainability in Logistics

Person B: Responsible for Land services Scandinavia

Person C: Logistics Analyst

Company C: Process Developer for inbound transports