UNIVERSITY OF GOTHENBURG
SCHOOL OF BUSINESS, ECONOMICS AND LAW

Operational freight transport efficiency – a critical perspective

Niklas Arvidsson
niklas.arvidsson@handels.gu.se

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Göteborg, On a beautiful November day 2011

Abstract

Freight transport efficiency, as one proposed abatement strategy for transport related emissions, is a concept that has received much research attention the last decade, often from the transport buyers' perspective. In contrast, the aim of this research is to explore the subset concept of operational freight transport efficiency and how it affects transport related emissions. The focus is on the transport operators and their interfaces with other actors such as transport providers/forwarders, transport buyers, and society. The concept is argued to be "fuzzy", in the sense that it means different things depending on who you ask, and a "wicked problem", in the sense that the problem has no clear solutions with significant and present tradeoffs. The methodology or vessel used in this licentiate thesis to launch a "critical spirit" is "phronetic social science". After phronetically testing these efficiency measures some recommendations are presented in paper 1. A suggestion on operational decarbonisation is provided in paper 2 and the attitudes and trade-offs among the actors are explored in paper 3. This thesis identifies a gap in the sense that a common semantic definition of the concept of operational freight transport efficiency measures do not exist. The thesis proposes that the gap be filled with the following derived definition of operational freight transport efficiency: "A set of utilisation measures of time, space, vehicle, fuel and driver in the movement of goods". From the operators point of view as well as from an aggregated level, another gap is the trade-offs between environmental and economic considerations. Most operational freight transport efficiency improvement measures are likely to reduce emissions, however; it is probable that mere cost-reduction measures will not lead to reduced emissions in the long term. The traverse across these topics represented by the present thesis is offered as a theoretical contribution to the discussion about defining what is meant by sustainable logistics. In other words, what the word sustainable means in a logistics context.

Keywords: operational freight transport efficiency, operator, sustainability, logistics, phronetic

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Department of Business Administration
School of Business, Economics and Law
University of Gothenburg
P.O Box 610, SE 405 30 Göteborg, Sweden

Content

Tables

Figures

"Would you tell me, please, which way I ought to go from here?"
"That depends a good deal on where you want to get to," said the Cat.
"I don't much care where" said Alice.
"Then it doesn't matter which way you go," said the Cat.
Alice's Adventures Lewis Carroll

1 Introduction

Transport has long been an important yet problematic sector in the economies of cities and nations. Transportation is important for economic growth, but it is also the cause of 13-15 per cent of total global greenhouse gas emissions (Fuglestvedt et al., 2008; IPCC, 2007) although this figure also includes passenger transportation. According to OECD (2003), freight likely contributes to approximately 30 per cent of transport related energy consumption, which in turn accounts for roughly 20 per cent of all energy consumption in the Western world. Energy consumption has a strong correlation with the level of development. The benefits derived from this in terms of an increase in mobility and exportation of comparative advantages have so far compensated for the increase of energy used (Rodrigue et al., 2009). From the world's power production, 86 per cent is based on fossil fuels. Freight transport was responsible for 8 per cent of total emissions in 2004 (IPCC, 2007). Therefore, it is important to address these issues.

Emissions are not the only challenge; others include large investments, congestion, safety, and negative spillovers or externalities to non-users through air pollution, noise, aesthetics, water quality, competition for open space, etc. These are all examples of negative externalities. These challenges have provoked numerous policy responses to reduce the negative effects. Researchers have studied the concept of externalities for nearly a century, referring to techniques such as polluter pays and internalise external costs. A relatively new term has surfaced as a response—green/sustainable logistics/distribution/transportation. Belz and Peattie (2009), for instance, stress the importance of sustainable distribution as a means to integrate or "tackle" sustainability issues in the macroeconomic allocation of objects without compromising the efficiency of the conventional distribution functions but also delivering a substantial reduction of environmental and social impacts at a global level. Transport efficiency can be viewed as one of many possible ways to cope with the negative consequences of transportation. So far, the different actors of the system—transport operators, transport providers and transport buyers—have agreed on transport efficiency as economically and environmentally desirable. This thesis will use phronesis and critical theory to explore the concept of operational freight transport efficiency, clarify and consider the problems and risks we face and outline how things may be done in a different way using an interpretive narrative of the consequences of the issues that need to be addressed. This helps achieve the scope and fulfil the scholarly role of facilitating adaptation by conversing transport operators' and, to a lesser extent, societal needs related to these issues, in accordance with Corley and Gioia (2011), for example. Examples of *transport efficiency measures* are: eco-driving, keeping the right tire pressure, the use of aerodynamic trucks, ITS, improving the load factor, minimizing empty backhauls and a modal shift. *Operational* refers to what can be achieved in daily operations with available resources. The introduction informs the reader about the background of the transport efficiency discussion and shows how transport efficiency measures play a part.

1.1 Framing the problem

Market barriers are quite frequent in nearly all markets. A producer might claim a case of asymmetric information on the behalf of the public or a lack of public knowledge about the producer's product, which could be the cause of failed market penetration of that product. Market failures, a subset of market barriers, are present when the market's use of goods and services is not efficient.

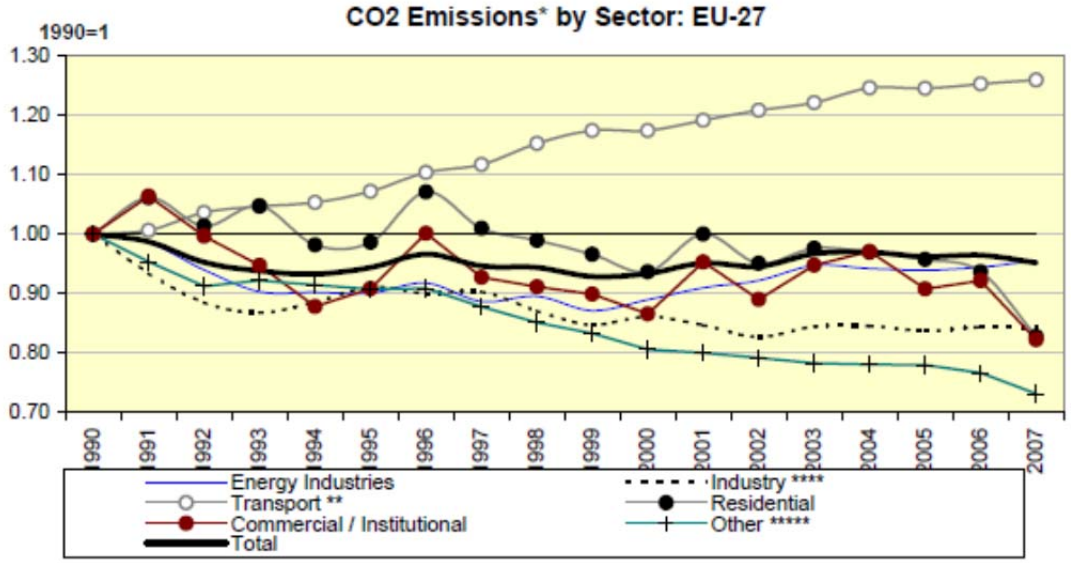

Figure 1 Carbon dioxide emissions by sector EU-27.

Figure 1 from the European Commission (2010b) is a pictorial presentation of what could be a market failure in transportation. Despite the advances in engine efficiency over the past century and the recent focus on transport efficiency, the trend is clear—transport is the only sector that increases its emissions (shares of total CO_2 emissions). In other words, transport related emissions grow faster than total emissions. Furthermore, world transport emissions of CO_2 are expected to more than double by 2050 (OECD, 2009; Proost and van Dender, 2010) even though the goal is to half the emissions by 2050.

The improvements in fuel efficiency have not been enough to offset the increase in transport emissions. This has led the European Commission to emphasise the importance of decoupling freight traffic growth from economic growth (CEC, 2001a, 2001b); transport efficiency is considered one tool to break the link between "environmental bads" and "economic goods." However, very little evidence on a decreasing trend or decoupling effect has been shown in absolute terms. The transport sector has experienced unprecedented growth in emissions over the past three decades. The growth of emissions can be observed in both passenger and freight transport. In Europe the growth in freight transport has been faster than economic growth. Between 1995 and 2006 the average annual growth for EU (27) economy was 2.4 per cent and freight transport grew 2.8 per cent, exceeding the economic growth (Figure 2) (European Commission, 2009). Projections indicate further growth in freight transport. The growth is unbalanced in terms of the figures being skewed in favour of air and shipping. Air and short sea shipping have both grown rapidly over the past decade and low-cost flights now account for 25 per cent of all scheduled intra-EU air traffic, according to Geerlings (2008). This unbalanced growth is a trend of much concern since the growth is occurring mostly in the faster and more energy-intensive modalities, which conflicts with the aim of a more sustainable transport system in Europe.

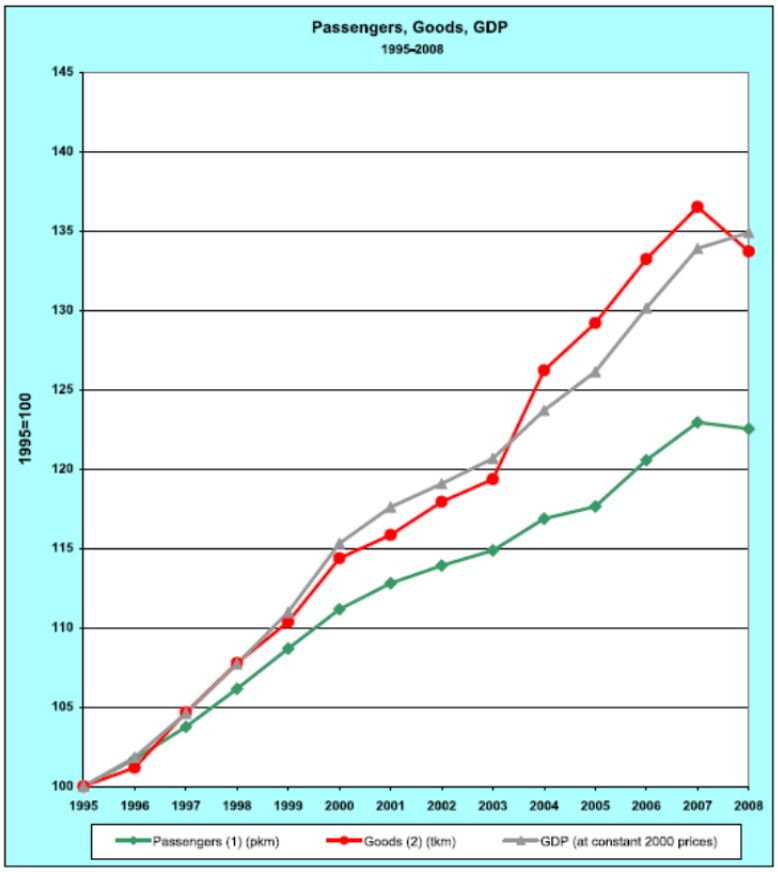

Figure 2 Transport growth in EU-27 (European Commission, 2010a).

A number of reports (e.g. Interlaboratory Working Group, 2000; Ecofys, 2001; Intergovernmental Panel on Climate Change, 2001; Greenpeace International and European Renewable Energy Council, 2010) state that many energy efficiency improvements are not realized; it could be argued that transport efficiency is closely related to energy efficiency, of which both could be seen as a union of two sets. A problem facing the transport industry is that it is a major contributor to various pollutants and research shows that measures counteracting this development such as transport efficiency measures are not being realized or that they have not had the desired effect. An example of such a realisation is shown in Figure 2 as a decoupling of transport from GDP as proposed by the European Commission (2001), for example.

Transport efficiency and energy efficiency have long been decarbonizing measures advocated by governments, NGOs and consultancy firms worldwide. The Breakthrough Institute (2011) argues that consulting firms such as McKinsey and Company (2009) and Rocky Mountain Institute (Lovins, 1990, 2005) promote cost reducing efficiency measures as a way to single-handedly reduce U.S. consumption of energy 25 per cent by 2020. Cost reducing means that the net pay-back is positive. Also the International Energy Agency (IEA, 2009) and IPCC (Intergovernmental Panel on Climate Change. Working Group I, 2007) arrived at similar conclusions that energy efficiency will drive the greatest reductions in emissions needed to stabilize the global climate (UKERC, 2007). In this sense, to quote Weizsäcker et al. (1998, p. 38), efficiency is "better than free: not a free lunch, but a lunch you're paid to eat." This "Kappa" will in part critically elaborate on this type of reasoning in a freight context.

From a logistics research point of view, a lot of research has been conducted on the use of different transport efficiency measures. However, less research has been conducted on the problems and possibilities with reductions in transport-related emissions of using these measures for the actors in the logistics system, especially for the operators—the actor group performing the transport act. Furthermore, few researchers in logistics have tried to place freight transport efficiency measures into a greater context and to examine the evidence that these improvements have led to reductions in transport-related emissions, along with studying the logistical implications for the actors in the system. It would be valuable to study this development from the transport operator's perspective, since a small change would have great impact because of the sheer number of small transport operators in operation. According to Murphy et al. (1996), small companies are an important group to incorporate, since they usually attach much less importance to management of environmental issues than larger firms. Few things can be studied in isolation, so the interface between the other actors and society must also be an integral part of the analysis.

1.2 Purpose

The aim is to explore the concept of *operational freight transport efficiency* and how it affects transport related emissions. The focus is on the transport operators and their interfaces with other actors such as transport providers/forwarders, transport buyers, and society.

1.3 Research questions

To be able to answer the purpose of the thesis, a series of sub-questions was created. The background to the formulations of these questions is explained in the methodology chapter.

RQ1: What should be included in the concept of operational freight transport efficiency for the transport operator?

RQ2: From the perspective of a transport operator, what are the likely economic and environmental effects of operational freight transport efficiency measures in terms of opportunities, barriers and implications?

1.4 Delimitations

Freight transport is studied. The focus is mainly on lorry transport. No particular delimitation in terms of type of goods is made but the emphasis is nevertheless on shorter distribution and the collection of smaller quantities of goods in urban areas, which would partly exclude bulk, construction and energy distribution.

The focus is on the environmental and economic dimensions. In this respect and through the remainder of the thesis, both “economic” and “environmental” refer to an equal consideration of the two to meet the need for the present and future needs. Social dimensions are left out in order to limit the scope. This should be explored in future research; however elaboration on consequences of this delimitation is made.

This paper considers operational measures and solutions with respect to transport efficiency. The industry is eager to know how they might contribute to a more sustainable transportation system and increase their competitiveness at the same time. Measures for future alternative fuels and vehicle technology improvements are important but are not considered to have operational characteristics and therefore are not a major part of the thesis. Also, the

localization of warehouses and centralization or decentralization are strategic and are not part of the thesis. However, some measures could be seen as more strategic in character, but they affect the operator operationally to the point that a delimitation seems unnecessary, e.g., regulations from local municipalities in urban areas. Many of the efficiency measures analysed in this thesis possess characteristics that affect or are affiliated with other levels, tactic and strategic.

1.5 Bridging theory and methodology with research questions and papers

This section will clarify how the connections between the different sections of this licentiate thesis are related. The unit of analysis is operational freight transport efficiency and the perspective is of the operators. From now on the concept of operational freight transport efficiency is sometimes abbreviated to transport efficiency.

In order to produce operational recommendations from the papers, a thorough study of the concept of transport efficiency will be made. The concept of (freight transport) efficiency is illuminated in a range of different disciplines in a funnel fashion (see Figure 8 Research process), and this is presented in the theory section. Some of the theories are also presented in "Future research", which could make careful observers conclude that the funnel is in the shape of a bow tie. This is because this area is important but is partly outside the scope of this thesis. The concept of operational freight transport efficiency is also defined in the "Results" section.

The papers treat different aspects of opportunities and barriers in relation to implementing operational freight transport efficiency measures. What can be expected by the operators? Would they take the first step? The barriers are mostly economic, but some of the possibilities offer new business opportunities to the operators. Furthermore, the analysis would falter in its critical approach since the common understanding in the logistics industry is the notion of transport efficiency as an economic and environmental solution with few drawbacks. This is an a priori and axiomatic-like notion that will also be scrutinized. As with most works of this nature, with the same amount of time and effort put into it, the development has not been linear, contrary to what is depicted below, but instead has been formed by an iterative, mildly intuitive, eclectically adaptive and reflexive process.

The tool used to study the unit of analysis, transport efficiency, is critical theory; as explained in the theory section, this is used, as Alvesson (2003) puts it, as a means "to consistently support a dialectic way of interpreting society, and argues that […] phenomena must be understood in a historical context" (p. 154). He continues, saying "critical theory is not an exercise in fault-finding, but in problematizing those ideas, [...] structures, and practices that strongly prevent communicative action and constrain human possibilities" (ibid, p. 166). The author tries to acquire and maintain a critical spirit or as Facione (2010, p. 9) puts it, "use the metaphorical phrase ***critical spirit*** in a positive sense. By it they mean 'a probing inquisitiveness, a keenness of mind, a zealous dedication to reason, and a hunger or eagerness for reliable information.'"

Critical theory provides us with tools to analyse and problematize. This thesis will elaborate on ways to do this in logistics. It is also a way to be modest about research, to admit that what we might think we know today, we might challenge tomorrow. The methodology or vessel used to launch this critical spirit is Flyvbjerg's (2001) phronetic social science. Phronetic research is "dialogical," as Flyvbjerg puts it (p. 139), in the sense that it includes a multitude

of voices, with no one voice claiming final authority. It emphasizes values, prudence and what is better or worse for humans as the starting point for action. The goal is to produce input into the ongoing dialogue and praxis in society rather than producing verified knowledge. The task of phronetic social science is to clarify and deliberate about the problems and risks we face and to outline how things may be done differently. The result of phronetic research is a pragmatic interpretation of the studied practices, a practical-moral and context-dependent action oriented knowledge. Critical theory is sometimes criticized for having a gap between the theory and practice of critique. Lyytinen (1992) argues that much of the research is fragmentary and theory-heavy. Perhaps the common sense approach in phronesis could help make this link between theory and practice, or as Schram and Caterino (2006) put it, the special thing about Flyvbjerg's challenge to social science is the way it bridges theory and practice in a way that unites empirical and philosophical subdivisions in the discipline (p 1).

An important part of this thesis is the Kappa, a frame of the thesis. It shows how the papers are related and the theory used, and it presents a possible first step toward contributing to a dialectic conversation in the area of "sustainable logistics." Therefore, the thesis is a hybrid between a collection of papers and a monography. The connections are presented in Figure 3.

RQ\Kappa+papers	Kappa	Paper 1	Paper 2	Paper 3
RQ1: What should be included in the concept of operational freight transport efficiency for the transport operator?	Theory	Empiric	Empiric	
RQ2: From the perspective of a transport operator, what are the likely economic and environmental effects of operational freight transport efficiency measures in terms of opportunities, barriers, and implications?	Possible implications	Opportunities and barriers	Opportunities	Opportunities and barriers

Figure 3 Relationships between papers and RQs.

1.6 Outline

The aim of this section is to give the reader a quick overview of the different sections of this thesis. The *Introduction* supplies the reader with a background, problem, purpose and delimitations within the research area. The *Theory section* elaborates on the theory used in the papers as well as an attempt to produce a seed of a theoretical definition of operational freight transport efficiency from a literature review while also presenting different views on efficiency. A series of implications from theory are also presented. The concept is argued to be "fuzzy" and "wicked" and a semantic gap is identified. A definition is formed and implications of the concept under study are discussed. In the *Methodology section,* the author tries to respond to a multidisciplinary call [in the "Kappa"] as well as a variety of research methods [in the papers, but also to some extent in the analysis and discussion] and also describes phronesis. The case study is operational freight transport efficiency. In the end of the methodology chapter research quality is discussed. The *Results* section provides an analysis and discussion of the concept of operational freight transport efficiency and a definition of operational freight transport efficiency as an answer to RQ1. Also, this section summarizes opportunities, barriers and possible implications of implementing these measures from RQ2. This part also stresses the link between efficiency and productivity on a company

level. The *Concluding discussion and future research* elaborates on the implications of the empirical and theoretical findings together with the theory chapter and papers.

If you want the truth to stand clear before you, never be for or against. The struggle between "for" and "against" is the mind's worst disease. Sent-ts'an, c. 700 C.E

2 Theory

An often-cited definition of sustainability is the United Nations General Assembly Resolution 42/187 (1987) that *sustainable development* meets the "needs of the present" while at the same time does not "compromis[e] the ability of future generations to meet their own needs." The *triple bottom line* was introduced by Elkington, who stressed that economic, environmental and social considerations are equally as important for decision making in organizations partly by asking if cannibals eating with a fork can be viewed as progress (Elkington, 1998). The frequently used term *efficiency* commonly relates to a ratio between resources and products, costs and benefits or inputs and outputs of a defined process. A ratio of output to energy input contributes to a process involving two forms of energy; the output is often work and the input can be labour, material, heat, electricity or other forms of energy (Tanaka, 2008). Energy efficiency is defined by the EU Directive (2006) as ''a ratio between an output of performance, service, goods or energy, and an input of energy,'' (Liimatainen and Pöllänen, 2010). To operationalize this, the research literature proposes a range of different measures; see Liimatainen and Pöllänen (2010) for a selection of examples. They suggest the use of tonkilometers/kWh, total haulage and energy consumption. Efficiency also can be seen as the inverse of intensity, which is the ratio of energy input to output, kWh/tkm or MJ/tkm. A similar term is "effectiveness," which disregards input and is more qualitative in character. While efficiency can be defined as doing things in the most economical way or a good input to output ratio, effectiveness is doing the right things, setting the right targets or measures to achieve an overall effect or goal. However, efficiency and effectiveness also leaves open questions. What is "good" and the "right thing", according to whom?

This chapter contains a short summary of ways to view transportation and different notions of operationalization. This is followed by a range of perspectives on efficiency. It is divided into derived or induced demand, business administration and operational management and logistics. This section will start with a short summary of perspectives on transportation, as a flow or a chain.

2.1 Transportation as a flow

Wandel et al. (1992, p. 98) presents a good and useful model of the difference between transport and traffic. Figure 1, the three layer model, depicts the infrastructure, transport flow and material flow. In a freight transportation market, the interplay between the actors can be considered supply and demand actions in which the transport operators or forwarders supply and the transport buyers consume. The focus of this thesis is on operators who supply a lorry service. The uppermost layer consists of products that are moved to different nodes, such as production and storage. In the next layer, load units such as pallets, vehicles or containers are moved between nodes. This is e.g. where consolidation and modal shifts take place. The last layer shows the infrastructure and how this allows for the other layers to operate. There are many versions of this model, for instance; Sheffi (1986), Lumsden (1998) and Stefansson, (2006).

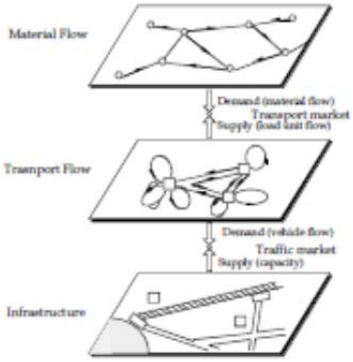

Figure 4 Wandel's three-layer model.

2.2 Transportation as a chain

Supply chain management, logistics and transportation/distribution[1] have a wide variety of definitions. A good differentiation is presented in Ramstedt and Woxenius (2006), who state that the concepts have evolved over the years and are sometimes used in disparate and even confusing contexts. This is why Ramstedt and Woxenius (2006) stress the significance of producing operational definitions, and they define the concepts: *supply chains* focus on a product and range over the chain of actors, activities and resources that facilitate its availability at the place of consumption. *Logistics chains* focus on items and range from creation of an item number until it is consumed or becomes part of another item. *Transport chains* focus on consignment and range from movement, physical handling and activities that are directly related to transport such as dispatch, reception, transport planning and control. They also highlight the difficulties in defining the exact roles of the actors because of the diversity in demand, mode choice, levels of vertical and horizontal integration, division of labour and differences in the use of language, country and historical variations. An actor can play several roles and the same role can be played by several actors. By using terminology from the transportation domain, the authors identify and distinguish between actors in the freight transport chain in Table 1 below.

[1] Supply chain management, logistics and distribution (SCM) as defined by the Council of Supply Chain Management Professionals (http://cscmp.org/digital/glossary/document.pdf):

Supply chain management "encompasses the planning and management of all activities involved in sourcing and procurement, conversion, and all logistics management activities."

Logistics: "The process of planning, implementing, and controlling procedures for the efficient and effective transportation and storage of goods including services, and related information from the point of origin to the point of consumption for the purpose of conforming to customer requirements."

Distribution: "The activities associated with moving materials from source to destination."

Table 1 Categories of transport chain actors Source: Ramstedt and Woxenius, 2006.

Abstract terms	Generic actor names	Roles	Practically used actor names
Source	Consignor	Send goods	(Product) Supplier
Sink	Consignee	Receive goods	(Product) Customer
Management	Transport co-ordinator	Co-ordinate transport services	Forwarder, Third party logistics provider, Agent
Link operator	Transport operator	Move goods	Road haulier, Rail operator, Shipping line, Airline
Node operator	Terminal operator	Tranship, consolidate or deconsolidate goods	Port, Airport, Intermodal terminal operator, Consolidation terminal operator

2.3 Operational

Operationalization is a process of defining concepts into measurable factors or variables to describe what is part of a concept and what is not part of a concept. For many fields of science, operationalization is important. An example is to operationalize hunger in terms of "time since last feeding," as Tolman did according to Feest (2005). Operationalization is closely related to operational definition, which Demining (2000) defines as, "a procedure agreed upon for translation of a concept into measurement of some kind" (p. 105). The term is also commonly referred to as a tool to make "fuzzy concepts" more distinguishable and/or measurable. "In general, we mean by a concept nothing more than a set of operations; the concept is synonymous with the corresponding sets of operations" (Bridgman 1927, p. 5). He warned us to be careful not to slip into conceptual confusion to use the same word to refer to the subjects of different operations because we might get into the sloppy habit of using one word for different situations.

Even though the Swedish word "operativ" is not entirely translatable to operationalization or operational, this could serve as one interesting aspect of its focus and potential impact in transportation. According to Aronsson and Huge Brodin (2006) and Vägverket (2004), the fundamentals of the transport work from a company are decided on strategic and tactical levels. It is decided on these levels where the production and warehouse facilities should be situated, lead times and service levels to customers and if production should be performed in house or be outsourced. According to Vägverket (2004, p. 21), 70-80 per cent of the freight costs and transport work is decided on a strategic and tactical level, which leaves only 20-30 per cent that can be affected on an operational level. Drewes Nielsen et al. (2003) claim that this order may vary. Sometimes the more operational measures have strategic qualities; for instance, companies that are heavily dependent on JIT scheduling of product flows seem to be in the uppermost layer in the hierarchy. Along the same lines, Aronsson and Huge Brodin (2006) found that different measures may have characteristics from different levels. For example, consolidation (increased load or fill rate) can be viewed as both a tactic and strategic decision. The authors also mention that "strategic and tactical decisions influence the operational outcome" (ibid, p. 396), and researchers agree that the strategic decisions have larger impacts than the operational decisions (ibid, p. 397). Worth noticing is that they studied transport efficiency from a transport buyer perspective, not the operator's perspective. McKinnon (2010b) presents an augmented version of the different levels of logistical decision-making: strategic, commercial, operational and functional, where the operational level is defined as scheduling of production and distribution operations.

According to Hokey and Seong (2006), the operational efficiency of third party logistics providers—defined as equipment utilization or labour productivity—dictates the competitiveness and even survival of the company. In order to facilitate an increase in

productivity and price control in the highly competitive industry of third party logistics, the authors propose the use of data envelopment analysis (DEA[2]) to measure operational efficiency. One way to improve operational efficiency is to imitate best practice firms through benchmarking. They also argue that operational efficiency measured by input and output ratios may reflect the true overall productivity better than traditional financial measures. Operational efficiency is defined by Jeong and Phillips, (2001) as "equipment utilization."

Freight Best Practice is an organisation funded by the Department for Transport (DfT) in the U.K. and managed by AECOM to promote operational efficiency within freight operations (Freight Best Practice, 2009b). The organisation defines operational efficiency as a series of measures: back-loading (avoid empty running and minimize the empty journey legs) and allocating operational costs (savings are divided between operator and transport buyer). They also define fuel management as a tool to monitor improvements in operations, in which driver training, office systems and vehicle management systems are an important part. Another report by Freight Best Practice (2009a; 2011) suggests a greater number of key indicators for operational efficiency and divides them into the following groups: costs, operational, service, compliance, maintenance and environmental.

Ramstedt and Woxenius (2006) define the operational level from a buyer perspective as the activities that are not fixed. Examples of fixed activities are locations of warehouse and production facilities, main supplier and customers. The general agreements between the actors are considered fixed. Also studying the process from a buyer perspective, Forslund and Jonsson (2009) state that supply chain management largely concerns downstream and upstream process integration, where two companies perform together and agree on activities in the chain. They identify a series of factors that are important for this integration. The lack of well-functioning supplier relationships is due many times to a lack of trust, different goals and priorities and lack of parallel communication structure, and, to lesser degree, a factor called operational tools. Factors including manual performance data gathering, registering and report generation and non-standardized performance metrics were found not to significantly affect process integration. A possible explanation of this result could be the low existence of standardized metrics, according to the authors.

2.4 Derived or induced demand

The concept of derived demand is a common notion, for instance in Anderson et al. (2005), so common that it often does not entail an explanation. The basic idea is presented in (e.g. Rodrigue et al., 2009)—a consumer buying a product in a store will most likely trigger a new product in its place. This in turn generates production, resource extraction and transport. However, an unsold good can be stored on the shelf until it is sold, with a possible discount of the price of the good if it is not sold. However, unsold capacity in a lorry cannot be stored and the amount of transport offered simply exceeded the demand for it at a given point of time (Rodrigue et al., 2009). It is difficult to match the demand with an equal amount of supply. Most often companies would like to have additional capacity that they may sell for higher prices at times when the demand exceeds the supply. For freight as a derived demand, every part of the chain necessitates movements of raw materials to products on different modes:

[2] The tool is a nonparametric linear programming methodology that uses multiple inputs and outputs to measure the efficiency of multiple decision making units (DMUs).

> "Thus, transportation is directly the outcome of the functions of production and consumption."[3]

According to this derived demand viewpoint, transportation does not exist for the purpose of movement but rather to accommodate a need for a product to be moved from a place of production to a place of consumption. Using this view, if two routes are available, the shorter route is preferred because less transportation is ideal, but if the same type of thinking accounts for the total costs in an international setting, the answer might not be as simple. More transportation could be an outcome of a different viewpoint, induced demand, in which transportation costs are related to other costs and where efficiency might reduce costs. Standardization is one of the tools used, and the containerization of freight as argued by Hesse and Rodrigue (2006) could be an example of this development in transportation. What happens if transportation and products become cheaper because of an efficiency improvement? In relation to this discussion, it is also important to take a deeper look at the relationship between productivity and efficiency.

Rodrigue and Hesse (2006) discuss derived demand and implicitly also talk about efficiency and growth (globalization) in a "chicken and egg" manner, advocating the view on logistics as an integrated demand (both induced and derived) rather than just a derived demand. Does cheap and standardized transportation induce demand or do other factors affect the demand for products and therefore increase the demand for transportation? The basis of derived demand is that transport exists because it is a "spatially differentiated function of supply and demand and is thus considered to be 'derived' from other activities." Hesse and Rodrigue (2006) put it another way: "if transportation is a subservient function of other processes and exists as an outcome of the physical flows they generate" (p 503) why should researchers care? A derived demand is one of the core concepts in logistics that Rodrigue (2004) and Hesse and Rodrigue (2006) try to challenge. According to Hesse and Rodrigue (2006), global production networks are engines of efficiency and productivity that were expanded from existing production systems that were more regional from the onset. The rationale of these systems is quite simple—growth from which additional value is generated. They argue for the induced demand viewpoint, that a "greater importance be placed on distribution as a factor of production and consumption as it is not a mere consequence of economic processes, but often a force actively shaping them" (Rodrigue, 2006, p 15). Moreover, "distribution should be considered as more than a space of flows, but also an economic process that adds value beyond mere transport costs" (ibid). On the notion of integrated demand, Rodrigue (2006) offers a possibility to view the concept as derived on an operational level, as it is a highly debatable topic. He calls it closely derived, when it is perceived as more imbedded in the process. He argues that from an operational point of view the concept of derived demand still holds. The interaction that takes place is the outcome of a process generating a surplus at the origin (supply), and this surplus is used (demand) to a destination, with an underlying operational use of modes, terminals and distribution centers. Hesse (2008) continues this type of reasoning by suggesting a close integration between distribution via logistics and material management, where the induced transport demand of physical distribution and the derived demand of materials management are proposed to be the integrated demand of logistics, also in Rodrigue (2006). This means that distribution is derived from production, and that these activities are shaped by distribution capabilities:

[3] http://people.hofstra.edu/geotrans/eng/ch1en/conc1en/derivedemand.html.

> "Production, distribution and consumption are therefore difficult to separate" (Hesse, 2008 p 6).

A common argument for proponents of transport as a derived demand is that transportation is not valued in and of itself, but as a means to reach a destination. However, it is difficult to ignore that transportation constitutes a large proportion of GDP and the workforce.

2.5 Business administration perspective on efficiency

Much of the following information is covered in the first weeks of an introductory course in BA and could be viewed as practical wisdom. The point is to stress the relationship between efficiency and productivity; nonetheless this seems to have been forgotten in the debate about freight transport efficiency in a sustainability context. However, it would be a misunderstanding to believe that this link always nullifies any efficiency gains in terms of emissions, only that it is important to study this connection more carefully.

Eliasson and Samuelson (1991), who studied performance measurements in the public sector define efficiency as a relation between output and input that is normally expressed in terms of financial value, although it also can be expressed in non-financial terms. Efficiency is how well the organization is running its operations and the extent to which the greatest benefit can be obtained from a given amount of resources or doing things right. According to Ax et al. (2009), a high degree of internal efficiency is often associated with a high degree of productivity and cost effectiveness. *Effectiveness* is defined as the level of goal completion, i.e., the extent to which the organization is achieving these long term goals or doing the right things. Measures of efficiency and effectiveness are often designed as specific ratios, but can be expressed as absolute values.

Another definition of efficiency is a company's economising with limited resources (Ax et al., 2009). They define efficiency as "degree of fulfilling a goal" and the degree is a relationship between what has been accomplished in terms of value to what has been put into process, also in terms of value. They highlight a series of problematic aspects of efficiency:

1. Efficiency is not an objective term of how well a company performs its business. The degree of efficiency is decided in relation to a goal; if the level of the goal is decreased, efficiency is increased.

2. It might be difficult to determine if a company is efficient on its own merits only. An increase in efficiency might be due to an increase in demand or a technology change.

3. The company might have several goals that contradict each other. Profitability and high wages is one example of such a trade-off. Therefore it is important to identify if several goals are present and if these goals are in line with each other.

4. The time horizon is important. Short term, the company might be able to "squeeze" the maximum amount of efficiency by using all resources. This might jeopardize long term profitability, where development and renewability are important factors. Available resources in the short term are important, even though this means lower efficiency levels. The authors argue that the companies that value these factors are the most efficient in a long term perspective.

These difficulties have made some come to the conclusion that it is impossible to establish a company's efficiency level. The company's ability to survive has been proposed as the ultimate level of efficiency (Ax et al., 2009). In terms of productivity, Ax et al. (2009) acknowledge the same relationship as efficiency, but what has been achieved (output) and the resources used (input) are discussed in terms of quantities and not in terms of value. All the examples given are with respect to a specific time period. However, they mention that the two concepts are closely related, but not exactly how they are related. Efficiency expressed in physical rather than financial terms is sometimes called productivity (Eliasson and Samuelson, 1991). Productivity is expressed as output divided by input, a measure that does not provide any useful information unless it is put into relation to productivity from another time period, company or subdivision.

For a review of a business administration and production view on efficiency, the author recommends Sjögren (1996), who stated that efficiency can either be a relative or absolute measure. In quantitative or value terms, the difference between what is utilized and what is achieved is a measure of absolute efficiency. Relative efficiency is the ratio between resources used and production output. For the measure to make sense, it needs to be set in relation to goal, and the choice of input and output varies depending on this goal.

For an analysis of the business administration view on efficiency, Sjögren (1996) points out that it usually has the goal of profit maximizing. The assessment of input and output usually is in monetary terms. In the study of production processes the term productivity is defined:

> "Productivity, which also can be called 'internal efficiency,' is the relationship (ratio) between what is physically produced and physically sacrificed" (Berg and Karsson, 1991, p. 97).

Sjögren (1996) highlights that no distinction is made between productivity and efficiency in an analysis of a production process. Bohm (1986) explains that the difference between business administration efficiency and efficiency on a societal level is that the latter takes all individuals' preferences into account. He also points out that these two efficiencies are not necessarily the same in all instances.

One of the core features of companies is the strive for efficiency (Coase, 1937) and few companies are self-sufficient in terms of resources. So far, theories from different areas have been used to have a critical perspective on transport efficiency. A reason for this approach may lie in the definition of business administration. Different thoughts on efficiency from a business administrative perspective are presented below, along with a few definitions of BA. It is difficult to critically analyse a concept through the lens of a topic area that axiomatically addresses something as positive without further ado:

> In business, administration consists of the performance or management of business operations and thus the making or implementing of major decisions. Administration can be defined as the universal process of organizing people and resources efficiently so as to direct activities toward common goals and objectives. (Business Administration, Wikipedia retrieved 2010/11/12)

There are numerous ways to define business administration; one definition presented by Brunsson, 2010) defines BA as "the management of organisations." Fournier and Grey (2000,

p. 17) propose a series of criteria, of which one is presented here to show the difference between critical and non-critical management studies. First, they suggest that critical management studies are not governed by principles of efficiency and productivity, at least not if subordinating knowledge. They do not try to contribute to "the effectiveness of managerial practice and organizations." As they argue, "the invocation of notions of such power, control and inequality typically betoken some form of critical approach, whilst efficiency, effectiveness, and profitability do not" (Shenhav, 2009).

Another way to look at efficiency is through organizational efficiency and effectiveness (Pfeffer and Salancik, 2003). They define the effectiveness of an organization as its ability to create acceptable outcomes and actions. How well an organisation meets the demands from actors that are concerned with its activities is an external standard. Organizational efficiency is an internal standard of performance. The question of what is being done is not posed, merely how well it is performing. Efficiency is relatively value free and is measured as the ratio between utilized resources and production output. It involves doing things better than what is currently performed. External pressure on the organization is often expressed in terms of doing things more efficiently. Borgström (2005) refers to Pfeffer and Salancik when she concludes that efficiency has changed from an internal measure used to find waste to a measure of goal fulfilment. She concludes that efficiency is the internalization of effectiveness, which is related to Liljegren's notion (1988) that efficiency is an operationalization of effectiveness, which in turn is a co-creation of goals.

> "No one can be found who will deny that in the case of any single individual the greatest prosperity can exist only when that individual has reached his highest state of efficiency; that is, when he is turning out his largest daily output." (Taylor, 1911, Chapter 1)
>
> But if one has visions of service, if one has vast plans which no ordinary resources could possibly realize, if one has a life ambition to make the industrial desert bloom like the rose, and the work-a-day life suddenly blossom into fresh and enthusiastic human motives of higher character and efficiency, then one sees in large sums of money what the farmer sees in his seed corn—the beginning of new and richer harvests whose benefits can no more be selfishly confined than can the sun's rays. (Ford, 1922, Chapter xix)

Weber, frequently quoted by many organizational theorists, had a much darker perspective on efficiency; he used the term rationalization, in which efficiency plays a great part. Weber argued that the rationalist order had become an iron cage in which humanity was imprisoned "perhaps until the last tonne of fossilized coal is burnt" (DiMaggio and Powell, 1983, p. 147).

2.6 Operations management and logistics perspective on efficiency

Operations management and logistics are usually considered a part of business administration, but in this instance these areas are divided in order for the reader to get a more comprehensive view of different perspectives of efficiency and its relation to productivity.

From the field of operations management, Stevenson (2001) views efficiency as a tool to improve productivity, but efficiency should not be confused with productivity. Efficiency is a more narrow concept that "pertains to getting the most out of a fixed set of resources;

productivity is a broader concept that pertains to effective use of overall resources". Heizer and Render (1999) define productivity as the ratio of outputs (goods and services) to inputs (resources, such as labour and capital). The job of the operations manager is to improve this ratio, "improving productivity means improving efficiency" (ibid, p 16). Chase et al. (2006) defines efficiency as "doing something at the lowest possible cost." Later they define it as a ratio of actual output of a process relative to some standard or to measure the loss or gain in a process. Lumsden (2006) defines efficiency as the degree of fulfilment to a certain goal, not far from Chase et al. Mentzer and Konrad (1991) define efficiency in a logistics performance context as "[a] measure of how well the resources expended are utilized" (p 34) and "The ratio of resource utilized against the results derived" (ibid). According to Caplice and Sheffi (1994), there is no need to create new metrics because the critical elements of logistics management remain the same—time, distance and money. Samuelsson and Tilanus (1997) formulate the efficiency dimensions as time, distance, speed and capacity. Caplice and Sheffi (1994) propose a series of ratios as indicators for performance measurement in logistics. These logistics metrics were later reworked by McKinnon (2004) and proposed as a base for transport efficiency measures. The three types of logistics key indicators are:

1. Utilisation, which measures input usage and is usually expressed as a ratio of the actual input of resources to a norm value.
2. Productivity, which measures transformational efficiency and takes the form of input: output ratios.
3. Effectiveness, which measures the "quality of process output" as a ratio of the actual quality achieved to some norm.

McKinnon and Ge (2004) springboard from these types when constructing a series of indicators together with senior managers of manufacturing, retailing and logistics firms: vehicle loading, empty running, fuel efficiency, vehicle time utilization and deviations from schedule. The first three indicators are utilization measures, the fourth is a productivity measure and the last assessed the effectiveness of the delivery operation. These measurements were constructed to measure the effectiveness in a food supply chain in the U.K. Several restrictions in this structure were mentioned; the indicators were constructed to measure operational, rather than commercial performance due to a lack of account of costs from the study participants. The main goal for green logistics should be to decouple economic growth from freight related externalities, rather than the growth of transport work (McKinnon et al., 2010) by affecting the parameters above. Similar ratios are also presented in REDEFINE (1999) project: value density, modal split, handling factor, average length of haul, vehicle carrying capacity, load factor and empty running. The same report presents a series of options to reduce road freight transport or its externalities, reduce transport intensity, modal shift, increase efficiency, better vehicles/fuels, better use of vehicles in an attempt to link economic activity and CO_2 emissions from road freight transport. Also Samuelsson and Tilanus (1997) define efficiency as ratios, fractions or percentages. They define transport efficiency as a subset of supply chain efficiency, where supply chain efficiency is not only focused on "transformations of place" transportation, but also transformation of time (storage) or form (assembly). They point out that starting points will have to be developed in the future for these other efficiencies. Supply chain efficiency should be seen in a greater context; different actors might have objectives that conflict with one another.

Caplice and Sheffi (1994) defines a series of metrics useful when producing performance measures, but also talks about the objective of the manager in the transport function. The

overriding objective of the manager is to "maximize the output (in terms of quantity, quality, or both) while minimizing the input consumed". The transport function is often modelled as converting labour, equipment and other resources into tonne km. The prime objective of the transport manager is to produce the requested tonne km to a certain service level at the lowest possible cost, (ibid, p 18). Caplice and Sheffi (1994) also elaborate on the definition of productivity, as defined by the National Commission on Productivity as "the return received for a given unit of input" (ibid, p 18). They also note that among managerial accountants the term has been so popular (and misused) that it is now equated with efficiency, effectiveness, work measurement, cost reduction, program evaluation and most any other related concept.

"Productivity measures capture the efficiency of a process" (ibid, p 22).

McIntyre et al. (1998), on the contrary, stress the importance of not focusing too much on performance measurements unless they incorporate a more long term point of view. In the article they analyse and debunk more than twenty different researchers' and professionals' suggestions how to green the supply chain while highlighting a dilemma between reducing environmental impact and increasing financial costs. Most techniques have been found to be time and cost focused, focusing on "financial climate change." This approach tends to promote a short term perspective. They further argue that work on greening the supply chain benefits from a more long-term perspective. These two mindsets seem diverge, developing in different directions, and this is a worrying from an environmental point of view. The suggestion is to amalgamate both perspectives so the long term is represented in performance measurement. Eastern Europe was used as an example of a disastrous effect of an incorrect use of a performance measurements system. Before the fall of the wall, the governments found a fixed relationship between inputs and outputs of factories. The input of a plant was taken as a measurement of the plant's performance, since it was easier to measure than its output. This erroneously provided plant managers with the incentive to maximize input per unit of output, leading to highly inefficient manufacturing practices.

Performance measurements ratios in logistics reflect an accounting or management-science orientation to identify inputs of some form with outputs in another form. Mentzer and Konrad (1991) put forward one problem with using ratios in this respect—the measures do not measure all the aspects of the actual inputs and outputs. As an example, waiting for a vehicle to leave the terminal until the vehicle is full may improve the utilization efficiency but the measurement will not disclose the damage done to customer service. Customer service measures in turn would not reveal the anger of a customer over the delay or depict the potential future loss of customers or orders. These measures are by definition fragmented and represent only a part of reality. If these flawed measures are used for decision making, it is important to establish and select these measures carefully. Mentzer and Konrad (1991) state that it is not sufficient to measure efficiency alone and they make the following argument to support the statement: if a goal is partially achieved, the effort is only partially successful regardless if the portion achieved was done so with prudence with respect to resource utilization. Therefore, performance is the sum of effectiveness (where the goals are incorporated in terms of outputs) and efficiency (incorporating inputs) and the evaluation of the overall process is needed to merge these two measurements.

2.7 Examining drivers of output and demand in a transportation context

So far, this paper has presented different views and interpretations of efficiency and transport efficiency. A potentially dangerous conclusion, a "regime of truth" as Foucault (1980) puts it,

would be that transport efficiency is an inducer of demand in transportation through cost reductions or, worse still, the only inducer of demand. This is simply not true. This section will elaborate on other potential drivers (or non-drivers) of productivity in a freight transportation context and show one problem with linking productivity with demand increase through price.

McKinnon et al. (2010) present a detailed overview of research conducted on the potential drivers (and non-drivers) of freight traffic growth. A series of factors or trends are presented in relation to restructuring the logistics system (McKinnon and Woodburn, 1996; McKinnon, 1998; Cooper, 1998). They also state that applying cost efficient improvements does not always lead to a lower environmental impact, and they provide the lack of internalized cost of externalities as an argument. The cost and service trade-offs generally underestimate the environmental effects. "The resulting decisions may optimize logistics operations in economic terms to the detriment of the environment" (2010, p. 15). A range of other studies have studied some of the logistics system restructuring in detail with the conclusion that the environment might lose on implementation of centralization (Matthews and Hendrickson, 2002), just-in-time (Whitelegg, 1995), spatial distribution or globalization (Rodrigue, 2004; Vanek, 2001) and standardisation (Rodrigue, 2004). Other studies have concluded the opposite—centralization leads to an increase in transport work but it also opens up a possibility for a modal shift, especially in the consolidated inbound flows (Kohn and Brodin, 2008) and just-in-time does not induce logistics costs (Tracey, 1995). Aronsson and Huge Brodin (2006) argue that strategies such as standardisation and centralization might not be drivers of growth of emissions in transportation.

There are numerous other macro factors than those presented above that play a part in greater energy consumption in transportation, such as rate of consumption, income increase, labour efficiency increase, new energy sources, population increase, the elimination of trade barriers, etc. An argument against linking cost reducing efficiency measures to increases in productivity and demand is that the transportation market could have features of market failures and barriers—a low priority of transport in general, split incentives, asymmetric information and the existence of externalities. In markets with these characteristics, cost reductions for one actor might not translate to reductions in price of the transportation service, at least not in the short term.

2.8 Implications from theory

From a transport operator's perspective, however, many measures can be affected on a daily operational level, not just by tactical and strategic measures such as customer demands. Many of the efficiency measures analyzed in this thesis possess characteristics of affecting or affiliating to other levels, tactic and strategic. Sometimes an operational measure for one actor might be considered strategic from the perspective of another actor. For example, from a transport buyer's perspective, a modal shift could be seen as an operational measure (Aronsson and Huge Brodin, 2006), but from a transport operator's perspective, running a single modal lorry service is more of a strategic issue. If the operator decides to increase the service, by offering a multimodal service, the act of offering either of the two becomes operational, part of the daily routine. To clarify in the context of this thesis, operational refers to the measures the operator can affect in daily operations with available resources and in close proximity to these operations, alone and with other actors, without changing the structure of the transport system to a greater extent.

Transport efficiency could be argued to be a *fuzzy concept*. In short it means that it is not clearly defined and has multiple meanings, depending on who you ask. Transport efficiency can be vague, but it does have meaning and definition that can vary depending on what actor you ask in the logistics system, ranging from just encompassing eco-driving for some transport operators to a wide array of measurements as concluded by researchers, policy makers and some transport buyers. Another problem with fuzzy concepts is its lack of clarity and difficulty in measuring its effect; to operationalize it as Markusen (1999) puts it. One of the goals is to reduce fuzziness in the fuzzy concept—transport efficiency—with the aim of attaining more certainty and knowledge of the concept by approaching it curiously, cautiously and critically from different directions. In this sense the concept could also be argued to be a *wicked problem* in a policy context as well as for the transport operator, at least as long as transportation is predominantly high in carbon use. According to APSC (2007), a wicked problem is difficult to define, has internally conflicting goals and the nature and extent to which the concept applies is different and depends on which stakeholder one asks. Usually these problems do not have clear solutions. The solutions are often "better or worse" or "good enough" rather than verifiably right or wrong. Furthermore, these problems are usually socially complex, not just technically complex. Solutions proposed by literature often include coordinated action from many stakeholders.

> In terrain which is politically contested, in which the resources to address difficult human issues are necessarily finite, there are rarely clear questions, let alone easy answers. Progress is nearly always marked by consultation, discussion, negotiation and iteration. (Australian Secretary of the Department of the Prime Minister and Cabinet, in APSC, 2007, p 17)

According to the same report, these problems are usually imperfectly understood and therefore it is important to approach them by discussing it with all relevant stakeholders in order to ensure a full understanding of the complexity. The proposed changes cannot be imposed on the stakeholders, but should be widely understood, discussed and owned by the stakeholders that are affected by or targeted for change. Some argue that studying social [complex] problems is to be something to partly avoid (Silverman, 2001). Silverman also argues that "[it] can offer participants new perspectives on their problems" (ibid, p. 16) and he continues with a phronetic sentence, "[may be] able to contribute to the identification both of what is going on and, thereby, of how it may be modified in pursuit of desired ends" (ibid, p. 16).

The author argues that transport efficiency is related to energy efficiency, because both could be seen as a union of two sets. Most transport efficiency measures have an element of energy pertaining to these measures but obviously there are energy efficiency measures that are not related to transportation and there are transport efficiency measures that are not directly related to energy efficiency. As has been shown, there are different definitions of what efficiency, productivity and their relations are.

It is important to mention that many of the quotes from the theory section are from literature from the end of the past century and the environment was not on the agenda to the same extent as it might be today. Today the message is somewhat more multifaceted. According to one report made by the EEA (2008), the concept is not so simple, while at the same time painting a graphic picture of the duality status of efficiency in logistics:

> "[Governments] could improve the transport efficiency of the economy, effectively decoupling transport growth from economic expansion" (Transport at a crossroads TERM, 2008).

While the message is dialectically different later in the same report:

> "Freight transport activity has grown faster than the economy during most years of the last decade. Freight transport growth can be attributed to improved transport efficiency[!]..." (ibid, 2008).

The European Commission (2009) states that transport is closely related to the rest of the economy and transport demand is closely linked to economic growth. "Transport allows competition and, through it, it fosters competitiveness and innovation, and facilitates economic growth" (ibid, p 6). It somewhat ambiguously states in a section on urban sprawl that "urban quality and efficiency are key variables for economic growth as for compliance with the requirements of sustainable development" (ibid, p 15).

To sum up the literature on productivity and efficiency, productivity usually focuses on the numerator/output and could be defined as the amount of output in relation to the input that can be produced in a specific time period. Efficiency usually focuses on the denominator/input and is commonly defined as the input used relative to the value/quantity of output. This is, in many respects, a simplified view of the difference between the concepts, which are claimed to be more complicated by some. Figure 5 is an attempt to explain the differences between productivity and efficiency; it is an extrapolation of the validity and reliability pictorial presentation. Note that a problem arises when the goal (middle) is not the same, as can be the case when environmental goals sometimes do not align with economic goals, as suggested by McIntyre (1998). How should the "norm value" be chosen? What is the best practice frontier?

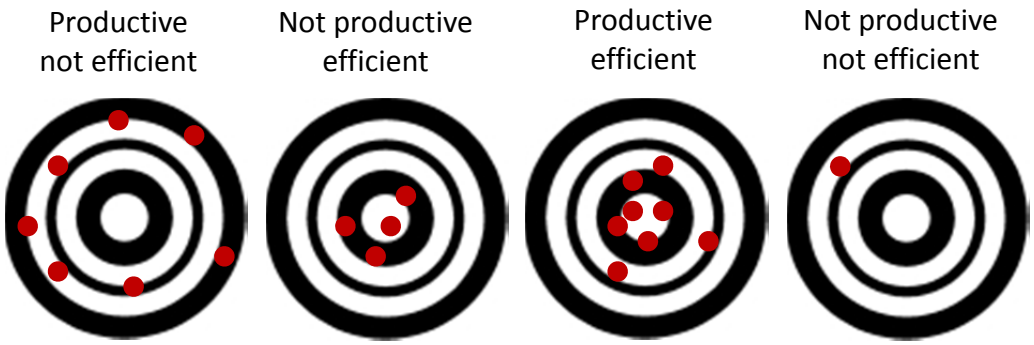

Figure 5 A pictorial presentations of the differences between efficiency and productivity.

For a transport operator, the first target could be an operator who manages a lot of trucks with goods to various locations. Unfortunately, the goods are not delivered on time despite a generous time window, the trucks are not full, the vehicles used are old, the trip length is longer than necessary and the driver is not educated in eco driving, etc.

"Any job that involves interaction with other people is moral work, and all moral work depends on practical wisdom" Barry Schwartz (TED.org), "On our loss of wisdom."

3 Methodology

Logistics and transport research has traditionally been dominated by the natural sciences and quantitative-based economics. Logistics research has no discipline of its own, and it could be argued to use the application of research inspired by different traditional disciplines. It has also been developed through multidisciplinary studies, according to Thomsen et al. (2005), Solem (2003) and a call for the use of a wide variety of research methods (Carter et al, 2008), for a purchasing context (Dubois and Araujo, 2007), and for an operational context (Meredith et al., 1989). Methodological choices cannot be divorced from theoretical points of departure as highlighted by Dubois and Araujo (2007). Coming from a purchasing background, they argue that theories are not method neutral, often theoretical approaches are developed in conjunction with method and not independent of theory. Meredith et al. (1989) presents a generic research framework (Figure 6), which also shows the close relationship between critical theory and phronesis (≈interpretive). In this context, Popper can be viewed as pertaining to the rational dimension and Flyvbjerg and Alvesson more than the existential dimension. Phronesis as explained in this section is argued to be a methodology in the sense that it is a problem driven approach, but also an ontological position and even a viewpoint.

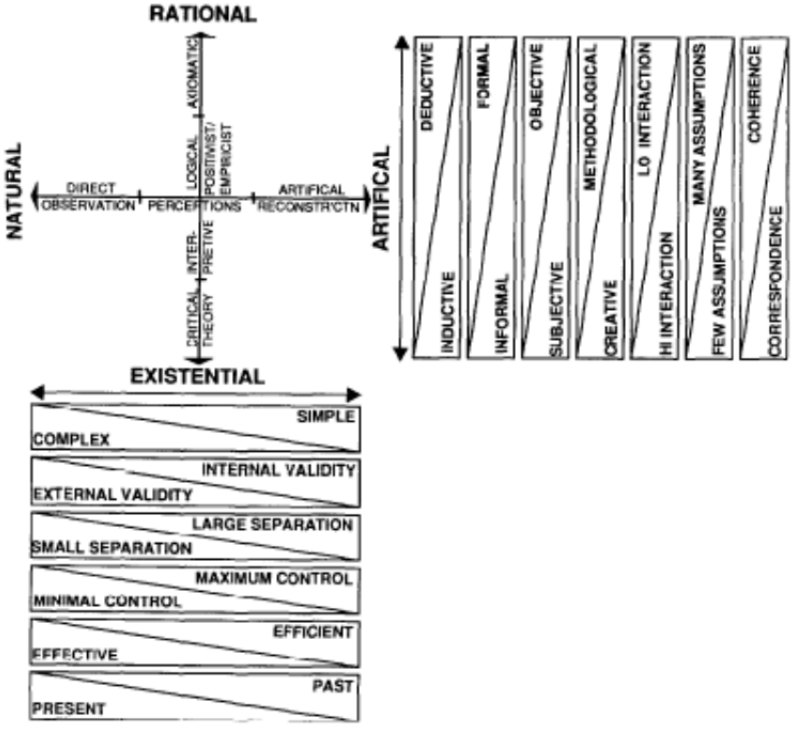

Figure 6 A generic research framework Meredith et al. (1989).

Croom et al. (2000) argues that logistics research has a relative lack of theoretical work compared to other areas and compared to the amount of empirical based studies (Figure 7). This is later supported by Vafidis (2007, p. 181), who concludes that many of the most cited authors are not logisticians, reinforcing the argument that the logistics discipline lacks strong theoretical foundations, being a very applied discipline with much of its roots in other areas. The finding that the research area is mainly empirical-descriptive makes the argument that the theoretical development is crucial to the establishment and development of supply chain

management study. The authors stress that their intention is not to state that empirical studies are valueless. As Flyvbjerg (2001) stated, the “both and” perspective rather than the “either or” is preferred. A concern is the lack of a significant body of a priory theory, a point that Andrew Cox argues in his 1997 treatise. The analysis of the supply chain literature made by Croom et al. (2000) highlights contrasting themes, and this constitutes a great challenge for the field. They continue to argue in line with Thomsen (2005) when they recognize that developments in our understanding of supply chain management require a multidisciplinary perspective in order to address these contradictions and to explore the subject from a multitude of perspectives. Specific theoretical schools or disciplines mentioned in the article are transaction cost economics, inter-organizational theory, systems thinking, information technology, industrial dynamics, production economics, social theory, production engineering, marketing and strategic management. The same recommendations are put forward by Stock (1995), who suggests using theories from philosophy of science, psychology, organisational behaviour, consumer behaviour, political science, sociology, geography, economics and management with the argument that logistics is a boundary spanning activity in practice and it should be so in theory. Lammgård (2007) reasons along the same lines and suggests applying marketing, purchasing and environmental management in a logistics context. Therefore, it is important for researchers to be aware of complementary studies outside their own field of expertise. Perhaps as Dietrich (1994) pointed out nearly two decades ago, a future development of theory may require and benefit from a *cosmopolitan approach* that incorporates a wide range of contrasting technical and social disciplines. Vafidis (2007), who made an empirical analysis of Swedish and Finnish logistics dissertations between 1994-2003, argues that logistics research remains in its infancy and a rather scattered stage in terms of research documents appearing more like individual reports rather than an accumulation of a knowledge-creation and methodological tradition offering two orientations to choose from: a disciplinary orientation with a focus on disciplinary contribution and academic discussion and a practitionary orientation with focus on practical contribution and practionary discussion.

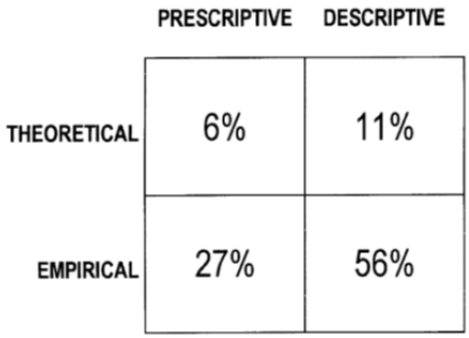

Figure 7 Framework for classifying literature according to the methodology oriented criterion, (Croom et al., 2000).

According to Frankel et al. (2005), research methods are merely a tool to solve a specific problem. They conclude that if we would like to develop and test new theory in logistics, we should start by questioning our paradigms and methodologies and continuously debate them with open minds. The following section is based on Flyvbjerg's recommendations in producing phronetic social science. Flyvbjerg himself, now a professor at Oxford, has performed research in the area of logistics, city planning and sustainability, among other areas. In his book, "Making Social Science Matter: Why Social Inquiry Fails and How It Can Succeed Again" (2001), there are many similarities with this research within "Sustainable Logistics." The section constitutes of three parts. First there is an introduction to phronesis,

followed by a brief exposition of case studies and finally an account of how the papers have been constructed.

Flyvbjerg starts out by stating that the war between the sciences, natural and social, is unnecessary. They both complement each other. Where social science is weak in explanatory and predictive theory, natural science is stronger. In terms of reflective analysis and discussion of values and interests, social science could be argued to be stronger.

> "Where science does not reach, art, literature and narrative often help us comprehend the reality in which we live" (Flyvbjerg, 2001, p 18).

He also uses the hermeneutic-phenomenological argument, stating that the fundamental difference between the sciences is that natural science studies an object while social science studies self-reflecting humans and must therefore take into account the changes in interpretations of the objects of study. Or put another way, in social science the object is a subject. Flyvbjerg argues that "the problem for social science is that the background conditions change without the researcher being able to state in advance which aspects one should hold constant in order for predictions to continue to operate" (p 45).

"It is worth reiterating that Dreyfus' and Bourdieu's plea for the importance of context is not an ultimate proof that social science can never be explanatory and predictive - It only makes it probable that this is so" (p 46). In the following section the author will use Flyvbjerg to try to elaborate on Yearley's claim (2005) that, "…no single theory of social interests has been successfully stabilized" (p. 41).

3.1 Introducing phronesis

Greek philosopher Aristotle distinguished between three intellectual virtues. These are *episteme*, or knowledge production based on analytical rationality; *techne*, or concrete activities according to practical rationality; and *phronesis* which stands for context-dependent, practical common sense based on ethics or practical wisdom—the moral will and skill to figure out what is better or worse. Therefore, phronesis emphasizes values, prudence and what is better or worse for humans as the starting point for action. For Aristotle, phronesis was the most important of the three virtues and thus the all-important basis for social and political praxis (Flyvbjerg, 2001). The key properties of phronesis that are particularly valuable for social science are its emphasis on value-rationality and its embrace of context and focus on power relations. This has important implications for finding a ground on which social science's mission could be redefined and action taken. Ghoshal (2005) also mentions how it is not only morality that has been a victim of this endeavour of business academics to make management a science (see critical theory section)—common sense, too, has suffered. It is to this loss of wisdom of common sense that Donald Campbell (1988) referred to when he provided numerous examples of how the application of social theories had led to poor public policy decisions in the United States. Along the same lines, Rorty (1991) proposes his alternative look at science, to see it as solidarity. He advocates that science should seek to look for what is "sane or reasonable" instead of what is rational or methodological.

Phronetics is concerned with both understanding and explaining. Social scientists tend to generate either macro level or micro level explanations, often ignoring the critical connections. Instead of research that attempts to link macro level factors such as structure, scholars dichotomize with micro level actors' choices in different settings. Flyvbjerg argues

that structural analysis and studies of actors each get their share of attention, but often in different projects by different researchers. This is likely not the case in the logistics project the author is currently affiliated to, where actors in the logistics system, the connection between them, and the logistical structure in general is studied.

Phronetic research is "dialogical," as Flyvbjerg puts it, in the sense that it includes a multitude of voices, not one voice claiming final authority. The goal is to produce input to the ongoing social dialogue and praxis in society, rather than producing verified knowledge. On objectivity, the more eyes, we can use to observe one thing, the more complete our concept of that thing will be so. Objectivity in phronetic research is not "contemplation without interest," but employment of a variety of perspectives and affective interpretations in the service of knowledge. The result of phronetic research is a pragmatic interpretation of the practices studied. Phronetic research is an analytical endeavor, not a theoretical or methodological one.

> Phronetic social science explores historic circumstances and current practices to find avenues to praxis. The task of phronetic social science is to clarify and deliberate about the problems and risks we face and to outline how things may be done differently, in full knowledge that we cannot find ultimate answers to these questions or even a single version of what the questions are. (Flyvbjerg, 2001, p 140)

In relation to above, this licentiate attempts to contribute to the scientific conversation as well as provide an operational suggestion of how things could be done differently in the sense that the suggestion is possible to realize on an operational level tomorrow.

3.2 Case studies

A case study is an empirical inquiry that investigates contemporary phenomena in its real life context. Case studies are particularly useful when the boundary between phenomena and context is not apparent. It is especially suited for new research areas and when "how" and "why" questions are being posed (Yin, 2009). Case studies can be either single or multiple case studies. Flyvbjerg (2006) is a proponent of the former, arguing that a case study is a good way of gaining a sharpened understanding of why instances turned out the way they did by stating that a case study ought to involve an in-depth and over-time examination of a single instance or event. This thesis will deviate from this single case strategy; what will be studied in plurality is the concept of operational freight transport efficiency. As Thomas (2011) proposes, a case study is "analyses of persons, events, decisions, periods, projects, policies, institutions, or other systems that are studied holistically by one or more methods" (p. 513). In this sense the concept could be related to a phenomenon, event, decision and/or a policy.

In the famous example by Karl Popper (1963), "All swans are white," he concluded that it would only take a single case of a black swan to falsify the hypothesis mentioned. The proposition would then be considered invalid and be either revised or rejected. A case study could in the same manner have general significance and stimulate further investigations and theory-building. In this respect, the case study is well suited to identify "black swans" because of its in-depth approach: what appears to be white often turns out to be black at closer examination. The load factor dilemma presented later could be related to this reasoning.

Case studies can be used for learning something rather than evidence finding. Beveridge (1951) observed, before the breakthrough of quantitative studies in social science that "more

discoveries have arisen from intense observations of very limited material than from statistics applied to large groups" Beveridge argued this without saying that large random samples are without value. The advantage of large samples is breadth, while their predicament is one of depth. For the case study, the situation is the opposite. Flyvbjerg argues that Eckstein (1975) goes even further than Beveridge by stating that case studies are better for testing hypotheses than for producing them. Case studies, according to Eckstein, "are valuable at all stages of the theory-building process, but most valuable at the stage of theory-building where least value is generally attached to them: the stage at which candidate theories are tested". Flyvbjerg continues with a discussion regarding the power of the good example in which he argues that:

> One can often generalize on the basis of a single case study, and then the case study may be central to scientific development via generalization as a supplement or alternative to other methods. But formal generalization is overvalued as a source of scientific development, whereas the 'power of the good example' is underestimated (Flyvbjerg, 2001, p 77).

This thesis will use falsification methods as a case of criticizability (see Radnitzky et al., 1987) but not necessarily through positivism, and mix them with Eckstein's and Flyvbjerg's notions of how case studies can be used as a tool to refute an existing hypothesis. Flyvbjerg stresses the importance of choosing these case studies by means of different strategies, as in choosing the "extreme or deviant" case in order to shed light on a problematic situation or for "getting a point across in an especially dramatic way" as in Foucault's "Panopticon."[4] The following methodical guidelines are derived from a case study by Flyvbjerg; they constitute the basis of this licentiate thesis. Flyvbjerg (2001) proposes methodical guidelines for phronetic social science by using Aristotle's theories on the first, third and fourth questions and complementing with theories of Foucault on the second. All the questions are original except that the word *democracy* has been replaced by the word *transport efficiency*. It is argued that the substitution is valid on the basis of similarities such as complexity, actor dependent and that most scholars see transport efficiency and democracy as something for which to strive.

Questions:

1. Where are we going with [transport efficiency] in Sweden?
2. Who gains, and who loses, and by which mechanisms of power?
3. Is it desirable?
4. What, if anything, should be done about it?

Two research questions are created from these questions. The first question emanates from the simple fact that the concept under study is unclear and needs to be semantically defined. For Flyvbjerg, this was not a problem; the definition of democracy is rather well founded.

RQ1: What should be included in the concept of operational freight transport efficiency for the transport operator?

[4] http://en.wikipedia.org/wiki/Panopticon.

The second research question stems from question 1 and 2, but not studying mechanisms of power per se, above and by including the purpose of the thesis. Question 3 and 4 are briefly treated in the concluding discussion.

RQ2: From the perspective of a transport operator, what are the likely economic and environmental effects of operational freight transport efficiency measures in terms of opportunities, barriers, and implications?

Flyvbjerg supports the use of a problem driven approach rather than methodology driven, in the sense that it employs those methods that best help answer the research questions. Insights from many different theoretical areas are used in order to shed light on the problem at hand and to answer the research questions and form a hypothesis that attempts to negate some of the existing theory falsified by the power of the good example à la Flyvbjerg. Induction and deduction will be used in an iterative and reflexive process; the author is interested in the particular and the general.

3.3 Data collection and research process

It is important to match the research process with the data collection methods used. Interviews are probably the most widely employed method in qualitative research (Bryman and Bell, 2007). They are a good option for studies with a more interpretive assertion and they are the main source of empirical evidence for this study. Semi-structured interviews were conducted since it is important to understand the specific respondent's context and to be able to include open-ended and follow up questions. In addition, semi-structured interviews allow one to be flexible about the order of questions as well as to be able to include questions of interest depending on the specific respondent (Bryman and Bell, 2007). Observations are a good way to find out how things work and it is also a good step toward experiencing the subjectivity of the subjects under study, or, in other words, experience reality as the participants experience it. An attempt to oscillate between analysis and data collection will be made to build theory from case studies as ‘‘frequent overlap of data analysis with data collection’’ (Eisenhardt, 1989) is one way to go about this process: asking questions, generating hypotheses and making comparisons. The interviews conducted so far have been a number of interviews with actors in the transport industry, transport operators, freight forwarders and transport buyers. Also a case study in Amsterdam has contributed to this thesis. The observations conducted have been at meetings held by the traffic office, the transport operators of the western part of Sweden's annual meeting in Gothenburg and meetings conducted by Chalmers and University of Gothenburg and at workshops. These have been used to complement the interviews in an attempt to understand how things work and to provide different viewpoints. Group interviews also have been conducted at workshops conducted by Chalmers and University of Gothenburg as well as Volvo and Scania. Workshops are referred to as focus groups by Bryman and Bell (2007) and are a good way to identify factors of importance and compare the viewpoints between two actor groups. Focus groups were chosen for their advantages in capturing the dynamics in viewpoints from several participants in the groups (Kvale and Brinkman, 2009). Also, focus groups are useful for orienting oneself in a new field, for example, generating hypotheses based on informants’ insights and evaluating different study populations (Morgan, 1988).

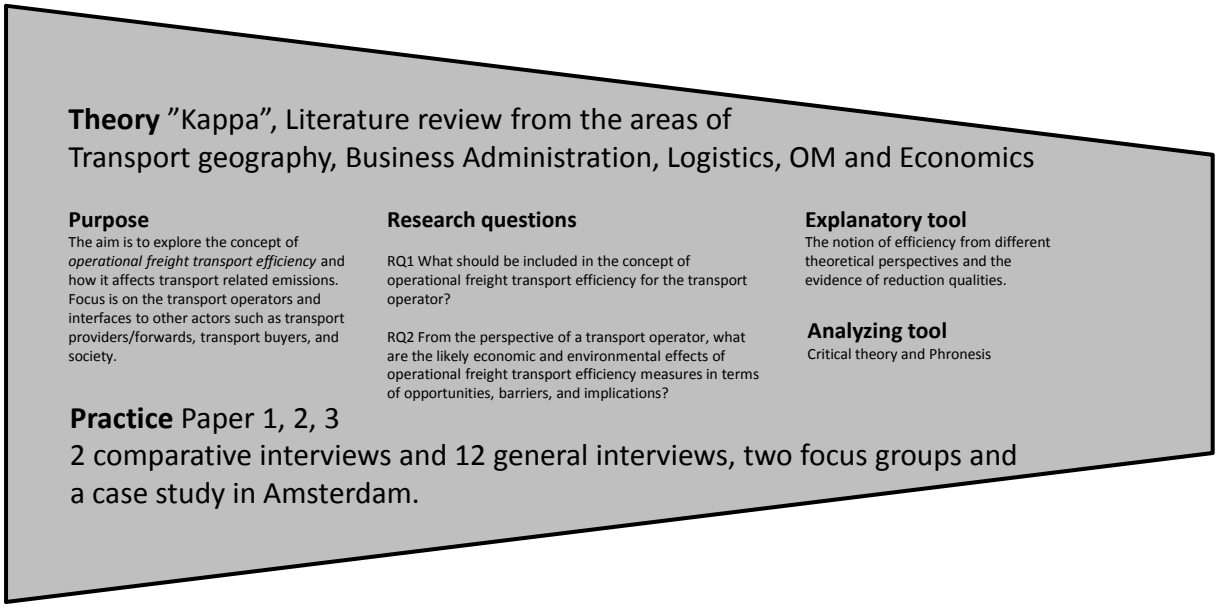

Figure 8 Research process.

Figure 8 is a pictorial presentation of the research process of this thesis. The concept of efficiency is illuminated from a range of different disciplines in a *funnel fashion*. To be able to answer the second part of the purpose of this thesis, likely economic and environmental effects for the transport operator in RQ2, it is imperative to come to terms with what transport efficiency is and its potential for reducing transport emissions. When this has been achieved, a battery of recommendations for the operators, springing from this baseline, could be produced. This licentiate thesis takes the perspective of the operators and as concluded, Paper 1 presents some recommendations after phronetically testing these efficiency measures. Paper 2 provides a suggestion on decarbonisation and Paper 3 shows the attitudes among the actors.

It is also important to know how the Kappa, RQs and papers are related (see Figure 9).

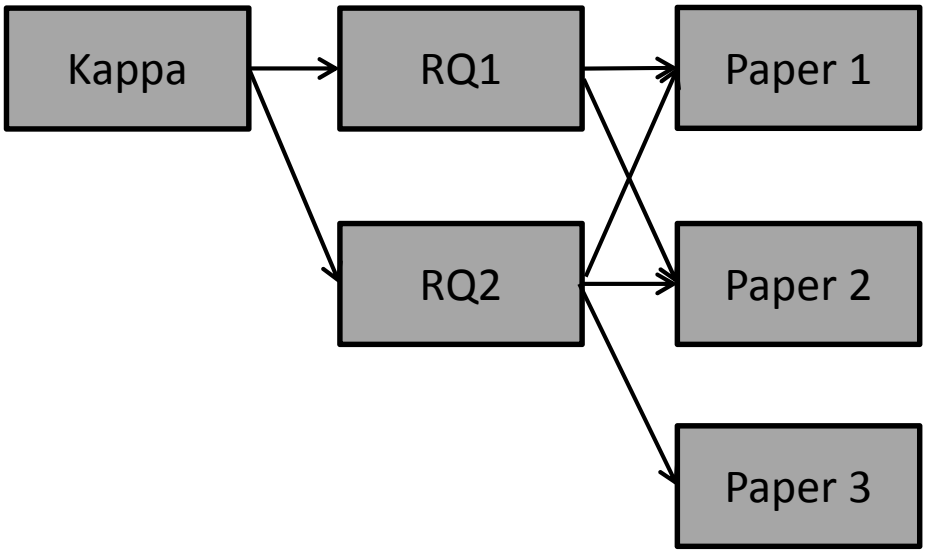

Figure 9 Relationships between Kappa, RQs and papers.

Paper 1—Method
Recorded expert interviews with CEOs at two major operators in Gothenburg—Björn Tynelius at GB Framåt and Roger Nilsson at TGM—and 10 general interviews form the empirical basis of this paper. Eight of these interviews overlap with Paper 3, while the other two were interviews with local and national government officials. Triangulation was performed in order to create the matrix and increase reliability. The literature review was conducted by the author of this thesis and later compared with the empirical findings. The interviews were recorded and transcribed and relevant data to be included in the paper were cross examined by all three authors of the paper: Niklas Arvidsson, Johan Woxenius and Catrin Lammgård. The majority of the paper was created by the first author.

Paper 2—method
The background to this paper was the phronetic concept that it must be possible to do things differently within the area of operational freight transport efficiency. Literature review was performed on similar projects from Dresden, Vienna, Zurich and a case study in Amsterdam. The Amsterdam section is based on a literature review as well as five recorded interviews in Holland conducted in January 2010 with the CEO of Cargo tram, the financial manager at Cargo Tram, a person in charge of public affairs at Cargo Tram, a municipality project manager involved with the project and two journalists writing about the project at MindsinMotion.net. The respondents where approached using Linkedin.com and they were later sent a draft document in order to have an opportunity to comment on the interview results in order to avoid misinterpretations and increase reliability. One respondent came with suggestions on changes and these changes were applied. I would like to thank the students, Fawad Awais, Patric Lindquist and Rafael Serrado, for their input in the paper. They helped out in part of the transcribing of the literature review for Dresden, Vienna and Zurich.

Paper 3—method
Two full day focus group seminars, with eight and ten participants respectively. All of them originated from different branches including food, pulp, agriculture, construction, vehicle production, clothing and personal care. They all have their base in Sweden. The researchers, Vendela Santén and Niklas Arvidsson, were moderating the focus group discussions with the aim to create informality in the discussions in order to get all members to speak openly while at the same time keeping the discussion within the different subject areas. During the focus groups notes were taken continuously. The notes were then summarized and sent out to the participants for their comments. The concept of transport efficiency was not defined by the facilitators of the focus groups, ex ante. Interviews were performed with five transport providers and three transport buying companies. Two researchers conducted the interviews, lasting about one to two hours each. The interviews were recorded and later transcribed. The factors were produced via coding, data were analyzed and compared from the interviews forming subject areas that were included in the discussions in the focus groups. Open coding has been carried out, which is “the process of braking down, examining, comparing, conceptualizing and categorizing data” (Strauss and Corbin, 1990). The outcome from the process was the identified common factors, and the relationship of these factors vis-à-vis the actors was explored further. The majority of the paper was created by Vendela Santén; I contributed with approximately 40 per cent of the work in the paper.

3.4 Critical theory

Historically critical theory has linked with social science and humanities. For obvious reasons the focus will be on the former of these two. According to Stanford (2005), critical theory

provides a base for social inquiry, both descriptive and normative, aimed at decreasing the domination and increasing freedom of all its forms. Put in another way, Alvesson (2003), formulates it as a process of reflection on established ideas, ideologies, and institutions to liberate these from confinement and relations of dominance. Similarly Foucault (1986) takes a critical perspective when one "places [oneself] neither beyond, nor within, but on the boundaries between the seemingly possible and impossible with clear intention of shifting these boundaries". Karl Popper, (1963) describes it as "Critisism, I said, is an attempt to find the weak spots in a theory, and these, as a rule, can be found only in the more remote logical consequences which can be derived from it. It is here that purely logical reasoning plays an important part in science" (p. 67).

According to Marshall (1998), the Frankfurt School was for the first part of the past century pioneering critical theory, with Adorno, Horkheimer, Fromm, Apel and Marcuse. After 1960, Jürgen Habermas has pretty much been a synonym with critical theory. His view is somewhat different than the Frankfurt school's early founders, one of language. The "ideal speech situation" is a utopia in which all have equal access to information and public debate. Furthermore, Habermas talks about distorted communication; for example, powerful economic groups that historically have been able to attain their agency goals without excluding topics from the discussion but rather using implicit non-deliberative means such as threatening to reduce investments. Critical theory works dialectically and does not juxtapose one set of truth claims in relation to another, instead searching for the internal contradictions and gaps in a system of thought and pushing these contradictions as far as possible. This method is sometimes referred to as internal critique.

For the past fifty years, the term has drawn on a wide range of other influences such as sociology, systems theory and psychoanalysis, via Max Weber, Vilfredo Pareto and Sigmund Freud, respectively. The critique against critical theory is commonly phrased, as through Held (1980), with the term "philosophic-historical reductionism," a tendency to move in favour toward philosophy rather than the social sciences. Also on a more general note, any narrative or system of ideas is a "regime of truth" (Foucault, 1980) with its own exclusionary and possibly oppressive consequences. One of the main critiques of critical theory relates to this universalism, the lack of conceptualization of power, and the difficulty critical theorists experience relating abstract theorizing to empirical analysis.

Ghoshal (2005) problematized the use of management theories from a range of different angles. One of his criticisms resonates quite well with Flyvbjerg's focus on values. Halldorsson (2009) also briefly mentions this critism. Ghoshal argues that these theories lack ethics or morality, mainly because they shift morality to the individual away from the unit of analysis, organizations or management. By doing this, Ghoshal points out that morality has had to be excluded from the management theories and the practices that such theories have shaped. Ghoshal concludes that management theories that focus on the economic aspects of man to the exclusion of all others might be incorrect. He denounces e.g. agency theories' explanatory and predictive powers by stating that numerous studies (ibid, pp. 80-81) showed little or no support for the predictions of these theories.

For logistics and transportation the same type of quandary could be identified. The economic dimension is regarded as the most important. According to Wagner (2005) in Wolf and Seuring (2010), many companies strive for win-win situations with regard to the economic and environmental dimensions. However, if trade-offs between environmental and economic

criteria are present or even negatively correlated, decision making is usually dominated by the economic dimension, according to e.g., Schaltegger and Synnestvedt (2002), Wagner (2005) and Wolf et al. (2010).

Halldorson et al. (2009) make similar invitations to Ghoshal's critical reasoning on management theories when they state that instead of calling for more focus on attributes of the supply chain as a solution, like integration, performance, collaboration and centralization. Maybe the way to go forward is to take a step back [also for the transport operator] and explore the operational intersection or boundaries with sustainability, society and SCM.

3.5 Critical theory in transportation

As the previous section has tried to show, critical theory signifies a heterogeneous array of different bodies of work and a wide range of different researchers who share a common critical sensibility. One common critique is that critical scholars are more articulate about what they are against than what they are for. Others disagree. By critical theory used in transportation the author do not necessarily mean a hypercritical negative view of everyone and everything but rather to acquire and maintain a critical spirit, or as Facione et al. (2010) puts it, "use the metaphorical phrase *critical spirit* in a positive sense. By it they mean 'a probing inquisitiveness,' a keenness of mind, a zealous dedication to reason, and a hunger or eagerness for reliable information" (p. 9).

Alvesson (2003) mentions "working with negations and counterpoints, seeing theory as provocation rather than a combination of concepts reflecting 'objective reality'". He continues, "critical theory consistently supports a dialectic way of interpreting society, and argues that social phenomena must be understood in a historical context" This is much the same way as Flyvbjerg argues (see Methodology), but phronesis also focuses on a value-induced course of direction. For me and in a transportation context, I interpret this as fewer emissions from transportation. I try to take advantage of the umbrella characteristics of critical theory by using a method of critique or doubt of the concept of operational freight transport efficiency and put it in a greater, and to some extent historical, context. I try to show how closely related cost reducing efficiency is with productivity, give examples of paradoxes; the load factor paradox and trade-offs between actors. I want to use the word critical in the title to prepare the reader for an attempt of a rebuttal of the cost reducing measures under study, but also positively and phronetically come with suggestions of ways to operate differently.

According to Eurostat (2009) and the European Commission (2009), one could argue that it is problematic, as stated earlier, that GDP growth correlates directly proportional to CO_2 emissions. As shown in Figure 1, transportation is the only major contributor to CO_2 emissions that have experienced a relative increase over the last 20 years, while also being an industry that have worked hard on efficiency measures and improving technical performance, engines and IT. Or on a company level, how should managers for transport operators choose measures that are cost neutral or even increase the supply chain costs for the sake of sustainability? Do managers have the necessary tools to do that?

"It is broadly recognized that it is fruitful to observe organizations based on metaphors that suggests alternative points of departure and foci" (Morgan, 1980; 1997; Grant and Oswick, 1996; Alvesson, 2003, p. 166).

In the past decade, or at least since the beginning of the financial crisis in 2008, research in logistics has focused on redefining conventional logistics theories of how things work, at least those views that cannot be functionally applied in times of crises. In logistics, researchers are to some extent redefining and repositioning themselves to serve up to the changes in reality, how to "handle" or "tackle" sustainability in logistics (Belz and Peattie, 2009)? One of those examples is redefining the concept of lean logistics, in which just in time is an important part in relation to transport and in terms of its potential effect on the environment, which will be elaborated on in this thesis.

When a decrease of emissions from transportation is referred to in this text it is not necessarily meant as a rather radical lowering of total transport emissions right away. Rather, it refers to an abbreviation of the more lengthy "lowering the rate at which emissions from transportation are growing". To say that tonne km should be minimized is highly controversial, since it is generating income for the transport operators. A growing amount of tonne km (transport work) is argued to be litmus for the economic development in general and that the exchange between people is growing. To say that emissions from tonne km ought to decrease is less controversial and to say that the rate at which emissions from tonne km increases should be lowered could be argued to be the least controversial, but this might change in the future.

3.6 Research quality

A problem with delimiting the social aspect of sustainability is that the conclusions do not account for this aspect (per definition) and might be suboptimal or skewed from a triple bottom line/sustainability perspective. To theoretically explore a concept of operational freight transport efficiency by moving in on it from a perspective of more general "efficiency" to "freight efficiency" (by benchmarking "private transportation") to "operational freight efficiency" calls for carefulness, especially if the author intends to draw conclusions from this exercise. Since these conclusions can only be drawn on generalisations from previous researchers in areas that the author is at best considered a novice. That is why no conclusions will be drawn, only a presentation of different "viewpoints" in an attempt to create a scientific conversation. However, the use of a critical approach from the onset might have resulted in these "viewpoints" to be skewed in favour of trying to show cost reducing efficiency as closely related to productivity. This might be true, but it is not necessarily the case in every instance and it is highly controversial. If one uses a "problem oriented" approach, focus on values, problematizing and critical theory one is almost bound to end up with a negation or something along the same lines of the concept studied?

In order to make the leap from cost reducing efficiency measures to an increase (or at least not the desired decrease) of emissions, at least two assumptions have to be made. The first has been treated in this licentiate so far: 1) an assumption that transport efficiency can turn into transport productivity if a time perspective is taken into account; 2) an assumption that there is a link between a rise of transport productivity and a rise of transport demand. The link is price reductions and the relationship is decided by the use of elasticities (Future research).

This thesis has had many working definitions of operational freight transport efficiency. One of the last ones before settling on the current definition was "allocation and utilization of resources". It turns out that researching the background of that definition ends up in a 1964 article on productivity (Amey, 1964). Whether this is problematic or humorous is for the reader to decide.

Research quality—credibility

Patton (2002, p 569) argues that neutrality and impartiality are very difficult, if not impossible to achieve, and this is particularly true of interpretive methods in which the researcher brings his/her preconceptions and interpretations to the problem under study. Therefore it is important that the researcher state beforehand the prior interpretation of the concept under study. In this licentiate, the author signals in the beginning that the thesis will "critically elaborate" on viewing operational freight transport efficiency as a "free lunch." This "view" is strengthened by the result in Paper 1, where transport efficiency measures are shown to be cost reducing, neutral and generating. The conclusion in Paper 2 is along the same lines, that the suggestion might not be cost reducing.

Contrary to Flyvbjerg (2001), Silverman (2001) suggests that the search for deviant cases should be aimed at overcoming any tendency to select a case that supports your argument. In this licentiate, both strategies have been used. In papers 1 and 3 the interviews (1) and focus group participants (3) where chosen so that no deviation or outlier case was identified beforehand. The participants in the focus groups were selected by inviting people from different companies and using snowball sampling by further asking the subject recruits to recruit their acquaintances. Paper 2 is an exception; the cases chosen where deviant by simply trying an unusual way of freight distribution in cities. The results reported in the paper are in line with previous research, with two cases being successful and two being unsuccessful. Initially the idea for the Paper 3 was to only interview one group, the operators, but both researchers identified the importance of looking at the differences in the attitudes of the two actor groups and managed to convince the people from Scania and Volvo, who were in charge of the funding, to make two focus groups.

Patton (2002) advocates multiple methods and multiple theories in a "triangulation" fashion, including using both quantitative and qualitative methods. Four types are known, of which at least three have been used in the papers to varying degrees:

Data triangulation: In all papers, data was gathered from at least two independent samples. In Paper 1 two main interviews were independently conducted asking the same questions. Paper 2 studied four cities, but only one city was studied using primary data. The last paper was mainly based on information from two focus groups. Data triangulation is related to Yin's (2009) multiple sources of evidence, an important part of construct validity.

Investigator triangulation: Paper 1 and 3 were co-authored by other researchers. However, data in Paper 1 was gathered mainly by the author of this thesis. All other interviews were always conducted by at least two interviewers.

Theory triangulation: The theoretical or methodological positions used in the licentiate are critical theory and phronesis. However, these two approaches are related and the relationship may not provide two independent theoretical positions. Another point in this respect is that these positions have mainly been used in the Kappa and in choosing the topics of the papers, and to a lesser degree in the actual papers. The theoretical underpinnings of the papers are critical in the sense that they display internal contradictions and gaps and phronetic by highlighting problems and risks and suggesting how things might be done differently, even though the latter also could be argued to be an analytical endeavour.

However, phronesis has received some critics in the so called "The Flyvbjerg Debate" instigated by Laitin (2003). Laitin argues that Flyvbjerg attempts to separate out phronesis (as a kind of a narrative) from its statistical and formal complements and that this undertaking is radically incomplete and subject to uncontrolled bias. Flyvbjerg countered by arguing that Laitin's critique was ill-founded, he equates phronetic disciplines with qualitative and narrative methods and misrepresents Flyvbjergs work as "either or" and unethical in the sense that Laitin, according to Flyvbjerg, tries to discredit phronesis and promote his own methodology as science (Flyvbjerg, 2004). He was later joined by Schram (2004) and Schram et al. (2008). They state that "the special thing about Flyvbjerg's challenge to social science is the way it bridges theory and practice in a way that unites philosophical and empirical subdivisions in the social sciences" (p 1).

Methodological triangulation: Different methods have been used, as is the case in most research. A valid criticism to this is that the basic methods that have been used so far are only qualitative, e.g., literature review, interviews and focus groups. In Paper 1, for instance, a literature review was conducted, followed by a series of interviews supporting or opposing the findings from the literature review. However, the two methodologies or ontological positions critical theory and phronesis are rather closely related in which the latter can be viewed as a lighter version of the former.

However, triangulation is partly challenged by Silverman (2001), even though he does not refute the method. He states that it might be tricky to aggregate data to arrive at an overall truth. It might be wise not to adopt an overly naïve optimistic view that the aggregation of data from different sources will end up in a production of a more complete picture, this is partly because of actions and accounts are situated and dependent on different contexts.

Research quality—empirical validity and reliability

Yin (2009) suggests four types of tests to measure the quality of empirical social research: construct validity, internal validity, external validity and reliability.

Construct validity: measures how well the concept has been operationalized. It is important to reiterate Bridgman's (1927) "we mean by a concept nothing more than a set of operations; the concept is synonymous with the corresponding sets of operations." How do we know that the definition proposed in this licentiate is the correct one? We do not. Without moving too far away from the original ratio definition, it tries to define what parts are part of the concept and what parts that are not by using triangulation, an attempt to establish a chain of evidence in terms of how the ratio definition was created, and gathering input from key informants. As has been noted previously, the definition deliberately lacks a goal.

Internal validity: to what extent the causal relationships are well founded. Some causal relationships have been put forward in the papers, but they are more descriptive and exploratory. The Kappa tries to make causal inference but also rival explanations have been addressed. This validity is further elaborated upon at the end of this thesis.

External validity: to what extent the case studies can be generalized beyond the case studies themselves. Usually other types of studies such as surveys, are easier to generalise (Yin, 2009). One aim of the papers in this thesis has been to provide deviant cases, and in this context that can be translated to take a perspective that has not been researched much before, exceptions from the norm. The perspective is the operators' and the papers show that this

perspective is worth looking into in more detail, preferably with the help of data analysis, to revise, broaden and potentially confirm the findings that economic and environmental dimensions are not always aligned.

Reliability: measures how well the research conducted can be repeated and show the same results. An interview guide used in the interviews of the two operators can be found in Appendix B. This is a shorter version of the interview guide used for all the interviews conducted for this thesis. In terms of transcription reliability (Kvale, 1996, p 163) the interviewer has chosen to record the interviews to increase the reliability, but for Paper 1 and Paper 2 there has only been one transcribe of the interviews, not two people independently typing the same passage of the taped interview. This method decreases reliability, according to Kvale (1996).

Research quality—theoretical validity and reliability

Even though, or maybe because of, the delimitation of the social aspect of sustainability the author ends up with a hypothesis that it is important to study the problem from this perspective, too. Much of the theory of the debates presented in the theory section and future research is difficult to scientifically resolve since it is futile to run control experiments to see changes in energy use at all levels, with and without the efficiency improvement. Again all the correlations presented in the thesis do not imply causation. Perhaps a way forward might be to study the concept of elasticities and the rebound effect, further elaborated on in the Concluding discussion and Future research. However, this effect is not mentioned at all in Stern (2007) and McKinsey & Company (2009) or to any greater extent in IPCC (2007) as concluded by UKERC (2007). A very important point concluded by, e.g., UKERC (2007), Alcott (2005), 4CMR (2006) or Ruzzenenti (2008) is the lack of consensus among the vast selection of different studies achieved to date, despite three decades of empirical work. Several studies reach different conclusions for the same sector and the same time period.

"A good city is one where we invite people out in the public space." Jan Gehl

"Products are paid for with products" Say, 1803, p 153

4 Results

The following paragraphs elaborate on the research questions and summarize the conclusions of the dissertation. A formulation of the thesis' results will follow from the empiric and theory material. This is represented by answering the formulation of the research questions. The section is divided into: "Defining operational freight transport efficiency," which tries to answer RQ1 and "Opportunities and barriers," summarised paper by paper as well as "Possible implications." The two latter captions are mainly focused on RQ2.

4.1 Defining operational freight transport efficiency

A semantic definition of the concept of operational freight transport efficiency is difficult to find in transportation literature. It is defined by McKinnon, Browne, Allen, etc., in a series of relative measurements involving energy, time, distance, weight or combinations such as tonne km and vehicle km or ratios such as tonne km/vehicle km (utilization). The author of this thesis found few attempts at a clear semantic definition. The definition of transport efficiency has been construed and constructed in the following way: a literature review of how other researchers define the concept was made in Paper 1 and in the "Kappa." Second, definitions were collected from the actors through interviews. Third, these definitions were put together to try to accommodate all the definitions. In this sense, a quantitative definition is transformed into a qualitative definition.

RQ1: What should be included in the concept of operational freight transport efficiency for the transport operator?

According to Wikipedia, this is a definition of *transport efficiency* as of 11/03/01:

> Transport efficiency is a measure of how much it costs (in dollars, time, energy or other kinds of overhead) to move a certain amount of something (goods, people, other types of load).

As mentioned, Mentzer and Konrad (1991) define efficiency in a logistics performance context as "[a] measure of how well the resources expended are utilized" and as "the ratio of resource utilized against the results derived" (p 34). Caplice and Sheffi (1994) highlight their view on the critical elements of logistics management—time, distance and money. Samuelsson and Tilanus (1997) advocate the following efficiency dimensions—distance, speed and capacity. According to Hokey and Seong (2006), the operational efficiency (equipment utilization or labor productivity) of third party logistics providers dictates the competitiveness (and even survival) of the company. Ax et al. (2009) define efficiency as the "degree of fulfilling a goal".

Caplice and Sheffi (1994) identify utilisation, productivity and effectiveness as important improvement indicators in logistics, and McKinnon and Ge (2004) use vehicle loading, empty running, fuel efficiency, vehicle time utilization and deviations from schedule when constructing a series of key indicators. McKinnon (2010, p. 22) also defines operational level

as scheduling of production and distribution operations and the functional level relating to the management of logistical resources.

The definition consists of measures of resources or utilization of these resources (Mentzer and Konrad, 1991; Hokey and Seong, 2006). To be operational in character the definition should include a time component and not include any structural changes (strategic) and the trading links are considered set (tactic, commercial), McKinnon (2010b). The resources should reflect some of the five key indicators suggested by McKinnon and Ge (2004) and in turn derived from Caplice and Sheffi (1994), since it is commonly used in logistics literature. Let us divide these indicators into a series of resources. Vehicle loading and empty running are space, fuel efficiency is fuel, vehicle time utilization and deviations from schedule is time. What is missing from an operator's perspective is vehicle and driver. This results in the following suggestion on a semantic definition of the concept of operational freight transport efficiency for the operator:

> **"A set of utilisation measures of time, space, vehicle, fuel and driver in the movement of goods"**

Possible and adequate measures include vehicle routing and scheduling, consolidation, back-haul, vehicle maintenance, modal shift and driver training. The definition does not contain the word "cost" to accommodate a cost neutral analysis of the different efficiency measures, but the cost is implicitly included, e.g., "cost of time," etc. "Time" could be economically interpreted as "as quick as possible" but in order for it to survive future analysis, it might benefit from being interpreted differently, since "as quick as possible" could also affect space utilization, as concluded in Paper 1.

Possible limitations: This definition does not take into account the trade-off between resources and actors. It also focuses on inputs, not outputs, which could be argued to be misused from a short term micro perspective, as concluded by McIntyre et al. (1998). This definition do not depict a goal, as proposed by Ax et al. (2009) and Sjögren (1996) nor does it contain a norm value, as suggested by Caplice and Sheffi (1994). The definition lacks a measure for some overhead costs such as order administration.

4.2 Opportunities and barriers

This section will focus mostly on RQ2, opportunities and barriers. Implications are treated in the end of this section but also at the end of the discussion section.

RQ2: From the perspective of a transport operator, what are the likely economic and environmental effects of operational freight transport efficiency measures in terms of opportunities, barriers and implications?

Paper 1—Opportunities and barriers
This paper attempts to address research questions 1 and 2, defining the concept as well as how the barriers and possibilities affect operational and strategic decision making in the transportation industry. The paper presents some of the literature within the area of transport efficiency. It also presents potential transport efficiency improvements for environmental performance, case studies, and a concluding matrix presenting costs and/or benefit for the actors. The efficiency measures are divided into driver, vehicle, ITS, utilisation, packaging, order, mode, regulatory/incentives, and coordinated distribution.

The paper depicts a rather gloomy picture of the situation. In the paper the authors show that the basic criteria for sustainability are not satisfactory for transport efficiency measures, especially not for transport operators. It seems that economic and environmental sustainability is not the same thing for some measures. Also, if all the environmental efficiency measures were to be economically profitable, they would be fully implemented, but they are not. As can be derived from Table 2, load factor efficiency and improved packaging could lead to a reduced amount of shipments for the freight industry but would be considered a benefit for transport buyers and society. Consequently, transport companies have alternatives in implementing the efficiency measures to reduce their impact of emissions. Either they can obtain an economic benefit from this change in behaviour, the first efficiency measures, or they could improve market share as a result of their environmental position and added goodwill by supporting the latter efficiency measures.

Table 2 Transport efficiency measures in distribution and the effect on actors in the system.

Measure/actors	Decision maker	Road hauliers	Transport providers	Transport buyers	Society
Driver efficiency	RH	+	+	+	+
Vehicle efficiency	RH/VM	+	+	+	+
ITS and route efficiency	RH/TP	+/-	+	+	+
Utilization efficiency—back-haul effect	RH/TP/S	+	+	+	+
Utilization efficiency—load factor	RH/TP/TB/S	+/-	+/-	+	+
Packaging efficiency	RH/TP/TB	-	-	+	+
Order efficiency	RH/TP/TB/S	-	-	+/-	+
Mode efficiency	RH/TP/TB/S	-	+/-	+/-	+
Regulatory and incentive efficiency	RH/TP/TB/S	+/-	+/-	+/-	+
Coordinated distribution	TP/TB/S	+/-	+/-	+	+

(-) cost, (+) benefit. RH: road haulier, TP: transport provider, TB: transport buyers, S: society, VM: vehicle manufacturer.

At a first glance, Table 2 could lead to the conclusion that transport efficiency measures, reduced environmental impacts and cost reduction for all actors do not always go together. One could argue that individual freight transport operators would not be able to achieve adequate system-wide improvements in urban freight efficiency by themselves. Furthermore, there may be a lack of concern about freight costs by the transport buyers, since these costs are often a small proportion of the total product cost. In some instances there may be reluctance toward coordinated distribution in cities among transport operators and providers, since there are conflicting corporative interests in this respect. In the interviews we asked all the actors who they thought would be the most likely actor to take the first step toward a more sustainable transport system and then rank the rest of the actors in descending order. All actors above were mentioned as potential first movers, but nearly no one picked themselves first. If transport efficiency is a free lunch, a win-win, this is a strange result. From the viewpoint of the road haulier, one paradoxical result of many of the environmentally beneficial transport efficiency measures presented in the matrix is a decrease in the number of total shipments. Therefore, implementing all of these measures would not be beneficial from an economic perspective, at least not in the short term and for all actors. This could partly explain the resistance to change within the freight industry. Nevertheless, the reluctance might be equally well explained by the fact that the road hauliers are hardened after many years of

improvements that they have not been able to keep the benefits from due to the strong market pressure. Let us recite the argument, "Those measures which yield economic as well as environmental benefits generally command the greatest support and are the easiest to implement" (McKinnon, 2003b). Turning this argument around, one rather pessimistic but also potentially premature conclusion could be that as long as the environmentally and economically sound do not point in the same direction, little more can be expected to happen in terms of transport efficiency, since there seems to be a difference in interests that creates major difficulties in practice. A combination of company initiatives, efforts by local authorities and government policies might be necessary to develop a sustainable urban freight system. The importance of this public-private cooperation is also acknowledged by e.g. Allen and Browne (2010).

Paper 2—Opportunities

This paper aims to analyse the potential use of trams and Electric distribution vehicles (EDVs) as cargo carriers in intermodal urban freight distribution. Transporting goods in urban areas, where most logistics chains start or end, is an activity that increasingly generates severe problems for many stakeholders. New transport solutions are necessary in order to decrease traffic congestion, noise and traffic pollution such as emissions of greenhouse gases and other pollutants in urban areas. A possible solution to these problems is to transform the current freight distribution system within cities, for example by favouring the enhancement of intermodal transport alternatives such as combining road and rail transport. If electricity is used, it is important to make sure that the production is not fossil based. The results are presented in a conceptual model (Table 3), as well as a potential zero emission scenario using electric vehicles on trams in Gothenburg. This paper is a contrasting picture to Paper 1, which illustrates a different approach to what one part of operational freight transport efficiency could be for a transport operator/forwarder in an urban setting. Or as Flyvbjerg puts it, "The task of phronetic social science is to clarify and deliberate about the problems and risks we face and to outline how things may be done differently". Mode or modal efficiency indicates the proportion of freight carried by different transport modes. As stated before, the degree of transport by train has decreased in favour of more reliable and time-efficient transport such as lorries and air. In terms of transport and energy efficiency, a modal change toward the increased use of train and ships is preferable. From the transport operator's perspective, this is considered a cost, or rather a loss in sales, unless offering a multimodal service. Nevertheless, this might be part of a feasible fossil-free freight fleet in the future.

Table 3 Cargo tram projects in Europe.

City Key factors	Amsterdam	Dresden	Wien	Zurich
Project owner	Private (City cargo)	Private (VW)	Municipality	Municipality
Funding	Banks/private	VW	Municipality	Municipality
Size of project	Large	Medium	Small demonstration	Small
Type of goods	Commercial, parcels etc	Automotive parts	Commercial, mainly retail	Electronic waste
Type of customers	Commercial	Private (VW)	Commercial/public	Public
Logistics character	Logistic service provider	Internal logistics	Commercial/recycling logistics	Recycling logistics
Infrastructure investments	Large	Small	Small	Small
Current status	On hold, bankrupt late 2008	Ongoing	On hold	Ongoing

Since it is rather costly to reload, goods that are transported greater distances are more likely to undergo a modal shift, which would make this a less likely efficiency measure for short-haul transport. However, some cities have implemented an intermodal city distribution by using the existing tram system, with mixed results. In theory this would be possible in many European cities, using existing cross docking distribution centres operated by transport operators or providers outside the city, adding an extra tram wagon suited for smaller electrical distribution vehicles, loading and unloading via ro-ro technique at the terminal station and in the city centre or by independent tram distribution wagons—so-called "cargo trams"—servicing the city at low traffic hours. The technological and economic feasibility of such a system for full-scale operation, the safety and reliability, and the willingness of various stakeholders to participate in such an implementation require further studies. Nevertheless, a combination of rail and road is a way to decrease the external effects while maintaining flexibility, according to Woxenius (1998) and Lammgård (2007) for example.

Paper 3—Opportunities and barriers

The purpose of this article is to describe and compare the transport buyers' and transport providers' views of challenges when improving transport efficiency and reducing environmental impact from freight transport. By investigating the attitudes of the actor groups, an increased understanding of the different perspectives is made and factors that are important for improving transport efficiency and reducing environmental impact are identified. The role of the different actors and what could be expected from each actor is discussed. Time, competence/knowledge, competition, willingness to pay, priority of transport, demand/service and follow up/measure are identified as important factors. The major similarities and differences from the viewpoints of the actors can be seen in Table 4.

Table 4 Summary of the factors identified as most important when improving transport efficiency and reducing environmental impact from freight transport based on the transport providers' and transport buyers' perspectives.

Important factors	Perspective of the transport provider	Perspective of the transport buyer
Competence and resources	Lack of competence and resources to work with environmental issues within the organization.	Knowledge and information were discussed rather than competence and resources
Knowledge and information	Competence and resources were discussed rather than knowledge and information	Lack of knowledge about all their transport operations and its environmental impact.
Demands	Demands such as cost and time can be a limiting factor. Greater time windows at delivery are needed and more flexible solutions.	To keep the time, i.e. JIT, and robustness in deliveries is a prerequisite.
Priority of transports	Notice the low willingness from the transport buyers to pay extra for environmental better solutions.	Low priority of transport in transport buying companies. Agrees on the low willingness to pay for environmentally better solutions.
Service and offers	Would the buyers be more open in discussions about possible solutions?	Would like the operators to offer more environmental services and being more proactive.
Follow up environmental goals	Raises the need for measuring the fulfillment of the goals.	Raises many challenges in the area of measuring environmental impact, difficult to measure in detail. More information from the transport provider is needed.

Table 4 provides possibilities by highlighting what factors are important for these actors in identifying key areas of interest. It also becomes an obstacle in the sense that not all factors have the same meaning for all actors. The transport buyers need to raise the focus of transport and environment in order to better understand the effects of transport in the system, and the transport providers need to be innovative and proactive in order to find business models that steer toward both efficient and sustainable transports.

4.3 Possible implications

Is there a link between efficiency and productivity on a company level? This section will start with a brief and simplified **paradoxical example**. Picture a transport operator and one of his/her employees coming up with a cost reducing (or resource reducing) efficiency improvement of thirty per cent. The transport operator could choose to save thirty per cent on the efficiency improvement of the input or further capitalize on the improvement by increasing output (≈productivity) by 42 per cent. The example lacks a profit margin; the ex-ante relation is 1/1 of output and input for the sake of simplicity. Appendix A develops a similar reasoning. The manager may choose to save resources or maximize profits. Numerically, because of the workings of ratios the savings in terms of inputs are lower than the potential output increase, even when disregarding a profit margin (0,3<0,43). Put in another way, the numerator is greater than the denominator in absolute terms:

$$Efficiency\ ratio = \frac{1}{0{,}7} = \frac{\frac{1}{0{,}7}}{1} \approx \frac{1{,}43}{1}$$

Figure 10 An example of the relationship between efficiency and productivity. A more mathematical elaboration is available in the appendix.

Is this inconsistent with common assumptions of practice and available theory of how firms usually work? The company has at least two reasons to capitalize on the improvement by increasing output from an efficiency improvement. The nominator in the right column is greater than the denominator in the left column. If a profit margin is applied, this difference is increased. Will the company save resources or capitalize on the improvement? To counter the argument, an increase in supply (output) might affect the price of the product or service that might lead the transport operator to lower the price of transport in order to sell the access units in terms of transportation services. This might drive transport buyers to promote production and distribution strategies (longer run) that increase the use of transport. These drivers also show that the types of policies that can curb transport demand growth could be principles that are based and/or influence the speed and price of transport towards slower, cost neutral or more costly transportation. The problem with this approach is that it would affect the economic sustainability of the transport operators. It is important to keep in mind that efficiency and cost effectiveness are an important part of the economical part of sustainability. Another potential problem with this reasoning is to link the transport service demand growth to the efficiency improvement, as opposed to other economic factors, for example. Finally, we should be careful when drawing conclusions from simple mathematical assumptions in general.

"You're trying to predict the behavior of complicated systems? Just model it as a simple object, and then add some secondary terms to account for complications I just thought of. Easy, right? So, why does your field need a whole journal, anyway? Liberal arts majors may be annoying sometimes, but there's nothing more obnoxious than a physicist first encountering a new subject." By Randall Munroe, also in Cullenward et al. (2011) http://xkcd.com/793/

"The best way to predict the future is to influence the conversation about what it could or should be." Corely and Gioia (2011)

5 Concluding discussion

The main goal of this chapter is to interpret the empirical and theoretical findings. What this thesis set out to do from the introduction was to answer the purpose of the thesis through the two research questions. A definition of the concept operational freight transport efficiency was created by consulting previous research literature in the area along with asking practitioners such as operators how they view this concept. The concept was dissected in Paper 1 and each part was analysed in a matrix concluding whether the measures were a cost or a benefit for the actors. From the operator's point of view many of the measures were difficult to reconcile with financial goals. The measures that are most likely to be implemented are those that offer benefits from the financial and environmental points of view. This is a new and important finding in the sense that previous work in this area has focused mostly on the transport buyers, where many more measures are financially viable. The conclusion of this paper is one of careful optimism: the increased focus on environmental issues and the cooperation among all parties involved could lead to better efficiency in the transport sector, including city distribution. Another possibility is for the operators to become principle actors in making transport efficiency a trademark and positioning environmentally better transports as a strategic issue. There are examples of transport operators and transport providers who have identified this business opportunity and are already moving in this direction, which may offer them a competitive advantage in the future.

5.1 Conclusions

After finalizing the first paper, the author was momentarily feeling a bit weary. Are eco-driving, keeping the tyres at the right pressure or avoiding idling the only operational measures that the operators can do? Surely there are other possibilities? This paved the way for a study of cities in Europe that had implemented a low-carbon intermodal solution, with varied results that are presented in Paper 2. Currently, similar low-carbon research is going on in Gothenburg that is examining the opportunities to use busses or lorries connected to the electric grid. Also, evaluations of consolidation centers with electric distribution vehicles have been made (Browne et al. 2011).

The last paper showed similar (possibilities) and dissimilar (barriers) views from the actors studied. The discussion quickly converged around two themes when *demands* were discussed in the focus groups, cost and time. The literature (e.g., McKinnon 2003a; Halldórsson and Kovács, 2010) has questioned if the trends toward shorter lead times, more frequent shipments and smaller delivery windows really reduces environmental impact. Wolf and Seuring (2010_ state that there is *"limited evidence of environmental issues constituting a buying criteria for 3PL services".* However, Rogerson et al. (2011) mention that the transport operators' ability to respond to environmental demands will affect the transport buyers' interest for them as a supplier.

The difference in *priority of transport* issues in the two actors' systems might be explained by how efficiency is perceived. It is not always the case that efficiency from a transport buyers' perspective is the same as efficiency from a transport operator's perspective, where efficiency

gains from a transport buyer is also about production, inventory and marketing strategies that are experienced by the provider to be restrictive in their effort of making a more efficient transport system.

It was apparent from the workshops that actors today experience hierarchies in relation to each other, where both the transport operators and transport buyers were aware of the unbalance in the purchasing dialogue. For the operator, the challenge is to meet the demands from the transport buyer, turn these demands into a more sustainable offering and getting paid for it. The operators would like to have greater impact on the transport purchasing process instead of just reacting to demands from the buyers. In terms of service and offers, the transport operators were asking for more openness and flexibility from the transport buyers in the discussion concerning new business solutions. Both actors identified following up environmental goals as an important factor. However, the problem was discussed mainly among the transport buyers. In relation to this, Forslund and Jonsson (2009)—who study process integration where two companies agree on activities in the chain that could be related to the transportation purchasing process—conclude that a lack of supplier relationship and, to a lesser extent, the operational tools that could be converted to follow up environmental goals are the most important factors affecting this process.

This thesis is a hybrid between a monography and a collection of papers in the sense that it also suggests an embryo of dialectic contribution to conversation in our research community, as Huff (1999) suggests, or an attempt at prescience as Corley and Gioia (2011) put it, as well as an empirical contribution from the articles presented in the result section. These two are linked in the sense that they both constitute two important parts of my analysis of the research area—operational freight transport efficiency. What is not provided in the contribution to conversation is the last step of the scientific method, a validation of the hypothesis, testing the predictions against evidence. That is why this section elaborates on the implications.

Efficiency is typically connected with progress and development, the economic part of sustainability, but perhaps there is a flip side to the coin, especially in urban areas and for a freight distribution context. If efficiency under certain circumstances might lead to an increase in production with a higher utilization of resources (however used more efficiently) and a potential relative increase of emissions as a consequence, it seems important to find a way to embrace efficiency and curb a potential output growth of emissions from the transportation system. To lower the rate at which emissions from transportation are growing. This is why it is suggested that operational freight transport efficiency is not about minimizing costs in all situations, in order for the concept to survive two-thirds of a "stress test." Perhaps it is time to critically scrutinize the concept as "a free lunch." Green improvements are argued to be favoured by at least cost neutrality. Nevertheless, it is important to keep in mind that efficiency and cost effectiveness are an important part of the economic part of sustainability, as e.g. Behrends et al. (2009) concludes. But the economic part of sustainability is only a part and paramount any of the three pillars (profit, people, planet) might lead to the erroneous conclusion that public transportation, for example, is financially unsustainable and should be avoided[5]. Transport growth in itself is not bad, but in order to facilitate the environmental part of sustainability, it could be argued to be worth lowering the rate at which these emissions are growing, as a start. McKinnon (2010a) proposes a disclaimer to this reasoning—that an increase in emissions from transportation might be necessary to accommodate the demand

[5] http://people.hofstra.edu/geotrans/eng/ch6en/conc6en/revenueustransit.html.

from climate change to "realign vulnerable infrastructure, strengthen flood protection, expand renewal energy and nuclear power systems and relocate population" (p 9). In this sense, the relationship between economic sustainability (with transport growth as good) and environmental sustainability (not transport growth because of emissions, at least with the current carbon intense transport system) is paradoxical. It is worth reiterating that because efficiency may increase energy use and lead to the growth of emissions in areas other than transportation, and that there are fierce scientific discussions in yet other areas whether efficiency leads to growth of emissions, this is far from proof that operational freight transport efficiency leads to transportation growth of emissions, but it is worth looking into in more detail. If demand is considered fixed, sustainability could be argued to increase with efficiency. There are numerous other factors that play a part in greater energy use in transportation such as consumption, income increase, labour efficiency increase, new energy sources, population increase, distance, etc.

The aim of the theoretical research's contribution to conversation has been to nuance the discussion and to show that the concept of operational freight transport efficiency is more complex than at a first glance and probably not the panacea that we would like it to be with an inherently conflicting relationship to energy use. *Most operational freight transport efficiency measures are likely to reduce emissions, but it is probable that the cost-reducing improvements will not lead to the desired and calculated total emission-reducing effect in the long term.* Cost-reducing transport efficiency is an important driver to greater economic welfare, but it might have a limited impact on transport-related emission. In other words, there might be an over-estimation of the actual reducing effects these measures have. Perhaps it is time for a more balanced approach, recognising the benefits and potential costs of operational freight transport efficiency. Realistically speaking, do the managers of transport operators have the tools necessary to make these decisions? How should they opt to keep the costs neutral or even suggest an increase of supply chain costs for the transport buyers for the sake of sustainability? Can transport operators change? In a transport buying context, Lammgård (2007, p. 161) showed that from a strategic point of view logistics managers at transport buying companies experienced more internal pressure than external pressure from customers in the purchasing process of intermodal transport, even though this solution was one of the measures that was least likely to be implemented (ibid, p. 163) compared to a range of measures. But that is a slightly different story.

In terms of implications, I have elaborated on two different discussions/debates; the first debate is induced or derived demand and the second is the relationship (or lack thereof) between operational freight transport efficiency and operational freight transport productivity or the "saving qualities" of efficiency. Also, I will make an argument for the nexus of these two debates into one with the help of a third debate, rebound and elasticities.[6] This is an attempt to add to the scientific conversation in the area of sustainable logistics, a contribution that could help other conversations presented in the introduction such as Weizsäcker et al. (1998, p. 38), rather than rival them. It is an attempt to theoretically strengthen, rather than weaken. However, this contribution warrants closer examination. It is also important to mention that correlation does not always imply causation. Figure 11 presents relationships

[6] Most energy efficiency strategies, especially in the private sector, account for pure losses rather than economic feedbacks, such as energy efficiency in buildings from the use of isolation. These types of efficiencies are not part of this analysis since they deal with squandering to a greater degree rather than feedback mechanisms.

between the economic and environmental measures of some of the feedback mechanisms that play a part in a potential outcome process of more environmental impacts.

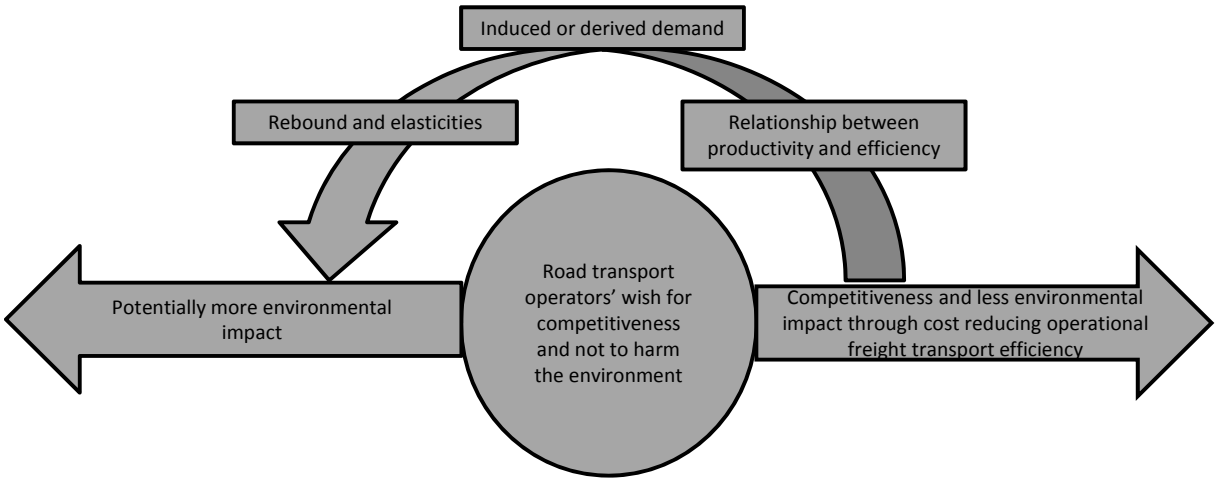

Figure 11 A selection of different feedback mechanisms/implications.

5.2 Future research

A more efficient use of resources is one of the fundamental issues when sustainable development is discussed in research and society. However, efficiency also may have a rebound effect that may work opposite to the efficiency aim, a tendency to increase emissions in some cases. This is a dilemma that science and society has to take into account when discussing efficiency.

The rebound effect is commonly described by economic literature as a counterbalancing effect on the conservational results expected by the evolution of more efficient technology (Saunders, 1992; Sanne, 2006). It was postulated for the first time in 1865 by William Stanley Jevons in his book, "The Coal Question," as a response to the new steam engine that was fuelled by coal. He proposed that the innovation would make coal more cost effective as a power source and lead to an increase of the use of steam engines in a wide variety of industries. This would increase total coal consumption, even though—and because—the amount of coal needed per unit work fell. He argued that every additional increase of efficiency of the steam engine would increase the coal use and would thus increase the rate of depletion of England's coal deposits (Jevons, 2001; see a thorough historic review in Alcott, 2008). While Schipper and Grubb (2000), Schipper et al. (1996, 1998), and Barker and Foxon (4CMR, 2006, 2008) argue that the rebound effect is small, and they did not find any substantial rebound effects when comparing energy use over time. However, Barker et al. (2009) show larger rebound effects.

Today the discussion pertaining the rebound effect, efficiency and growth regards the size of the total rebound. Is the size large enough to speak against efficiency as a resource saving strategy? What happens with the energy saved by efficiency strategies? The total rebound is the sum of the 1) direct rebound—in transport; the amount of increase in driving or purchase of transport services after an efficiency increase that might induce a price drop; 2) indirect rebound, an income effect. If the direct effect is limited (less than unity) the lowered price also leads to a possibility of spending money on other things. A transport operator might decide to use the saved money to invest in other activities that might in turn generate a need for transport. If the direct effect is around unity, the indirect effect can be expected to be small and vice versa. Nearly all consumption leads to transport and saving could be merely delayed

consumption; 3) macro economic rebound, if the price adjustment is significant, more competitors might enter the market. All together, these are often called economy wide effects/rebound. A serious problem in trying to resolve the debate is that it is futile to run control experiments to see the changes in energy use, with and without the efficiency improvement; after all, Herring (2008) concludes that there is only one past.

For more on the rebound effect see: Saunders (1992), Sanne (2006), Jevons (2001), Alcott (2005, 2008), Schipper and Grubb (2000), Schipper et al. (1996, 1998), Barker and Foxon (4CMR, 2006, 2008), Barker et al. (2009) and Herring (2008) as well as the forerunners Khazzoom, Brookes and Jevons. Everything boils down to the use of "elasticities," even in the macro rebound debate, according to Berkhout et al. (2000) and Dimitropoulos (2007), as concluded by Ruzzenenti and Basosi (2008, p. 3627).

Estimates of the size of efficiency rebound vary wildly from nearly zero (Lovins, 1988) to partly significant (Grubb, 1990; Von Weizsäcker et al., 1998; Howarth, 1997; Greening et al., 2000; Schipper and Grubb, 2000; Allan et al., 2006; and 4CMR, 2006) to greater than 100 per cent, what is normally called "backfire" (Jevons, 2001; Brookes, 1990, 2000; Greenhalgh, 1990; Giampietro and Mayumi, 2000; Rudin, 2000; Hanley et al., 2006; Herring, 2006). Further information can be found in Alcott (2008). Whether rebound is greater or less than unity is a matter of debate. Also, the earliest reference used in this presentation is from 1988 and the newest is from 2006.

The efficiency strategy theory holds that higher efficiency causes less resource consumption. Turning this argument around, lower efficiency would raise consumption. Therefore, whatever it is that explains consumption's rise must be strong enough to overcome this "shrinkage effect" of greater efficiency. Machine work is one of the greatest contributors to enhancing labour productivity. It is made more economical by the use of energy efficiency (Ayres and Warr, 2005). In nearly all new products, machinery, processes or material, there is almost always a preceding efficiency improvement as an economical catalyst. Efficiency improvements are rarely pure, as many efficiency advocates commonly note (see Lovins, 2005). These improvements often come with simultaneous improvements in the productivity of other factors of production, multifactor productivity, as concluded in UKERC (2007).

For more info on rebound and elasticities, see: Greene et al. (1992, 1999), Jones (1993), Haughton and Sarkar (1996), Small and Van Dender (2006) and Nässén and Holmberg (2009) for private transportation and for freight transportation; AEA (2008), Graham (2002, 2004), Graham and Glaister (2002), Beuthe et al. (2001), Bjørner (1999), Winston (1981, 1983), Maibach et al. (2008, p. 31), De Jong et al. (2004, 2010), Fiorello (2008), Hemery and Rizet (2007), Graham and Glaister (2002), De Jong (2001), Hemery and Rizet (2007), Hanly, Dargay, Goodwin (2002), Johansson and Schipper (1997) and Goodwin et al. (2004).

It might be interesting to compare private and freight transport by relating it to the rebound debate. It is relevant to mention the link between speed and transport volumes. According to Skinner et al. (2010), a number of studies show that the average person travel for 60-70 minutes each day. The same effect has been noted in a number of countries, has been constant over time and seems to be unchanged by an increasing number of transport possibilities. One implication of this is that with the development of faster transport modes, demand for travel increases measured in distance. People will be able to cover longer distances in a shorter period of time. In France, the distance travelled in the 1800s was a few kilometres, compared

to 40 kilometres today. What is particularly interesting with most of these analyses are that they all are based on private transportation, the end consumer perspective. It is reasonable to argue that some of the results of a direct rebound of 10-30 per cent could be related to the diminishing return of excessive private transport for an individual. People do not want to drive a car more than one hour a day; therefore, to some extent the total price of transport might be of lesser significance than freight transport (for the developed world), it is argued. This reasoning would perhaps also be a qualitative argument/hypothesis for a higher total price elasticity of demand (tonkm), in absolute terms, for freight transport than for personal transport. However, this needs to be studied further. In freight transport the time preference is exchanged for a labour wage for the driver.

The following section presents other potential areas of future research. Below is an argument about why it is important to look at several measures from different point of views, a paradox in relation to transport efficiency, presented more in depth in Paper 4:

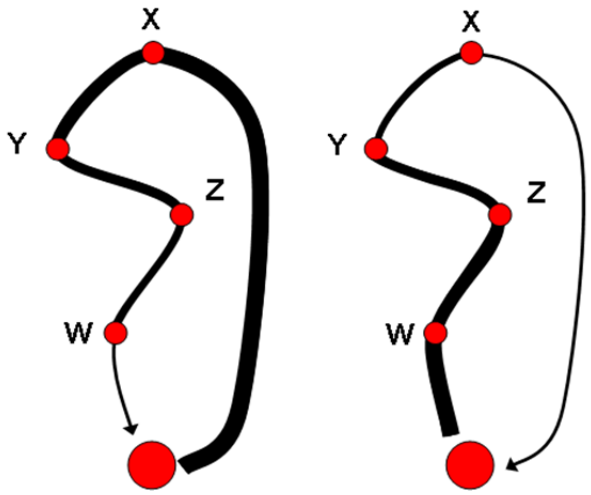

Figure 12 An example of potential sub-optimization of load factor. Created by Niklas Arvidsson and Fredrik Eng Larsson (2010).

It is shown that a lorry on a milk run returning to the point of origin after deliveries could be sub-optimized if the main indicator ruling the vehicle routing is load factor. If this was the case, the left route would be chosen, i.e., the lorry would start full, choose the longer route and deliver to customer x first and successively deliver to customers on its way back. This would lead to a higher average load factor than the right side alternative and a much higher CO_2 effect (10-20 per cent) since the lorry is full half of the way (left) rather than empty (right). Traffic work is constant and transport work is different comparing the two cases. The same paradox was also presented in a Swedish report on transport efficiency in which the author participated (FFI, 2011). Vehicle routing and the travelling salesman problem have been extensively studied, but applying our paradox to this problem calls for minor adjustments in the algorithms if these are to be used in the field of sustainable logistics.

It could be interesting to use freight best practice indicators, for example, as a template and DEA as a tool to compare what the operators in Gothenburg use to measure their operations and to produce a battery of recommendations for competitiveness from the theoretical contribution from this thesis and practice. The battery would benefit from a sustainability perspective if price reducing and non-price reducing measures are included.

Further investigate the relationship between transport efficiency and productivity from a sustainability perspective. Also explore the use of ratios in relations to transport efficiency. What are the problems/benefits of this approach? Which measures are, in monetary terms, cost reducing, neutral and costly for the operators? Explore each of the following five measures: utilisation measures of time, space, vehicle, fuel and driver in the movement of goods and find suitable additions to existing indicators. How can the operators include the social dimension of sustainability in transportation? Investigate CSR, CSI, Pareto, game theory, corporate environmental policy, environmental management systems and eco-efficiency, etc., in relation to this.

Forecast the future of energy efficiency and GHG emissions in Finnish, Swedish and Norwegian road freight transport until 2016 and 2030 in the light of current trends, and recommend measures to achieve the energy efficiency and CO_2 emission targets. Research proposal to be sent in together with Tampere University of Technology's Transport Research Centre Verne and the Institute of Transport Economics in Norway in September 2011.

Paper 1: To explore the trade-offs of transport efficiency measures from a different actor's perspective on the firm level and from a network perspective. Also, investigate whether the initial calculation of GB Framåt on the use of gas trucks is correct. Could it be an operational issue in the sense that the drivers are using both gas and petrol?

Paper 2: Investigate the effects of congestion in urban areas in relation to the size of freight vehicles. Would smaller and more vehicles contribute to or abate congestion? Explore the attitudes among the transport operators of the findings in paper 2. This could be in conjunction with CLOSER, a centre funded by Vinnova for transport efficiency in Gothenburg. The technological and economic feasibility of such a system for full-scale operations, the safety and reliability and the willingness of various stakeholders to participate in this implementation need to be investigated further.

Produce a map of Europe showing how many profit-generating kilometres of coastal road that would disappear for the operators if IPCC projections are correct.

One future goal for the area of sustainable logistics might be, at least, not to make it worse.

"It's not as important to know where the puck is now as to know where it will be." Wayne Gretzky

"What then is truth? A mobile army of metaphors, metonyms, and anthropomorphisms -- in short, a sum of human relations, which have been enhanced, transposed, and embellished poetically and rhetorically, and which after long use seem firm, canonical, and obligatory to a people." Nietzsche

References

4CMR (2006) "The macro-economic rebound effect and the UK economy",CAMBRIDGE CENTRE FOR CLIMATE CHANGE MITIGATION RESEARCH, Final Report to Defra, vol. 18. May, English.

AEA (2008) "MARKAL-MED model runs of long term carbon reduction targets in the UK, report by AEA for the UK Committee on Climate Change", English.

ALCOTT, B. 2005. Jevons' paradox. *Ecological Economics,* 54**,** 9-21.

ALCOTT, B. 2008. The sufficiency strategy: Would rich-world frugality lower environmental impact? *Ecological Economics,* 64**,** 770-786.

ALVESSON, M. 2003. *Critical organization theory. In: Czarniawska, B. & Sevón, G. The Northern Lights – Organization Theory in Scandinavia,* Malmö: Liber.

AMEY, L. R. 1964. The Allocation and Utilization of Resources. *OR,* 15**,** 87-100.

ANDERSON, S., ALLEN, J. & BROWNE, M. 2005. Urban logistics - How can it meet policy makers' sustainability objectives? *Journal of Transport Geography,* 13**,** 71-81.

ARONSSON, H. & HUGE BRODIN, M. 2006. The environmental impact of changing logistics structures. *The International Journal of Logistics Management,* 17**,** 394-415.

AUSTRALIAN PUBLIC SERVICES COMMISSION (2007) "Tackling Wicked Problems",English.

AX, C., JOHANSSON, C. & KULLVÉN, H. 2009. *Den nya ekonomistyrningen,* Malmö, Liber.

AYRES, R. U. & WARR, B. 2005. Accounting for growth: the role of physical work. *Structural Change and Economic Dynamics,* 16**,** 181-209.

BARKER, T., DAGOUMAS, A. & RUBIN, J. 2009. The macroeconomic rebound effect and the world economy. *Energy Efficiency,* 2**,** 411-427.

BARKER, T. & FOXON, T. (2008) "The Macroeconomic Rebound Effect and the UK Economy. A Research Report for the UK Energy Research Center",UK ENERGY RESEARCH CENTRE, UK.

BEHRENDS, S. 2009. *Sustainable freight transport from an urban perspective,* Göteborg, Chalmers University of Technology.

BELZ, F.-M. & PEATTIE, K. 2009. *Sustainability marketing: a global perspective,* Chichester, West Susses, U.K.; Hoboken, NJ, John Wiley & Sons.

BERG, J. & KARSSON, O. 1991. LPP-modellen med tillämpningar. *In:* ELIASSON, G. & SAMUELSSON, L. A. (eds.) *Productivitet och lönsamhet.* Lund: Studentlitteratur.

BERKHOUT, P. H. G., MUSKENS, J. C. & W. VELTHUIJSEN, J. 2000. Defining the rebound effect. *Energy Policy,* 28**,** 425-432.

BEUTHE, M., JOURQUIN, B., GEERTS, J.-F. & KOUL À NDJANG' HA, C. 2001. Freight transportation demand elasticities: a geographic multimodal transportation network analysis. *Transportation Research Part E: Logistics and Transportation Review,* 37**,** 253-266.

BOHM, P. 1986. *Samhällsekonomisk effektivitet,* Stockholm.

BORGSTRÖM, B. 2005. Exploring efficiency and effectiveness in the supply chain : A conceptual analysis. *The 21st Annual IMP Conference.* Rotterdam, Holland: Jönköping University.

BREAKTHROUGH INSTITUTE (2011) "Energy Emergence, Rebound & Backfire as emergent phenomena, a review of the literature", Breakthrough Institut, English.
BRIDGMAN, P. W. 1927. *The Logic of Modern Physics,* New York, Macmillan.
BROOKES, L. 1990. The greenhouse effect: the fallacies in the energy efficiency solution. *Energy Policy,* 18**,** 199-201.
BROOKES, L. 2000. Energy efficiency fallacies revisited. *Energy Policy,* 28**,** 355-366.
BROWNE, M., ALLEN, J. & LEONARDI, J. 2011. Evaluating the use of an urban consolidation centre and electric vehicles in central London. *IATSS Research,* 35**,** 1-6.
BRUNSSON, N. 2010. *Företagsekonomins frågor,* Stockholm, SNS Förlag.
BRYMAN, A. & BELL, E. 2007. *Business Research Methods,* New York, Oxford University Press.
BRYMAN, A. A. B., E. 2007. *Business Research Methods*, Oxford University Press, Oxford.
BUE BJØRNER, T. 1999. Environmental benefits from better freight transport management: freight traffic in a VAR model. *Transportation Research Part D: Transport and Environment,* 4**,** 45-64.
CAPLICE, C. & SHEFFI, Y. 1994. A Review and Evaluation of Logistics Metrics. *International Journal of Logistics Management,* Vol. 5**,** pp.11 - 28.
CARTER, C. R., SANDERS, N. R. & DONG, Y. 2008. Paradigms, revolutions, and tipping points: The need for using multiple methodologies within the field of supply chain management. *Journal of Operations Management,* 26**,** 693-696.
COASE, R. H. 1937. The Nature of the Firm. *Economica,* 4**,** 386-405.
COMMISION OF THE EUROPEAN COMMUNITIES. 2001a. *European Transport Policy for 2010: Time to Decide* [Online]. Brussels. Available: http://ec.europa.eu/transport/white_paper/documents/doc/lb_com_2001_0370_en.pdf [Accessed].
COMMISION OF THE EUROPEAN COMMUNITIES (2001b) "A Sustainable Europe for a Better World: A European Union Strategy for Sustainable Development",Brussels.
COOPER, J., BLACK, I AND PETERS, M 1998. Creating the sustainable supply chain: modelling key relationships. *Transport Policy and the Environment and Planning A,* ed D Banister**,** 176–203.
CORLEY, K. G. & GIOIA, D. A. 2011. Building Theory about Theory Building: What Constitutes a Theoretical Contribution? *Academy of Management Review* Vol. 36**,** 12.
CROOM, S., ROMANO, P. & GIANNAKIS, M. 2000. Supply chain management: an analytical framework for critical literature review. *European Journal of Purchasing & Supply Management,* 6**,** 67-83.
CULLENWARD, D., SCHIPPER, L., SUDARSHAN, A. & HOWARTH, R. 2011. Psychohistory revisited: fundamental issues in forecasting climate futures. *Climatic Change,* 104**,** 457-472.
DE JONG, G., GUNN, H. & BEN-AKIVA, M. 2004. A meta-model for passenger and freight transport in Europe. *Transport Policy,* 11**,** 329-344.
DE JONG, G., SCHROTEN, A., VAN ESSEN, H., OTTEN, M. & BUCCI, P. (2010) "Price sensitivity of European road freight transport - towards a better understanding of existing results", *A report for Transport & Environment, Report 9012-1*, Significance/CE Delft, Delft.
DEMING, W. 2000. *The new economics: for industry, government, education*, MIT Press.
DIETRICH, M. 1994. *Transaction Cost Economics and Beyond: Towards a New Economics of the Firm,* London, Routledge.

DIMAGGIO, P. J. & POWELL, W. W. 1983. The Iron Cage Revisited: Institutional Isomorphism and Collective Rationality in Organizational Fields. *American Sociological Review,* 48**,** 147-160.

DIMITROPOULOS, J. 2007. Energy productivity improvements and the rebound effect: An overview of the state of knowledge. *Energy Policy,* 35**,** 6354-6363.

DUBOIS, A. & ARAUJO, L. 2007. Case research in purchasing and supply management: Opportunities and challenges. *Journal of Purchasing and Supply Management,* 13**,** 170-181.

ELIASSON, G. & SAMUELSON, L. A. 1991. *Produktivitet och lönsamhet,* Lund, Studentlitteratur.

ELKINGTON, J. 1998. *Cannibals with forks: the triple bottom line of 21st century business,* Oxford, New Society Publishers.

EUROPEAN COMMISSION (2001) "European Transport Policy for 2010: time to decide",*White paper*, Office for official publications of the European Communities, Luxembourg.

EUROPEAN COMMISSION (2009) "The Future of Transport Focus Groups", Directorate General Transport and Energy, Brussels.

EUROPEAN COMMISSION (2010a) "ENERGY AND TRANSPORT IN FIGURE",*Part 3 : TRANSPORT*, Directorate-General for Energy and Transport in co-operation with Eurostat, Brussels.

EUROPEAN COMMISSION (2010b) "EU ENERGY IN FIGURES 2010 CO2 Emissions by Sector Extended time serie",Unit A1/j, English.

FACIONE, P. A. 2010. *Critical Thinking: What It Is and Why It Counts*, Measured Reasons and The California Academic Press, Millbrae, C.

FEEST, U. 2005. Operationism in psychology: What the debate is about, what the debate should be about. *Journal of the History of the Behavioral Sciences,* 41**,** 131-149.

FFI (2011) "Slutrapport i FFI-projektet, Förstudie transporteffektivitet",D.nr: 2009-01425

FIORELLO, D., MARTINO, A., SCHADE, W., SCHADE, B., WIESENTHAL, T 2008. High oil price, the transport system and the european economy: some results from a model-based analysis. *European Transport Conference.*

FLYVBJERG, B. 2001. *Making Social Science Matter: Why Social Inquiry Fails and How It Can Succeed Again*, Cambridge University Press.

FLYVBJERG, B. 2004. A Perestroikan Straw Man Answers Back : David Laitin and Phronetic Political Science. *Politics and Society,* Vol. 32**,** p. 389-416.

FLYVBJERG, B. 2006. Five Misunderstandings About Case-Study Research. *Qualitative Inquiry,* 12**,** 219-245.

FORD, H. 1922. My Life and Work. The Project Gutenberg EBook.

FORSLUND, H. & JONSSON, P. 2009. Obstacles to supply chain integration of the performance management process in buyer-supplier dyads: The buyers' perspective. *International Journal of Operations; Production Management,* 29**,** 77-95.

FOURNIER, V. & GREY, C. 2000. At the Critical Moment: Conditions and Prospects for Critical Management Studies. *Human Relations,* 53**,** 7-32.

FRANKEL, R., NASLUND, D. & BOLUMOLE, Y. 2005. The "white space" of logistics research: a look at the role of methods usage. *Journal of Business Logistics,* 26**,** 185–209.

FREIGHT BEST PRACTICE. 2009a. *Fleet Performance Management Tool Incorporating CO2 Emissions Calculator* [Online]. Department for Transport. Available: http://www.businesslink.gov.uk/bdotg/action/detail?itemId=1084564348&type=RESOURCES [Accessed 2011-04-28].

FREIGHT BEST PRACTICE. 2009b. *Your route to operational efficiency* [Online]. Available: http://www.freightbestpractice.org.uk/ [Accessed 2011-02-14].
FREIGHT BEST PRACTICE. 2011. *Various Key Performance Indicators* [Online]. Available: http://www.freightbestpractice.org.uk/performance-management [Accessed May 1st 2011].
FUGLESTVEDT, J., BERNTSEN, T., MYHRE, G., RYPDAL, K. & SKEIE, R. B. 2008. Climate forcing from the transport sectors. *Proc Natl Acad Sci*, 454–458.
GEERLINGS, H. & MEIJEREN, M. V. D. S.-V. 2008. The dominance of the Lisbon agreement as a barrier for an environmentally oriented transport policy in Europe; the gap between theory and implementation in policy integration *European Transport \ Trasporti Europei*, 14-32.
GHOSHAL, S. 2005. Bad management theories are destroying good management practice. *Academy of Management Learning & Education,* Vol. 4, 75–91.
GIAMPIETRO, M. & MAYUMI, K. 2000. Multiple-Scale Integrated Assessments of Societal Metabolism: Integrating Biophysical and Economic Representations Across Scales. *Population & Environment,* 22, 155-210.
GOODWIN, P., DARGAY, J. & HANLY, M. 2004. Elasticities of Road Traffic and Fuel Consumption with Respect to Price and Income: A Review. *Transport Reviews,* 24, 275-292.
GRAHAM, D. & GLAISTER, S. (2002) "Review of income and price elasticities of demand for road traffic (Contract number PPAD 9/65/93) ",Centre for Transport Studies, Imperial College of Science, Technology and Medicine, English.
GRAHAM, D., GLAISTER, S. 2004. Road traffic demand elasticity estimates: a review. *Transport Reviews,* 24, 261-274.
GRANT, D. B. & OSWICK, C. 1996. *Metahpor and organizations,* London, Sage.
GREENE, D., L. 1992. Vehicle Use and Fuel Economy: How Big is the Rebound Effect? *The Energy Journal,* 13, 117-144.
GREENE, D. L., KAHN, J. R. & GIBSON, R. C. 1999. Fuel Economy Rebound Effect for U.S. Household Vehicles. *The Energy Journal,* 20, 1-31.
GREENHALGH, G. 1990. Energy conservation policies. *Energy Policy,* 18, 293-299.
GREENING, L., GREENE, D. L. & DIFIGLIO, C. 2000. Energy efficiency and consumption -- the rebound effect -- a survey. *Energy Policy,* 28, 389-401.
GREENPEACE INTERNATIONAL AND EUROPEAN RENEWABLE ENERGY COUNCIL (2010) "Energy Revolution: A sustainable world energy outlook",Greenpeace International.
GRUBB, M. J. 1990. Communication Energy efficiency and economic fallacies. *Energy Policy,* 18, 783-785.
HALLDÓRSSON, Á., KOTZAB, H. & SKJØTT-LARSEN, T. 2009. Supply chain management on the crossroad to sustainability: a blessing or a curse? *Logistics Research,* 1, 83-94.
HALLDÓRSSON, A. & KOVÁCS, G. 2010. The sustainable agenda and energy efficiency: Logistics solutions and supply chains in times of climate change. *International Journal of Physical Distribution and Logistics Management,* 40, 5-13.
HANLEY, N. D., MCGREGOR, P. G., SWALES, J. K. & TURNER, K. 2006. The impact of a stimulus to energy efficiency on the economy and the environment: A regional computable general equilibrium analysis. *Renewable Energy,* 31, 161-171.
HAUGHTON, J. & SARKAR, S. 1996. Gasoline Tax as a Corrective Tax: Estimates for the United States, 1970-1991. *The Energy Journal,* 17, 103-126.
HEIZER, J. & RENDER, B. 1999. *Operations Management* New Jersey, Prentice-Hall.

HELD, D. 1980. *Introduction to critical theory: Horkheimer to Habermas,* Berkeley, University of California Press.

HEMERY, C., RIZET, C. (2007) "Fuel price elasticity of road freight transport demand in France",Torino, presentation hold at Cost 355 – WATCH “Changing behaviour towards a more sustainable transport system.

HERRING, H. 2006. Energy efficiency--a critical view. *Energy,* 31**,** 10-20.

HERRING, H. 2008. Rebound effect. *Encyclopedia of Earth*.

HESSE, M. 2008. *The City as a Terminal: The Urban Context of Logistics and Freight Transport,* Hampshire, Ashgate Publishing.

HESSE, M. & RODRIGUE, J.-P. 2006. Global Production Networks and the Role of Logistics and Transportation. *Growth and Change,* 37**,** 499-509.

HOKEY M. & SEONG J.J. 2006. Benchmarking the operational efficiency of third party logistics providers using data envelopment analysis. *Supply Chain Management: An International Journal,* 11 259 - 265.

HOWARTH, R. B. 1997. ENERGY EFFICIENCY AND ECONOMIC GROWTH. *Contemporary Economic Policy,* 15**,** 1-9.

HUFF, A. S. 1999. *Writing for scholarly publication,* Munich, Sage Publications.

IEA (2009) "How the energy sector can deliver on a climate agreement in Copenhagen",OECD/IEA, English.

INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE. WORKING GROUP I 2007. *Climate Change 2007 : the physical science basis : contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change,* Cambridge, New York, Cambridge University Press.

INTERLABORATORY WORKING GROUP (2000) " Scenarios for a Clean Energy Future",Oak Ridge National Laboratory, Lawrence Berkeley National Laboratory and Berkeley, CA, Oak Ridge, TN. English.

JEONG, K.-Y. & PHILLIPS, D. T. 2001. Operational efficiency and effectiveness measurement. *International Journal of Operations & Production Management,* 21**,** 1404-1416.

JEVONS, W. S. 2001. *The coal question : an inquiry concerning the progress of the nation, and the probable exhaustion of our coal-mines,* Basingstoke, Palgrave.

JONES, C. T. 1993. Another Look at U.S. Passenger Vehicle Use and the 'Rebound' Effect from Improved Fuel Efficiency. *The Energy Journal,* 14**,** 99-110.

KOHN, C. & BRODIN, M. H. 2008. Centralised distribution systems and the environment: how increased transport work can decrease the environmental impact of logistics. *International Journal of Logistics Research and Applications: A Leading Journal of Supply Chain Management,* 11**,** 229 - 245.

KVALE, S. 1996. *Interviews: an introduction to qualitative research interviewing,* Thousand Oaks, Sage Publications.

KVALE, S. & BRINKMAN, S. 2009. *Interviews - Learning the Craft of Qualitative Research Interviewing*, SAGE.

LAITIN, D. D. 2003. The Perestroikan Challenge to Social Science. *Politics & Society,* 31**,** 163-184.

LAMMGÅRD, C. 2007. *Environmental Perspectives on Marketing of Freight Transports.* Doctoral Thesis, School of Business, Economics and Law, Göteborg University.

LIIMATAINEN, H. & PÖLLÄNEN, M. 2010. Trends of energy efficiency in Finnish road freight transport 1995–2009 and forecast to 2016. *Energy Policy,* 38**,** 7676–7686.

LILJEGREN, G. 1988. *Interdependens och dynamik i långsiktiga kundrelationer.* Doctoral Monograph Stockholm School of Economics.
LOVINS, A. (1990) "The Negawatt Revolution",ROCKY MOUNTAIN INSTITUTE, English.
LOVINS, A. (2005) "Energy End-Use Efficiency",ROCKY MOUNTAIN INSTITUTE, Snowmass, CO 81654. English.
LOVINS, A. B. 1988. Energy Saving from the Adoption of More Efficient Appliances: Another View. *The Energy Journal,* 9**,** 155-162.
LUMSDEN, K. R. 1998. *Logistikens Grunder,* Lund, Studentlitteratur.
MAIBACH, M., SCHREYER, C., SUTTER, D., VAN ESSEN, H.P., BOON, B.H., SMOKERS, R., SCHROTEN, A., DOLL, C., PAWLOWSKA, B., (2008) "Handbook on Estimation of External Costs in the Transport Sector",*IMPACT Project*, DELFT, English.
MARKUSEN, A. 1999. Fuzzy Concepts, Scanty Evidence, Policy Distance: The Case for Rigour and Policy Relevance in Critical Regional Studies. *Regional Studies: The Journal of the Regional Studies Association,* 33**,** 869-884.
MARSHALL, G. 1998. *A Dictionary of Sociology,* Oxford, Oxford University Press.
MATTHEWS, H. S. & HENDRICKSON, C. T. 2002. The Economic and Environmental Implications of Centralized Stock Keeping. *Journal of Industrial Ecology,* 6**,** 71-81.
MCINTYRE, K., SMITH, H. A., HENHAM, A. & PRETLOVE, J. 1998. Logistics Performance Measurement and Greening Supply Chains: Diverging Mindsets. *The International Journal of Logistics Management,* 9**,** 57-68.
MCKINNON, A. 1998. Logistical restructuring, road freight traffic growth and the environment. *Transport Policy and the Environment***,** 97–110.
MCKINNON, A. 2003a. Logistics and the environment. *In:* HENSHER, D. A. & BUTTON, K. J. (eds.) *Handbook of Transport and the Environment.* London, UK: Elsevier Ltd.
MCKINNON, A. 2010a. *Green Logistics: the Carbon Agenda* [Online]. Available: http://www.logistics.pl/pliki/McKinnon.pdf [Accessed 2011-02-05 2011].
MCKINNON, A. C. 2003b. Logistics and the Environment. *In:* HENSCHER, D. A. & BUTTON, K. J. (eds.) *Handbook of Transport and the Environment.* Oxford: Elsevier Ltd.
MCKINNON, A. C. 2010b. *Decarbonising Logistics A European Perspective* [Online]. EDINBURGH, UK: Logistics Research Centre Heriot-Watt University. Available: http://sydney.edu.au/business/__data/assets/pdf_file/0003/64956/alanm.pdf [Accessed December 2010].
MCKINNON, A. C., CULLINANE, S., BROWNE, M. & WHITEING, A. 2010. *Green Logistics: Improving the Environmental Sustainability of Logistics,* London, Kogan Page Publishers.
MCKINNON, A. C. & GE, Y. 2004. Use of a synchronised vehicle audit to determine opportunities for improving transport efficiency in a supply chain. *International Journal of Logistics,* 7**,** 219-238.
MCKINNON, A. C. & WOODBURN, A. 1996. Logistical restructuring and road freight traffic growth. *Transportation,* 23**,** 141-161.
MCKINSEY & COMPANY (2009) "Unlocking Energy Efficiency in the U.S. Economy",MCKINSEY & COMPANY, US.
MENTZER J. T. & KONRAD B. P. 1991. An efficiency/effectiveness approach to logistics performance analysis. *J. Business Logistics,* 12**,** 33 – 62
MEREDITH, J. R., RATURI, A., AMOAKO-GYAMPAH, K. & KAPLAN, B. 1989. Alternative research paradigms in operations. *Journal of Operations Management,* 8**,** 297-326.
MORGAN, D. L. 1988. *Focus Groups as Qualitative Research,* Newbury Park, SAGE.

MORGAN, G. 1980. Paradigms, Metaphors, and Puzzle Solving in Organization Theory. *Administrative Science Quarterly,* 25**,** 605-622.

MORGON, G. 1997. *Images of organisation,* Sage, Thousand Oaks.

MURPHY, P. R., POIST, R.F., AND BRAUNSCHWEIG, C.D. 1996. Green logistics: Comparative views of environmental progressives, moderates, and conservatives. *Journal of Business Logistics,* 17 191-211.

NÄSSÉN, J. & HOLMBERG, J. 2009. Quantifying the rebound effects of energy efficiency improvements and energy conserving behaviour in Sweden. *Energy Efficiency,* 2**,** 221-231.

OECD (2009) "Transport Outlook 2009 (preliminary version): Globalisation, Crisis and Transport",INTERNATIONAL TRANSPORT FORUM, OECD Publishing, OECD.

PATTON, M. Q. 2002. *Qualitative Research & Evaluation Methods,* USA, Sage Publications.

PFEFFER, J. & SALANCIK, G. R. 2003. *The external control of organizations: a resource dependence perspective,* Stanford, Stanford Business Books.

POPPER, K. 1963. *Conjectures and refutations : the growth of scientific knowledge,* London.

PROOST, S., VAN DENDER, K., (2010) "What Sustainable Road Transport Future?: Trends and Policy Options",OECD PUBLISHING, English.

RADNITZKY, G., BARTLEY, W. W. & POPPER, K. R. 1987. *Evolutionary epistemology, rationality, and the sociology of knowledge,* Peru, Illinos, Open Court.

RAMSTEDT, L. & WOXENIUS, J. 2006. *18th Annual Conference for Nordic Researchers in Logistics (NOFOMA).*

REDEFINE (1999) "REDEFINE summary report. Relationship between demand for freight transport and industrial effects", Institute for Prospective Technological Studies

RICHARD B. CHASE, F. ROBERT JACOBS & NICHOLAS J. AQUILANO 2006. *Operations Management for Competitive Advantage,* New York, McGraw-Hill/Irwin.

RODRIGUE, J.-P. 2004. Freight, gateways and mega-urban regions: The logistical integration of the BostWash corridor. *Tijdschrift voor Sociale en Economische Geografie,* 95**,** 147-161.

RODRIGUE, J.-P. 2006. Challenging the derived transport-demand thesis: geographical issues in freight distribution. *Environment and Planning A,* 38**,** 1449-1462.

RODRIGUE, J.-P., COMTOIS, C. & SLACK, B. 2009. *The geography of transport systems,* New York, Routledge.

RODRIGUE, J.-P. & HESSE, M. 2006. Guest Editorial: Global Production Networks and the Role of Logistics and Transportation *Growth and Change, Special Issue on global production networks*.

ROGERSON, S., ANDERSSON, D. & JOHANSSON, M. I. 2011. Context influencing freight purchasing. *IPSERA.* Maastricht.

RORTY, R. 1991. *Objectivity, Relativism, and Truth - Philosophical Papers,* Cambridge, Cambridge University Press.

RUDIN, A. 2000. Let's stop wasting energy on efficiency programs. *Energy & Environment,* 11**,** 539-551.

RUZZENENTI, F. & BASOSI, R. 2008. The role of the power/efficiency misconception in the rebound effect's size debate: Does efficiency actually lead to a power enhancement? *Energy Policy,* 36**,** 3626-3632.

SAMUELSSON, A. & TILANUS, B. 1997. A framework efficiency model for goods transportation, with an application to regional less-than-truckload distribution. *Transport Logistics,* 1**,** 139-151.

SANNE, C. (2006) "Rekyleffekten och effektivitetsfällan – att jaga sin egen svans i miljöpolitiken", *Rapport 5623* NATURVÅRDSVERKET, Swedish.

SAUNDERS, H., D. 1992. The Khazzoom-Brookes Postulate and Neoclassical Growth. *The Energy Journal,* 13**,** 130-148.

SCHALTEGGER, S. & SYNNESTVEDT, T. 2002. The link between 'green' and economic success: environmental management as the crucial trigger between environmental and economic performance. *Journal of Environmental Management,* 65**,** 339-346.

SCHIPPER, L. & GRUBB, M. 2000. On the rebound? Feedback between energy intensities and energy uses in IEA countries. *Energy Policy,* 28**,** 367-388.

SCHIPPER, L. & MEYERS, S. 1996. *Energy Efficiency and Human Activity: Past Trends and Future Prospects,* Cambridge, UK., Cambridge Univ Pr.

SCHRAM, S. & CATERINO, B. 2006. *Making political science matter: debating knowledge, research, and method*, New York University Press.

SCHRAM, S. F. 2004. Beyond Paradigm: Resisting the Assimilation of Phronetic Social Science. *Politics & Society,* 32**,** 417-433.

SCHRAM, S. F., CATERINO, B. & GREEN, E. 2008. Making political science matter: debating knowledge, research and methods, New York: New York University Press, 2006, 304pp., ISBN 0814740332. *Public Administration and Development,* 28**,** 250-250.

SHEFFI, Y. 1986. Shipper/Carrier Interaction in the Transportation Market: An Analytical Framework. *Journal of Business Logistics,* 7**,** 1-27.

SHENHAV, Y. 2009. The Historical and Epistemological Foundations of Organization Theory: Fusing Sociological Theory with Engineering Discourse. *The Oxford handbook of organization theory.*

SILVERMAN, D. 2001. *Interpreting Qualitative Data: Methods for Analysing Task, Text and Interaction,* London, Sage Publications.

SJÖGREN, S. 1996. *Effektiva kombiterminaler - en tillämpning av DEA.* Doctor, Göteborgs universitet.

SKINNER, I., VAN ESSEN, H., SMOKERS, R. & HILL, N. (2010) "Towards the decarbonisation of the EU's transprt sector by 2050",Final report produced under the contract ENV.C.3/SER/2008/0053 between European Commission Directorate-General Environment and AEA Technology plc, see www.eutransportghg2050.eu, English.

SMALL, K. A. & VAN DENDER, K. (2006) "Fuel Efficiency and Motor Vehicle Travel: The Declining Rebound Effect",University of California-Irvine, Department of Economics,

SOLEM, O. 2003. Epistemology and Logistics: A Critical Overview. *Systemic Practice and Action Research,* 16**,** 437-454.

STEFANSSON, G. 2006. Collaborative logistics management and the role of third-party service providers. *International Journal of Physical Distribution & Logistics Management,* 36**,** 76.

STERN, N. (2007) "Stern Review: The Economics of Climate Change",HM TREASURY, London.

STEVENSON, W. J. 2001. *Operations Management,* New York, McGraw-Hill/Irwin, Brent Gordon.

STOCK, J. R. 1995. Advancing logistics research and thought through the "borrowing" of theories from other disciplines: some "old" ideas whose times have come. *The twenty fourth annual transportation and logistics educators conference.* San Diego.

STRAUSS, A. & CORBIN, J. M. 1990. *Basics of Qualitative Research: Techniques and Procedures for Developing Grounded Theory,* Thousand Oaks, Calif, SAGE.

SWEDISH ROAD ADMINISTRATION (VÄGVERKET) 2004. Climate strategy for the Road Transport Sector (Klimatstrategi för vägtransportsektorn). Publication 2004:102, in Swedish.

TANAKA, K. 2008. Assessment of energy efficiency performance measures in industry and their application for policy. *Energy Policy,* 36**,** 2887-2902.

TAYLOR, F. W. 1911. *The Principles of Scientific Management,* New York, NY, USA and London, UK

THE EUROPEAN PARLIAMENT AND THE COUNCIL OF THE EUROPEAN UNION (2006) "Directive 2006/32/EC of the European Parliament and of the Council of 5 April 2006 on energy end-use efficiency and energy services and repealing Council Directive 93/76/EEC", Brussels.

THOMAS, G. 2011. A Typology for the Case Study in Social Science Following a Review of Definition, Discourse, and Structure. *Qualitative Inquiry,* 17**,** 511-521.

THOMSEN, T. U., DREWES NIELSEN, L. & GUDMUNDSSON, H. 2005. *Social perspectives on mobility,* Hampshire, Ashgate Publishing.

TRACEY, M., CHONG LENG TAN, VONDEREMBSE, M AND BARDI, E 1995. A re-examination of the effects of just-in-time on inbound logistics. *The International Journal of Logistics Management,* 6**,** 25–38.

TRANSPORT AT A CROSSROADS TERM (2008) "Indicators tracking transport and environment in the European Union", EEA Report, English.

UKERC (2007) "The Rebound Effect",University of Oxford, Oxford. English.

UNITED NATIONS GENERAL ASSEMBLY RESOLUTION 42/187 (1987) "Report of the World Commission on Environment and Development: Our Common Future",Oxford University Press.

VAFIDIS, D. 2007. *Approaches for knowledge and application creation in logistics.* Dissertation, Turku School of Economics.

WAGNER, M. 2005. How to reconcile environmental and economic performance to improve corporate sustainability: corporate environmental strategies in the European paper industry. *Journal of Environmental Management,* 76**,** 105-118.

WANDEL, S., RUIJGROK, C. & NEMOTO, T. 1992. Relationships among shifts in logistics, transport, traffic and informatics. *Logistiska framsteg.* Lund: Studentlitteratur.

VANEK, F. M. 2001. Analysis of the potential for spatial redistribution of freight using mathematical programming. *European Journal of Operational Research,* 131**,** 62-77.

WEIZSÄCKER, E. U., LOVINS, A. & LOVINS, L. 1998. *Factor four : doubling wealth - halving resource use : the new report to the Club of Rome,* London, Earthscan.

WHITELEGG, J. (1995) "Freight Transport, Logistics and Sustainable Development", London.

WINSTON, C. 1981. A Disaggregate Model of the Demand for Intercity Freight Transportation. *Econometrica,* 49**,** 981-1006.

WINSTON, C. 1983. The demand for freight transportation: models and applications. *Transportation Research Part A: General,* 17**,** 419-427.

WOLF, C. & SEURING, S. 2010. Environmental impact as buying criteria for third party logistical services. *International Journal of Physical Distribution & Logistics Management,* 40**,** 84-102.

WOXENIUS, J. 1998. *Development of small-scale intermodal freight transportation in a systems context.* PhD thesis, Chalmers University of Technology.

YEARLEY, S. 2005. *Making sense of science [Elektronisk resurs] : understanding the social study of science,* London, SAGE.

YIN, R. K. 2009. *Case Study Research: Design and Methods,* Fourth Edition, SAGE Publications. California.

Appendix A

Consider a firm on a market with perfect competition, which transforms resources β (energy, labor, raw material etc.) into output α. Each resource has a unit cost c, and each output can be sold on the market at a price p. We assume p>c. The firm is risk neutral with profit function

$$\pi = \alpha p - \beta c.$$

We now consider two subsequent time periods. In the first period, the firm has efficiency α_0/β_0. Now, due to process improvements, the firm has the possibility to realize efficiency improvements in the next period:

$$\frac{\alpha_1}{\beta_1} > \frac{\alpha_0}{\beta_0}.$$

The firm can then choose to realize the efficiency improvement through reduced resource usage, $\beta_1=\beta_0\ \epsilon$, or by increased plant output, $\alpha_1=\alpha_0\ 1/\epsilon$, where $0<\epsilon<1$. Since both options yield the same efficiency, we have:

$$\frac{\alpha_1}{\beta_1} = \frac{\alpha_0}{\beta_0 \epsilon} > \frac{\alpha_0}{\beta_0}$$

Or

$$\frac{\alpha_1}{\beta_1} = \frac{\alpha_0\ 1/\epsilon}{\beta_0} > \frac{\alpha_0}{\beta_0}$$

Let us assume a $\alpha = \beta$ relationship. The profit function then yields:

$$\pi_o = \frac{\alpha_0 p}{\epsilon} - \alpha_0 c$$

Or

$$\pi_r = \alpha_0 p - \alpha_0 \epsilon c$$

We then differentiate π with respect to α_0:

$$\pi_o'(\alpha_0) := \frac{p}{\epsilon} - c$$
$$\pi_r'(\alpha_0) = p - \epsilon c$$

Let us assume p≥c and compare the two functions:

$$p(\frac{1}{\epsilon} - 1) > p(1 - \epsilon)$$

Thus:

$$\pi_o' > \pi_r'$$

We arrive at:

$$\pi_o > \pi_r.$$

Equation 1 Profit function with increase output or reduced input, own making.

Appendix B

Intervjumall – hållbar logistik

Denna studie syftar till att utforska transportörernas syn på hållbarhetsinriktade logistikåtgärder; åtgärder som syftar till att minska miljöpåverkan från godstransporter; antingen genom minskat behov av transporter, överflyttning till annat transportslag eller minskad miljöpåverkan från det transportslag som används idag.

Intervjuerna bidrar till att få mer kunskap om aktörernas syn på hållbar logistik i deras verksamhet och i förhållande till samhället. Det huvudsakliga syftet är att få en bild över transportörernas syn på vilka åtgärder som är mest intressanta idag och i framtiden. Vilka åtgärder har genomförts, vilka åtgärder är aktuella idag samt vilka åtgärder är mest intressanta på både kort och längre sikt? Det gäller både aktörens syn på åtgärder som aktören själv har möjlighet att genomföra samt åtgärder som anses ha potential till förbättring i samhället i stort. Närliggande frågor som också kommer att diskuteras i intervjuerna är huruvida godstransportfrågan är prioriterad i företagen, drivkrafter/hinder för att genomföra åtgärder samt vilka effekter som uppmätts av redan genomförda åtgärder. Hur aktörerna ser på framtida utvecklingen är också ett en fråga för diskussion.

Intervjuerna genererar underlag dels till en framtida enkätundersökning samt input till vilka åtgärder som anses vara intressanta att djupare analysera.

Målgrupp

Målgruppen är transportörer.

Genomförande

Intervjuerna kommer att genomföras av Niklas Arvidsson, Handelshögskolan, i formatet ”semi-strukturerade” intervjuer. 4-6 st intervjuer planeras (2-3 intervjuer per aktör).

Utifrån litteraturen så sammanställs en ”brutto”-åtgärdslista med effektivitetsrelation som skall ligga till grund för att strukturera åtgärderna. Utifrån denna åtgärdslista ombeds transportörerna att identifiera genomförda, aktuella och framigenom intressanta åtgärder. Åtgärdslistan innefattar strategiska, taktiska och operativa åtgärder. Därutöver innefattas även tekniska, administrativa, samverkande och politiska åtgärder. Totalt sett är de åtgärder som är förknippade med och påverkar transporttrenderna i samhället inkluderade, utifrån vad som beskrivs i litteraturen.

Intervjufrågor

Bakgrund

Information om aktören	• Vilken typ av aktör? Typ av verksamhet?
	• Storlek på företaget; antal anställda? Omsättning?
Dagens logistik; (ej för myndigheter)	• Var ligger era produktionsanläggningar/terminaler I GÖTEBORG?
	• Hur mycket transporter genererar företaget? Finns

mätetal?

Åtgärder

Vi har funderat kring detta med transporteffektivitet för att att minska miljöbelastningen av ett företags transporter. Det finns ett antal parametrar som vi tror är viktiga. Jag kommer nu att fråga om ni jobbar med dessa. Antagligen finns det flera sätt än dessa som ni jobbar med som du gärna får berätta om sen.

-Har ni arbetat -eller kommer att arbeta- med eco-driving? Hur? Varför? Effekt? Hur jobba med framåt?

-Har ni arbetat -eller kommer att arbeta- med fordonens bränsleeffektivitet eller fordonsförbättringar? Hur?

Etc

Gå igenom nedan och försök ta reda på vad dessa åtgärder har för status hos operatörerna.

Ecokörning
Fordonsförbättringar
ITS ruttplanering
Fyllnadsgrad & backhaul
Förpackningseffektivitet
Ordereffektivitet
Modalmöjligheter
Regleringar och incitament
Samarbete i distribution

Har ni jobbat med andra åtgärder som jag inte har nämnt här? Vilka? Etc (samma frågor som ovan)

• Finns det åtgärder som företaget/organisationen valt bort?

• Vad var anledningen till det?

Framtid

Vilka åtgärder anser du vara viktiga för utvecklingen av ett hållbart transport och logistiksystem för samhället i stort?

Vilken aktör tror du har störst chans att påverka utvecklingen i rätt riktning? Transportör, speditör, transportköpare och/eller myndigheter?

Att tänka på under diskussionen om effektivitetsåtgärderna:

- Har ni genomfört åtgärder historiskt? När?
- Vad var drivkraften för att genomföra dessa åtgärder?
- Vilka effekter har ni sett av den genomförda åtgärden? (Både kvantitativa och kvalitativa.)

• Har ni planerat att genomföra åtgärder idag eller inom de närmaste 1-2 åren? • Vad är drivkraften för att genomföra åtgärden? • Vilka effekter tror ni att ni kommer att få av den genomföra åtgärden? (Både kvantitativa och kvalitativa.)
• Finns det åtgärder som företaget/organisationen valt bort? (se ovan) • Vad var anledningen till det? (se ovan) • Vilka åtgärder är aktuella att genomföra på längre sikt?

Appended papers

Paper 1: Arvidsson, N., Woxenius, J., Lammgård, C., (2011), Measures for increasing transport efficiency in urban freight distribution—from the operators' perspective, submitted to Transport Reviews. An earlier version was published in the proceedings and presented at Logistics Research Network, Cardiff, Wales, September 9-11, 2009.

Paper 2: Arvidsson, N., (2010), New perspectives on sustainable urban freight distribution: A potential zero emissions concept using electric cars on trams, Published in the selected proceedings and presented at WCTR, Lisbon, Portugal, July 11-15, 2010.

Paper 3: Santén, V., Arvidsson, N., (2011), Road freight transport efficiency and less environmental impact – the perspectives of transport buyers and operators, Published in the proceedings and presented at Nofoma, Harstad, Norway, June 9-10, 2011.

Paper 1

Paper 1: Arvidsson, N., Woxenius, J., Lammgård, C., (2011), Measures for increasing transport efficiency in urban freight distribution—from the operators' perspective, submitted to Transport Reviews. An earlier version was published in the proceedings and presented at Logistics Research Network, Cardiff, Wales, September 9-11, 2009.

Measures for increasing transport efficiency in urban freight distribution—from the operators' perspective

Niklas Arvidsson, Johan Woxenius, Catrin Lammgård
Department of Business Administration, School of Business, Economics and Law at University of Gothenburg,
Box 610, SE-405 30 Gothenburg, Sweden
niklas.arvidsson@handels.gu.se; johan.woxenius@handels.gu.se; catrin.lammgard@handels.gu.se

Abstract

This paper seeks to establish a set of measures for transport efficiency improvements from the perspective of the road haulier, particularly regarding improvements suitable for urban distribution and their effects. The first part of the paper addresses literature within the area of transport efficiency. The second part reviews potential transport efficiency improvements with respect to environmental impact and number of actors involved in the decision. The third part presents results from interviews with the CEOs of two transport operators regarding their opinions of the transport efficiency measures. Finally, the conclusions about transport efficiency measures are summarised in a matrix, also taking into account whether these measures can be considered as costs or benefits for the actors involved. The results show ambiguous and often intricate relations with regards to costs and benefits for the actors in the system. They also explain part of the inertia to change within the freight industry. However, an increasing number of transport operators are now offering more sustainable transport solutions and this service might gain them a competitive advantage in the future.

Keywords: Transport efficiency, sustainability, urban freight distribution.

1 Introduction

Freight transport is woven into today's society, creating tremendous economic and social benefits. Ships, aircrafts, trains and lorries support globalisation and distribute commodities to locations near us. We cannot do without it, but we all know about the negative side effects in terms of emissions, accidents, visual and audio encroachment, barrier effects and not least, time losses because of congestion. With the recent downturn in the global economy, there is growing concern that environmental issues could be neglected in favour of economic aspects, but it could be argued that there are no alternatives to the redirection of transport systems toward economic, social and environmental sustainability.

Urban freight distribution is often provided in inefficient ways, and the industry is particularly resistant to change (e.g., Behrends et al., 2008). A French study (discussed in Small and van Dender, 2007) finds that the marginal external congestion costs of urban traffic are ten times higher than inter-urban traffic. Still, there is an abundance of ideas for improvements. A wide range of trials and pilot projects have been carried out by commercial actors themselves or as projects with public funding at the local, national and EU levels. Many projects have been successful, but the mechanisms of analysis, learning and implementation are not functioning to satisfaction (Lindholm, 2008). As Uherek et al. (2010) puts it, "Although transport problems are well identified and [some of] their solutions are also known and accepted, there is a lack of action on implementation" (p. 4798). Therefore, there is a need for a structured approach with options and measures the stakeholders can use when working to improve the economic, social and environmental efficiency of urban freight transport. Access to and un-

derstanding these measures and their effects is particularly important for Europe's hundreds of thousands of small and medium road hauliers lacking their own R&D departments, budget, negotiation power and at times the vision of how to operate in a different way.

The purpose of this paper is to analyse improvement and efficiency measures suitable for urban distribution and comment on their effects. This is examined from the perspective of the road haulier. The analysis of potential measures is structured along with the actor categories that need to be involved, i.e., only the road hauliers themselves or if they need to cooperate with transport buyers, 3PLs, other transport operators and policy makers.

The paper is divided into four parts. The first part of the paper is a literature review of transport efficiency. The second part reviews potential transport efficiency measures for improving the environmental performance. The third part presents the empirical findings from two transport operators' cases. The fourth part summarises these measures in a matrix taking into account whether these efficiency measures are costs or benefits for the actors involved.

The method primarily used for data collection is expert interviews. The empirical foundation of the transport efficiency measures identified is a series of 12 interviews conducted with representatives from road hauliers, other actors in the transport system and previous literature. The empirical basis for the point of view of the operators was collected mainly through structured personal interviews with CEOs of the two major distribution hauliers in Gothenburg. As subcontractors, they pick up and distribute to the two main forwarders in the Swedish transport market, DB Schenker and DHL. The same questions were asked to both CEOs and they had an opportunity to comment on the interview results in order to avoid misinterpretation and to increase reliability. The actors were interviewed in a Swedish context, although the aspects covered should apply to city distribution in other cities as well.

2 Transport efficiency and the environment

The past decades have shown a growing awareness of environmental problems. In the 1980s and 1990s acid rain and the diminishing ozone layer were of public interest, followed by an increasing awareness of climate change and some successful measures to counteract these effects. Potential conflicts may appear between the city centre's function as a commercial zone with its freight movements and as an area where people live, shop and relax. In relation to transport efficiency and the numerous measures that can be used to promote more environmentally sustainable distribution, those which yield economic and environmental benefits command the greatest support and are the easiest to implement (McKinnon, 2003).

On an EU level, congestion is the external effect that costs the most for society. Road congestion causes costs corresponding to approximately 1 per cent of the GNP in the EU (European Commission, 2001). This corresponds to 123 billion euros in 2007, approximately the same size as the total EU budget (European Commission, 2009). Road hauliers both contribute to and suffer from this problem. From a more national perspective, fuel economy standards, vehicle emission standards and fuel quality standards have been the main regulatory measures taken by governments (Timilsina and Dulal, 2009).

One interpretation of transport efficiency is producing a service with less resource consumption without reducing the logistics performance in terms of costs and delivery service (Aronsson and Huge Brodin, 2006). Cost and the environment impact often point in the same direction, a solution for lower cost for transportation almost always reduces pollution as well. This paper explores some of the reasons why this might not always be the case, optimising transport efficiency might be at the expense of overall logistics costs, especially for the operator.

The impact of transport efficiency on the environment can be analysed in a bottom-up vehicle approach (Léonardi et al., 2008) where the focus is the vehicle and its driver, e.g., on reducing mileage, increasing the energy and CO_2 intensity per transport unit and changing driv-

er behaviour. A variety of mainly vehicle-related performance measures/ratios tries to link the amount of goods produced or consumed to freight transport. The handling factor ratio converts the weight of goods produced in a system to freight tonnes lifted. The handling factor can be used as a measure of the number of links in a supply chain. Together with the average distance of haul multiplied by the number of links (≈handling factor), the transport intensity can be determined by transferring the tonnes lifted into tonne km. The modal split specifies the amount of tonnes carried or tonne kms carried out by different traffic modes. For lorry traffic, the most common traffic mode within the EU, two more measures could be identified—the average load factor on trips and the proportion of kms run empty, partly explained by the back-haul effect. All these measures combined with fuel efficiency result in an analytical tool to improve transport efficiency by improving the ratios above (e.g., McKinnon, 1996 and 2003; McKinnon and Piecyk, 2009). Adding a time and fuel dimension, some of these ratios can be translated into vehicle loading, empty running, fuel efficiency, vehicle time utilisation and deviations from schedule (McKinnon and Ge, 2004). A similar presentation for city distribution with an extended focus on time-related performance indicators such has speed per delivery round is presented in Allen et al., (2003). All these measures have different dimensions of output such as tonnes, vehicle kms and tonne-kms,(eg.De Jong et al., 2010).

A review of the literature concerning freight vehicle activities in urban areas, with a focus of economic, social and environmental considerations of these activities and suitable transport efficiency measures is presented in Browne et al. (2010b) and Whiteing et al. (2007). Sustainable urban distribution from a policy level is addressed by Danielis et al. (2010), Anderson et al. (2005) and Allen et al. (2003). Other studies focus on particular parts or measures such as light goods vehicles (Browne et al., 2007; 2010a), low emission zones, etc. (Browne et al., 2005; Allen et al., 2003) or studying the survey techniques used in urban freight distribution (Browne et al., 2010b) and summarising the UK research in urban freight over the past 30 years comparing similarities and differences. The similarities are the number of vehicle deliveries per establishment and that deliveries take place in the morning. Among the differences mentioned are the increased use of third party logistics operators, a reduction of the number of goods dispatch places, increase in delivery distance, spreading deliveries over more days of the week, increased use of light goods vehicles, greater seasonal peaks in delivery traffic, changes of handling systems and increase in dwell times.

One perspective, other than that of the driver or vehicle, is to include not only operational measures but also policy/regulations and organisational measures; they could be examples of a macro perspective complementing the traditional micro perspective (eg. Santén and Blinge , 2010). A division along the lines of operational, tactical and strategic is yet another way of approaching the concept. Aronsson and Huge Brodin, 2006) serve as examples in which transport efficiency is analysed with respect to micro and macro measures, presented in a matrix separated by changes in technology and structural domains. The decision hierarchy is divided in operational, tactical and strategic levels to illustrate environmental impact at different levels of the supply chain. The study proposes a holistic logistics perspective on structural changes but does not consider the different actors in the supply chain, only the transport buyer. They conclude that nearly all measures lead to both reduced logistics and environmental costs.

The forwarders depend on how their customers value environmental aspects, which varies among transport buyers. This was shown by a large survey in 2003, including answers from 567 transport buying company units in Sweden, where environmental aspects had a higher priority in large-sized companies as well as in manufacturing companies rather than in wholesale companies (Lammgård, 2007). This means that the environmental performance of a transport is an added-value service to some segments of buyers, and some of the largest 3PLs are now offering services with environmentally better performance.

A somewhat critical perspective, represented by Rodrigue et al. (2001), focuses more on the conflicting relations of green logistics, costs (environmental costs are often externalised), time/flexibility (extended production, distribution and retailing structures consuming more space, energy and emissions), network (concentration of environmental impact around major hubs and along corridors), reliability (modes used are the least environmentally efficient—lorries and air), and warehousing (inventory shifted in part to roads, contributing to congestion and space consumption) with the argument that reducing logistics costs does not necessarily reduce the environmental impact. Others suggest a more long-term perspective in the use of logistics performance measures (McIntyre et al., 1998).

3 Measures for increasing transport efficiency

The perspective promoted in this paper chooses to focus on the road haulier together with the actors involved in the decision making process concerned with gaining energy efficiency in transport. The focus is not only on operational measures—driver and vehicle—but also on those macro or strategic measures that affect the road haulier directly or indirectly in an urban setting. The transport operator, or road haulier, is the actor moving the goods. In addition there is often a middleman between the transport operator and the transport buyer and is typically called a freight forwarder or third-party logistics provider, often providing additional logistics services such as warehousing. In the reminder of the paper this organisation will be referred to as a 3PL.

As indicated above, most transport efficiency decisions depend on more actors than the road haulier. In order for these measures to be implemented properly and to reap the benefits of energy efficiency and cost reduction, co-operation between the actors within and outside the supply chain is in focus. Therefore, the transport efficiency measures are divided into four main groups. These are internal transport efficiency measures (to the haulier), joint transport efficiency measures with the customers (the logistics service provider or the shippers) and joint transport efficiency measures with the public sector. These measures are not mutually exclusive or collectively exhaustive, but are instead an attempt to encompass some of the literature within transport efficiency and logistics areas where the effects on transport efficiency may be increased or decreased. These four groups of transport efficiency measures are discussed below.

3.1 Internal transport efficiency measures

This section outlines two measures that the road hauliers can implement on their own.

3.1.1 Driver efficiency

Providing eco-driving training can improve fuel economy and reduce the environmental impact per vehicle and driver significantly, where the reduction of fuel consumption can be up to 25-30 per cent (Blinge and Svensson, 2006), even though the long-term savings are closer to 3-6 per cent (Swedish Road Administration, 2004). Nevertheless, eco-driving seems to be more effective if combined with additional driver incentives, 2-12 per cent (Hedenus, 2008). Today, many lorry drivers go through some kind of driver efficiency training. Maintaining the right tyre pressure, speed and minimising vehicle idling has a positive effect on fuel economy. In urban freight distribution, idling situations occur regularly and are not always driver related. According to McKinnon (2007) the increase of traffic congestion, in combination with stricter working time regulations for lorry drivers, could have a negative impact on delivery flexibility that is required to locate, collect and deliver suitable backloads. The stricter working time regulations adverse effect is later shown to have little effect (McKinnon et al., 2010,

p 209). Implementing these measures leads to a cost reduction for the transport operator and consequently lower transport costs for all actors under perfect market competition conditions.

3.1.2 Vehicle efficiency

According to Freight Best Practice (2009), fuel accounts for approximately 30 per cent of a road haulier's operational expenses. In a series of case studies presented at Freight Best Practice, the road hauliers used monitoring systems to observe fuel consumption with positive results. Vehicle manufacturers have long prioritised improving fuel economy. Between 1980 and 2006, the fuel consumption has been reduced by almost 40 per cent (Mårtensson, 2006) for the same type and size of vehicle, and Volvo, for example, estimates that lorries will be 15 per cent more efficient in 2020 (Hedenus, 2008). Aerodynamic improvements and alternative fuels are also important factors for efficiency improvement. Hedenus (2008) argues that the greatest improvements have been made; the improvements have more or less stagnated since the early 1990s. A contributing factor is vehicle emission standards and the contradiction between low emissions of NOx and low fuel consumption, where a decrease in NOx increases fuel consumption (McKinnon, 2010). Hybrids and electrical vehicles would make a significant contribution to energy efficiency (Åkerman and Höjer, 2006) and are best suited for the urban freight environment, where long hauls are less common.

In the UK, light goods vehicles (LGVs) with less than 3,5 tonnes of gross weight are growing in importance in vehicle numbers and activity levels and much of this growth is in urban areas (Browne et al., 2010a). This trend is confirmed by SIKA (2009) for the Swedish context. LGVs are the vehicle of choice in the final leg of many supply chains. The last row in Table 1 shows the calculated change between 1999 and 2008. Note the increased use of alternatives to petrol such as ethanol, diesel and gas. A decrease in the use of electric vehicles is significant even though the numbers are relatively small.

Table 1: 1000 kilometers driven by light lorries in Sweden, by fuel, 1999 and 2008, SIKA (2009).

At the end of	Petrol	Diesel	Electricty	Etanol-hybrid/E85	Other hybrids	Natural gas/ Bio gas	Other	Total
1999	2 440 786	1 843 570	1 687	0	3 693	0	166	4 289 902
2008	1 154 263	6 368 453	799	7 256	875	36 914	124	7 568 683
Diff	-53%	+245%	-53%	+	-76%	+	+25%	+76%

Improvements in fuel efficiency or vehicle efficiency would lead to improved economic efficiency for the road haulier unless the gains are offset by the higher investment cost of a lorry adapted to alternative fuels and the difference in fuel price. The load factor and the back-haul problem could also be seen as a time- or sales-related problem, and also therefore partly an internal measure.

3.2 Joint transport efficiency measures with the customers

This section presents six transport efficiency measures that the hauliers can take first, after consulting with the customers (in terms of shippers and forwarders/providers).

3.2.1 Intelligent transport systems and route efficiency

An effective way to reduce environmental impact is route planning, and according to Stefansson and Woxenius (2007), the use of information and communication systems could facili-

tate better planning and control of transport activities. Today these technologies, often with real time information, are readily available at affordable prices and could result in a cost reduction for the road haulier, if used efficiently.

From the road haulier's perspective, a significant pressure from vehicle suppliers, the government, 3PLs and transport buyers to incorporate these new applications into their operations has put additional strain on their already tight profit margins. They often cannot develop their own technical competence. Consequently, they risk being forced to invest in several costly systems with overlapping functionality in order to fulfil certain needs of their strong counterparts (Stefansson and Woxenius, 2007). In that case, this could induce a cost for the road haulier. Currently, there is work going on in EU projects working with standardisation of systems and information for freight transports which will reduce this risk, e.g., EASYWAY project (European Commission, Ongoing) and the ITS Action Plan adopted by the European Commission in 2009 (European Commission, 2009). The ITS and route efficiency measure bring benefits to all actors, but the outcome is somewhat more uncertain for the road haulier because of the risk of investment.

3.2.2 Utilisation efficiency—the back-haul effect

One third of the road transport distance is run empty, according to a study by McKinnon (1996). This is known as the back-haul effect or no-load shipments, and it is prevalent in nearly all types of transport. The problem occurs when the demand is asymmetric in volume at a certain time. The problem is universal. For example, oil tankers to Kuwait are emptier than those from Kuwait, and commuter traffic is denser into cities than away from cities in the morning. It is a common argument from politicians that investments in new roads are not needed because the hauliers must first utilise the slack capacity in the non-filled lorries. The market pressure to work on lessening the back-haul effect is very strong, since the availability of backloads is an important factor for determining the profitability of a transport operator. A common measure is to apply different pricing measures to attract goods to create a balance.

McKinnon (2007) argues that research shows a decline in empty backhaul mainly as a result of lengthening of freight journeys, growth of reverse logistics, increase in number of load matching agencies and Internet freight exchanges and various corporate initiatives to counter the back-haul effect. For example, according to Vierth and Mellin (2008), Swedish supermarket chain ICA has decreased the number of empty backloads by vertically integrating transport with an increase in consolidation and the use of returning delivery vehicles to collect inbound supplies. On the other hand, when the grocery retailer ICA takes control of its flow of soft drinks, the efficiency for Coca Cola might go down. Unfortunately, the only way to completely counteract the imbalances that cause empty running would be to incorporate enormous societal changes to ensure that input in one area equals the output in the same area. Nevertheless, measures to eliminate the back-haul effect benefit all actors.

3.2.3 Utilisation efficiency—load factor

The load factor is a measurement of vehicle utilisation that has been of interest to researchers and the industry for many years. The European Environment Agency (2006) concludes that the average load factor has also declined for heavy goods vehicles between the years 1990 and 2004. The load factors in Sweden measured in studies vary between 30 and 70 per cent (Blinge and Svensson, 2006). In theory this implies that the environmental impact of road transport could be cut to half of what it is today if more loads were consolidated. In reality this is a very difficult task partly because of route imbalances, but an increase in load factor could decrease the number of shipments and total fuel consumption. In order to cut lead times

in the supply chain, the industry has moved toward faster modes of transportation, lorries and air. This is supported by transport statistics such as Eurostat (2005), European Environment Agency (2006) and European Commission (2009).

Also from a societal perspective, an increase in load factor is something to strive for and examples of projects aiming to increase the load factor are plentiful. One successful example from Gothenburg is the use of c/o addresses at a terminal owned by a 3PL outside the city in order to coordinate deliveries to the Swedish Exhibit Centre in the centre of Gothenburg. This has saved more than one-third of the transport by consolidation (Swedish Exhibit Center, 2007). For the road hauliers, an increase in load factor could mean a decrease of frequency of shipments and a potential loss in sales partly due to loading times, time loading the vehicle in the morning might impede on available delivery time during the day. For the operator in city distribution the load factor is, in this respect, very dependent on delivery time restrictions, number of stops and the time available for loading. However, a high load rate would be positive for society since more service can be produced with less cost.

3.2.4 Packaging efficiency

The volume and weight of goods transported are a result of the design of transport and product packaging material and ultimately the product itself; therefore packaging efficiency is considered an important factor. Significant improvements can be achieved in packaging (Tilanus and Samuelsson, 1997). Home furnishing company IKEA is often used as an example of a company that successfully works with packaging optimisation; smaller companies do not have the same capacity to enforce these measures. On one hand, there is no real incentive for the operator to present packaging efficiency improvements to their customers, given that this would mean a potential loss in sales from a short term perspective since the actual revenue generating tonne-kms would go down per se. However, from a more realistic long term perspective the operators might feel pressure to come up with these improvements in order to avoid losing the customer to a competitor who might offer the same improvement. Packaging efficiency has a positive effect on the tonne km and could also result in a decrease in the number of shipments for the road haulier and a potential loss in sales from a short-term perspective.

3.2.5 Delivery efficiency

The way certain ordering systems are set up may affect transport efficiency. The diffusion of the use of just-in-time (JIT) strategies might act detrimentally to emissions from transportation (Halldórsson et al., 2009; McKinnon, 2007; McKinnon and Piecyk, 2009; Rodrigue, 2001). This is also true when combined with geographical changes in production (Hesse and Rodrigue, 2004).

Today the proponents of JIT strategies point at the benefits of in-house waste reduction associated with lower inventory levels. Others state that the lower levels of inventory, decreasing order quantities and increased shipment frequencies may increase the amount of transportation. The studies that support this theory are mainly qualitative (Yang et al., 2005; Schonberger, 2007). More quantitative studies such as Nathan's (2007) are needed on the effects of potential sub-optimisation, pushing the activities up the supply chain and adding extra nodes and links to the chain. Another way to lessen the impact of the order is by using the "nominated day delivery" system (McKinnon, 2007). Transport operators could achieve higher levels of efficiency by encouraging transport buyers to adhere to a certain delivery timetable. For city distribution, however, this is not always an easy task. Higher frequency of shipments is a trend that is in large part due to less storage capacity in city stores brought about by high costs

of rent and a priority for using the space for sales. The retailers also demand reliable and frequent deliveries to utilise their staff and loading dock efficiently. A use of JIT strategies and small inventory in a city environment could make the supply chains more vulnerable to congestion (Danielis et al., 2010).

Some solutions to these inefficiencies include wider time windows for road hauliers and an increased use of waiting for return loads. By offering this as a service, forwarders could counteract these environmental inefficiencies. A few already try to move in this direction. DSV offers more sustainable services to its Swedish customers at a lower price than its ordinary service, but more flexible delivery (within more days) than standard deliveries, and DHL offers so-called green tonnes where it offsets the environmental effects of a shipment somewhere in its network if the customer pays a surcharge.

For urban freight distribution, the trend might go in the opposite direction, as far as time windows are concerned. More cities are implementing stricter time windows for city distribution, mainly in order to reduce traffic congestion during peak traffic hours. These time window-trends call for careful analysis, since the driving forces and effects are different. An extensive review is available in Quak (2008). However, more research on the effect on other logistics costs is needed; for example, hauliers have identified a problem with charging their customers for waiting.

Measures of order efficiency benefit society and transport buyers, but they will reduce benefits to road hauliers and 3PLs, since this will ultimately lead to a decrease of frequency and speed in the system, therefore increasing utilisation and perhaps decreasing the number of shipments.

3.2.6 Mode efficiency

Mode efficiency or modal efficiency indicates the proportion of freight carried by different transport modes. As stated before, the degree of transport by train has decreased in favour of more "reliable" and time-efficient transport such as lorries and air. In terms of transport and energy efficiency, a modal change toward an increased use of train and ships is preferable**.**

According to logistics literature, goods that are transported greater distances are more likely to undergo a modal shift and this is a less efficient measure for short-haul transport like urban freight distribution. Worth noting as a counter argument is that some cities in Europe—Amsterdam, Dresden, Zurich, and Vienna—have implemented intermodal city distribution by using the existing tram system with mixed results (see Arvidsson, 2010). However, further studies are needed on the technological and economic feasibility of such a system for full-scale operation and the safety and reliability aspects along with the willingness of various stakeholders to participate in an implementation. From the transport operator's perspective, a move from lorry to train is considered a cost or a loss in sales, unless offering a multimodal service.

3.3 Joint transport efficiency measures with the public sector

While this paper addresses efficiency measures from a transport operator's perspective, it is also important to mention that in cases of conflicting corporate interests, local authorities can act as brokers using regulations and incentives, as tested within START (2009). In this EU project the cities of Gothenburg, Bristol, Ravenna, Riga and Ljubljana worked together to develop efficient access restrictions, consolidation of deliveries, and incentives to change the distribution of goods into more environmentally efficient ways. The public sector has a particular interest in achieving efficiency in urban freight transport, and therefore it is common

that regulatory measures are implemented. But the effects of these measures are not always evident (Quak, 2008).

3.3.1 Regulatory and incentive-based measures

Policies in urban freight transportation are implemented frequently by local authorities. Studies on their effects on supply chains (Danielis et al., 2010) show the complexity since the effects on environmental outcomes varies. For instance, the access-time restrictions might result in the use of more vehicles and drivers, and the vehicle type restrictions (in terms of dimension, weight, engine or fuel type) might increase fleet size and increase renewal rate. Loading/un-loading regulation and fiscal policies might increase consignment costs and loading factors. Urban transhipment and consolidation centres might increase consignment costs but increases consolidation and paves the way for the use of more environmentally efficient vehicles (Danielis et al., 2010).

A number of different regulatory- and incentive-based measures have been implemented in European cities. The trend is toward more consolidation, co-ordination and regulations paired with incentives. A number of European cities have introduced environmental zones (OECD, 2003) and low emission zones that help to accelerate the introduction of cleaner vehicles and reduce the number of older, more polluting vehicles (Browne et al. 2005).

Another way is to allocate road slots to individual vehicles or road space rationing, which is currently realistic only for selective bottlenecks such as bridges, tunnels and bus lanes. ICT solutions can support the prioritisation of which lorries could use the scarce capacity (Stefansson and Woxenius, 2007). Copenhagen introduced an incentive-based licensing system where transport operators were given access to preferred loading and unloading points if realising the required 60 per cent load factor. The transport operators were generally satisfied with the system and one out of five participating transport companies changed their planning behaviour (OECD, 2003). The City of Gothenburg tried a similar system in which a load factor of 60 per cent or more than 50 customer deliveries gave access to special loading zones and dedicated bus lanes, but the project gave mixed results and was terminated in 2007 (START, 2009). In 2008, strictly enforced time windows were implemented in a smaller area in the centre. Close collaboration between the Traffic and Public Transport Authority, the Police and transport operators were used to implement the regulations, resulting in a 55 per cent decrease of heavy-duty vehicles in less than a year. However, a negative impact was that the operators had to circulate more to conform to the time window restrictions. Furthermore, access restrictions in time or space could limit market activities, but also promote them by giving way to pedestrians. Both Danielis et al. (2010) and Browne et al. (2005) warn against potential suboptimal situations by enforcing too strict time restrictions.

Collaboration with local stakeholders and local authorities in a city is another way ahead and the City of Gothenburg is one example. A few years ago, the “Freight Group” started as a local collective effort with the Traffic and Public Transport Authority and the Swedish Road Haulage Association. The aim with this network is to discuss various future regulations and incentive measures with stakeholders such as hauliers, real estate owners, retailers and their local interest organisation, and lorry manufacturers (START, 2009).

Local traffic regulations should not always be considered as a fixed variable in the long run. Local authorities have demonstrated interest in co-operation with the transport sector and other stakeholders in the issues of city distribution. Local authorities/society might gain from regulatory and incentive efficiency measures but the outcomes are more uncertain for the other three groups of actors (road hauliers, 3PLs and transport buyers).

3.3.2 Coordinated distribution

Coordinated distribution is controversial since it risks challenging the competition laws. Even though, in theory, much could be done in terms of efficiency by consolidating different types of cargo and increasing cooperation between competitors, there are opponents nonetheless. Also, in very scarcely populated areas, urban delivery is a field where the gains might offset the risks with eliminating the free market forces. Still, road hauliers or 3PLs often show signs of resistance to cooperating with competitors. According to Blinge and Svensson (2006), smaller transport operators do not automatically collaborate in the ways required to make the system work and coordinated distribution projects are discontinued rather than extended. Furthermore, there are instances where transport buyers do not allow coordinated distribution of goods by the same 3PL. Own-account transport is much less efficient compared to third party or transport operators, if measuring utilisation per unit of vehicle used (Danielis et al., 2010). The effect of coordinated distribution would have a positive impact, especially on the urban freight load factor, addressing the "last mile" or "final leg" problem. On the other hand, it would also decrease the total number of shipments for the transport operator. Society benefits but the competitive laws may need to be revisited.

4 The transport operators view: Two Swedish cases

Gothenburg is the second largest city in Sweden. Two transport operators GB Framåt and TGM together perform a majority of the distribution in the Gothenburg greater area. This area has more than 900 000 inhabitants, of which 500 000 live in the inner city area. According to the CEO of TGM, "[TGM] and GB Framåt are by far the largest hauliers" in the Gothenburg area. TGM is the subcontractor of DB Schenker and performs most of their transport. The company has a fleet of 190 vehicles. The CEO of TGM is referred to as CEOTGM in the following section. GB Framåt performs most of the distribution for DHL in Gothenburg and has a fleet of more than 110 vehicles, of which nearly ten per cent are bio gas vehicles. The CEO of GB Framåt is referred to as CEOGBF in the following section. The number of employees is approximately equal to the number of vehicles in both companies.

The interview results below are categorised according to the main headings of the previous sections. The starting point in the interviews was transport efficiency and its potential effects. Transport efficiency was described by CEOTGM as less emissions and better economy, both for the operator and the customer. CEOGBF also highlighted the better economy but also speedy deliveries and an optimisation of the cargo loading.

4.1 Driver efficiency

CEOTGM and CEOGBF find eco-driving effective, especially on longer hauls. The time loss is small compared to the fuel saved, which results in less emissions and better economy for the transport operator. On shorter hauls, as in urban distribution, this measure is effective and is considered a positive measure in all respects by the CEOs. The elimination of idling was given as one example in an urban context.

4.2 Vehicle efficiency

Larger vehicles are better on long distances in order to increase volumes transported, but there is no real benefit of using them in city distribution, according to CEOTGM and CEOGBF. Instead, the vehicles are both shorter and smaller in order to make deliveries on time and to gain accessibility in the streets. CEOGBF points out that normally economy and the environ-

mental effects go hand in hand but not always. He gives an example when the investment cost for a gas and petrol-fuelled lorry is higher than an ordinary lorry. Also, the initial calculations for such a lorry show an increase of costs in operation. One reason for this might be that the drivers keep driving on petrol when the gas tank is empty. As a means to minimise the use of petrol, the drivers now have to collect petrol vouchers from the main office. CEOGBF points out that the environment benefits if the lorries are bought and replaced more frequently than today, but the tight margins do not allow this.

4.3 Intelligent transport systems and route efficiency

CEOTGM argued that it is very difficult to recoup a route planning system because of the investment cost and viewed these systems as a supplementary aid only. Since the distances are quite short, many drivers have good local spatial knowledge because they often drive the same route every day. CEOTGM says that each city distribution vehicle only drives approximately 10 000 km per year. Also the availability of free GPS in smart phones makes this somewhat redundant. Furthermore, route planning system facilitates and is one contributing reason for the development of increased competition from drivers from low cost countries, since it is no longer necessary to have local geographic knowledge to drive a lorry, CEOTGM concludes. However low price is the main reason for this competition, which is not as severe in city distribution as in long haul because language skills (speaking Swedish) are important. CEOGBF was slightly more positive about route planning and stressed the importance of proper freight planning before loading and having systems helping the loading process by sorting by postal codes. This is especially good help for new drivers. CEOGBF says that a parcel delivery vehicle has 60-85 stops in the city centre during a day with up to 120 deliveriesDeliveries have to exceed 25 kms in order for a GPS to be profitable (by reduced diesel consumption). Both CEOs identified time restrictions from customers as limiting for route efficiency.

4.4 Utilisation efficiency—the back-haul effect

The distribution in greater Gothenburg has balanced flows in terms of volume, according to both CEOs, much due to Gothenburg being a producing city. This is very different from Stockholm and many other cities, where more goods are delivered than picked up. However, the same applies to Gothenburg in the city centre.. CEOGBF points out that it is more work to get the goods out of the city due to large pickups. CEOGBF also highlights a balancing problem with respect to time: customers want to have goods picked up as late in the day as possible and this might force the transport operator to use more lorries for pick-ups even though the volume and number of stops might be less than delivery operations. CEOTGM stresses the importance of different pricing systems and it is better when the operator is getting paid in an A-B-A situation, rather than from A to B as the operator might lack in incentives to find a back-haul.

4.5 Utilisation efficiency—load factor

Higher load factors are possible when deliveries are coordinated in a network, which both companies have as a strategic advantage. CEOTGM refers to the term “public transport for freight,” which their customer DB Schenker is promoting in their marketing communication. “If we knew what we will deliver tomorrow, we would be even more efficient,” said CEOTGM. Planned deliveries means less transport and less emissions. For short haul transport, the lorries are usually filled in the morning for delivery throughout the day. Ability to increas-

ing the load factor can be limiting at times in city distribution, according to both CEOs. "In urban distribution the load factor is not the main focus—time is," says CEOTGM. CEOGBF says, “The deciding factor is time.” Situations occur when the lorry is not fully loaded due to time restrictions of at least three types. The first type is generated from goods receivers in the city who want goods delivered before a certain time, often in the morning. The second type is regulated time windows imposed by the municipality. The third type is internal and comes from the drivers themselves; at times the large number of stops during the day may limit the loading factor, especially for parcel deliveries. A large number of stops also usually means a shorter available loading time. CEOGBF also identifies seasonal variations as a problem for the load factor. CEOGBF says, “In the summer we might deliver 200 kg of parcel deliveries, where we normally deliver a tonne on the same run.” In general, improving the load factor is considered a good measure.

4.6 Packaging efficiency

Packaging efficiency improvements are often prompted by transport buyers, with the ambition of minimising transport. When the CEOs were asked if there was a lack of incentives from the operator’s point of view to come up with similar improvements, CEOTGM thought that competition is the incentive for packaging efficiency improvements. Therefore, “to get paid too much is no good” if they want to keep the customers. CEOGBF recognised that his company would like to transport as much as possible since it improves the revenue, but “competition plays its part as well. Also poorly packaged goods increases the risk for damages and lowers packaging efficiency. In sum, both CEOs considered packaging efficiency a good measure for improvements, which are needed to be competitive.

4.7 Delivery efficiency

On the question of whether the shippers are moving toward more or less JIT, CEOTGM was certain that the development was toward more JIT and smaller shipments. CEOGBF was unsure, but thought that the development would probably move toward smaller and more frequent shipments and backed it up with examples of how his company might benefit from this trend. Both CEOs identify this as an opportunity since they can coordinate shipments, use a hub and, according to CEOGBF, “get paid not just by volume but also per shipment.” CEOTGM sees possibilities in a transport network by making the milk runs shorter or longer depending on the supply of goods. They can still be effective even if some customers are lost. This may not be possible for a “company-owned” lorry where the size of the loops is more static. Another point discussed was whether the profit margin is different on small and big shipments. CEOTGM does not identify a significant difference while CEOGBF said he intuitively thought that the profit margin is bigger on smaller shipments, “since we get paid by the stop. The more stop on a milk run, the more revenue.” CEOTGM points out that the smaller shipments require more handling. This means higher costs that are reflected in their price list, since more frequent deliveries are more expensive per shipment than one main delivery once a month, for instance. One problem is that the goods supplier pays the delivery, not the receiver, which makes coordination of deliveries to one goods receiver more difficult.

4.8 Mode efficiency

This question was not included in the interview since neither of the companies runs a multimodal service. However, they can be part of an intermodal transport chain.

4.9 Regulatory and incentive efficiency

CEOTGM identifies sticks and carrots (and the interaction between the two) as important. CEOGBF would like to see more firm and clear rules, or more stick than carrot. "The environment can only be steered through laws and regulations. What if we did not have environmental zones today [through regulation], how would it have looked like then?" Gothenburg has had environmental zones since 1996 in order to exclude old lorries from the city. CEOGBF also points to the significance of cooperation between operators and municipality. "It is also important to stress for 'the public' that the lorries are not in the city for the sake of having fun or to pollute, but for delivering goods to the shops." Time restrictions from the municipality sometimes limit the load factor efficiency according to CEOGBF.

4.10 Coordinated distribution

Examples of coordinated distribution are given by both CEOs. In fact, the two 3PLs that these two forwarders work for—DB Schenker and DHL—have historically coordinated their distribution, especially in scarcely populated areas. An example of this is deliveries to an island north of the city called Marstand, but this cooperation has been terminated. The same happened with a similar project in Stockholm. "All these projects tend to end in Sweden," says CEOTGM, who raises problematic issues eg. who pays for damaged goods or the last delivery on a lorry. Also it is feared that the EU laws of competition restrict cooperation in distribution between competing 3PLs. The freight transport market has tight margins according to the CEOs. If this coordinated distribution is carried out, then there is a problem with pricing the services, according to CEOGBF. He also thinks it could be "messy" since the goods might have to go through too many terminals. Both CEOs think that transport is too cheap from a customer perspective and with respect to existing operating costs.

5 Conclusions

From the review we learnt that most previous research have had other perspectives than the transport operators'. *Driver efficiency* was regarded as effective, especially on longer hauls but somewhat less effective in urban distribution. This is surprising since the potential benefit of a skilled driver in an urban setting with frequent changes in speed and direction could be argued to be higher than for a driver operating his vehicle at constant speed along the highway. Regarding *vehicle efficiency*, there is no real benefit of using larger lorries in city distribution, according to the CEOs but instead adapt the lorries to an urban environment. Gas/petrol lorries may be more costly to use, because of behavioural reasons, but definately in investment costs. *Route efficiency* was hindered by time restrictions from customers, according to the CEOs. Route planning system in cities was of limited use and has allowed competition from low cost countries on the market (CEOTGM), but the importance of a proper freight planning system was emphasised (CEOGBF). The *back-haul effect* was of limited importance as the distribution in greater Gothenburg has rather balanced flows in terms of volume. Also, if the backhaul is included in the payment to the operator, then the incentive to find a backhaul is limited. However a limiting effect for back-haul was time. . Time constraints, along with seasonal variations, might offset the *load factor efficiency*. A potential for improvements is better planning of the deliveries facilitated by more and earlier information from the customers. The transport operators viewed work with *packaging efficiency* as a means to be competitive toward transport customers. Therefore these efforts are carried out despite the fact that transport operators probably would get higher revenues from not doing it in the short run. The CEOs interviewed believed in the trend toward smaller and more frequent shipments, which is the opposite of *delivery efficiency* as it is defined here. The advantages for the opera-

tors mentioned by the CEOs include coordinated shipments and using a hub. In the current price structure where the companies get paid by the number of stops, this would generate more revenue. *Mode efficiency* was not relevant for the interviewed CEOs but European experiences show that a move from lorry to train/tram in city distribution is considered a cost or a loss of sales. The transport companies recognise both sticks and carrots within *regulatory and incentive efficiency*. Interestingly, one CEO believed more in firm and clear rules (sticks) than voluntary incentives (carrots). *Coordinated distribution* was viewed as both positive and negative with arguments supporting both views. However, impediments for implementing this measure are the distribution between collaborators of costs for damaged goods, dividing costs and profits in the last leg and laws of competition.

Table 2: Transport efficiency measures in distribution and the effect on actors in the system.

Measure \ Actors	Decision maker	Road hauliers	3PLs	Transport buyers	Society/city
Driver efficiency	RH	+	+	+	+
Vehicle efficiency	RH/VM	+	+	+	+
ITS and route efficiency	RH/3PL	+/-	+	+	+
Utilisation efficiency - back-haul effect	RH/3PL /S	+	+	+	+
Utilisation efficiency - load factor	RH/3PL /TB/S	+/-	+/-	+	+
Packaging efficiency	RH/3PL /TB	+/-	+/-	+	+
Delivery efficiency	RH/3PL /TB/S	-	-	+/-	+
Mode efficiency	RH/3PL /TB/S	-	+/-	+/-	+
Regulatory and incentive efficiency	RH/3PL /TB/S	+/-	+/-	+/-	+
Coordinated distribution	3PL /TB/S	+/-	+/-	+	+

(-) cost, (+) benefit. RH: road haulier, TB: transport buyers, S: Society/City, VM: vehicle manufacturer.

From the viewpoint of the road haulier, looking at Table 2, one paradoxical result of many of the environmentally beneficial transport efficiency measures presented in the matrix is a decrease in the number of total shipments. Therefore, implementing these measures would not be beneficial from an economic perspective, at least not in the short term and for all actors. This could partly explain the inertia to change within the freight industry. Nevertheless, the reluctance might be explained by the fact that the road hauliers are hardened after many years of improvements they have not been able to keep the benefits due to the strong market pressure. Our results are in line with McKinnon (2003): “Those measures which yield economic as well as environmental benefits generally command the greatest support and are the easiest to implement”. Our conclusion is one of careful optimism—the increased focus on environmental issues and cooperation among all parties involved could lead to better efficiency in the transport sector, including city distribution. Road hauliers could become the principal actors in making transport efficiency a trademark and positioning environmentally better transportation as a strategic issue. There are examples of road hauliers and 3PLs who have identified this business opportunity and are already moving in this direction, which may offer them a competitive advantage in the future.

6 References

Allen, J., Tanner, G., Browne, M., Anderson, S., Christodoulou, G. and Jones, P. (2003) "Modelling policy measures and company initiatives for sustainable urban distribution," *Final Technical Report, EPSRC/DfT Future Integrated Transport Programme*, University of Westminster.

Anderson, S., Allen, J. and Browne, M. (2005) "Urban logistics - How can it meet policy makers' sustainability objectives?," *Journal of Transport Geography*, 13, 1, pp. 71-81.
Aronsson, H. and Huge Brodin, M. (2006) "The environmental impact of changing logistics structures," *The International Journal of Logistics Management*, 17, pp. 394-415.
Arvidsson, N. (2010) "New perspectives on sustainable urban freight distribution: a potential zero emission concept using electric vehicles on trams," WCTR, Lisbon, July 11-15, pp. 1-20.
Behrends, S., Lindholm, M. and Woxenius, J. (2008) "The impact of urban freight transport: A definition of sustainability from an actor's perspective," *Transportation Planning and Technology*, 31, 6, pp. 693-713.
Blinge, M. and Svensson, Å. (2006) "Environmental measures for freight transportation, summary of practical and theoretical examples," *CPM Report 2006:5*, Chalmers University of Technology, Gothenburg. In Swedish: Miljöåtgärder för godstransporter sammanställning av praktiska och teoretiska exempel.
Browne, M., Allen, J., Nemoto, T. and Visser, J. (2010a) "Light goods vehicles in urban areas," *Procedia - Social and Behavioral Sciences*, 2, 3, pp. 5911-5919.
Browne, M., Allen, J., Steele, S., Cherrett, T. and McLeod, F. (2010b) "Analysing the results of UK urban freight studies," *Procedia - Social and Behavioral Sciences*, 2, 3, pp. 5956-5966.
Browne, M., Allen, J., Woodburn, A. and Piotrowska, M. (2007) "Literature Review WM9: Part II - light goods vehicles in urban areas, carried as as part Work Module 1," *Green Logistics Project*, English.
Browne, M., Allen, J, Anderson, S (2005) "Low emission zones: the likely effects on the freight transport sector," *International Journal of Logistics*, 8, 4, pp. 269-281.
Danielis, R., Rotaris, L. and Marcucci, E. (2010) "Urban freight policies and distribution channels," *European Transport \ Trasporti Europei n. 46*, pp. 114-146.
De Jong, G., Schroten, A., van Essen, H., Otten, M. and Bucci, P. (2010) "Price sensitivity of European road freight transport - towards a better understanding of existing results," *A report for Transport & Environment, Report 9012-1*, Significance/CE Delft, Delft.
European Commission (2001) "White Paper – European Transport Policy to 2010: Time to Decide," Luxemburg.
European Commission (2007) "Sustainability and transport: a review," Joint Research Centre, Institute for Environment and Sustainability, Ispra, Italy.
European Commission (2009) "The Future of Transport Focus Groups," Directorate General Transport and Energy, Brussels.
European Commission "Intelligent Transport Systems," http://ec.europa.eu/transport/its/road/deployment_en.htm, accessed 2011-01-14.
European Environment Agency (2006) "Transport and environment: facing a dilemma," Office of Official Publications of the European Communities, Brussels.
Eurostat (2005) "Energy, transport and environment indicators," Data 1992-2002. Luxemburg.
Freight Best Practice "Your route to operational efficiency," http://www.freightbestpractice.org.uk/, accessed 2011-02-14.
Geerlings, H. and van der Sluis - van Meijeren, M. (2008) "The dominance of the Lisbon agreement as a barrier for an environmentally oriented transport policy in Europe; the gap between theory and implementation in policy integration," *European Transport\Trasporti Europei*, 39, pp. 14-32.
Halldórsson, Á., Kotzab, H. and Skjøtt-Larsen, T. (2009) "Supply chain management on the crossroad to sustainability: a blessing or a curse?," *Logistics Research*, 1, 2, pp. 83-94.

Hedenus, F. (2008) "On the Road to Climate Neutral Freight Transportation - a scientific feasibility study," *Publication: 2008:92*, Swedish Road Administration, Borlänge.
Hesse, M. and Rodrigue, J.-P. (2004) "The transport geography of logistics and freight distribution," *Journal of Transport Geography*, 12, 3, pp. 171-184.
Lammgård, C. (2007) *Environmental perspectives on marketing of freight transports - The intermodal road-rail case*, PhD, University of Gothenburg, Gothenburg.
Léonardi, J., Rizet, C., Browne, M., Allen, J., Pérez-Martínez, P. J. and Worth, R. W. (2008) "Improving energy efficiency in the road freight transport sector: the application of a vehicle approach," Logistics Research Network Annual Conference, Liverpool, 10th-12th September, pp. 133-138.
Lindholm, M. (2008) *A sustainability perspective on urban freight transport*, Licentiate of Engineering thesis, Chalmers University of Technology, Gothenburg.
McIntyre, K., Smith, H. A., Henham, A. and Pretlove, J. (1998) "Logistics Performance Measurement and Greening Supply Chains: Diverging Mindsets," *The International Journal of Logistics Management*, 9, 1, pp. 57-68.
McKinnon, A. C. (1996) "The empty running and return loading of road goods vehicles," *Transport Logistics*, 1, 1, pp. 1-19.
McKinnon, A. C. (2003) "Logistics and the Environment," In: Henscher, D. A. and Button, K. J. (eds) *Handbook of Transport and the Environment*, Elsevier Ltd, Oxford, pp. 665-686.
McKinnon, A. C. (2007) "CO2 Emissions from Freight Transport in the UK," Commission for Integrated Transport, London.
McKinnon, A. C. "Decarbonising Logistics," http://sydney.edu.au/business/__data/assets/pdf_file/0003/64956/alanm.pdf, accessed 2010-12-12.
McKinnon, A. C., Cullinane, S., Browne, M. and Whiteing, A. (2010) *Green Logistics: Improving the Environmental Sustainability of Logistics*, Kogan Page Publishers, London.
McKinnon, A. C. and Ge, Y. (2004) "Use of a synchronised vehicle audit to determine opportunities for improving transport efficiency in a supply chain," *International Journal of Logistics*, 7, 3, pp. 219-238.
McKinnon, A. C. and Piecyk, M. I. (2009) "Measurement of CO_2 emissions from road freight transport: A review of UK experience," *Energy Policy*, 37, 10, pp. 3733-3742.
Mårtensson, L. (2006) "Emissions from Volvo's trucks,"Volvo PM 20640/05-008, Gothenburg.
Nathan, S. (2007) "Environmental Impacts of Just-in-Time: Effects of Altered Supplier Transportation," *Independent Study*, Bren School, UCSB, pp. 30.
OECD (2003) "Delivering the goods - 21st century challenges to urban goods transport,"OECD, Paris.
Quak, H. J. (2008) *Sustainability of Urban Freight Transport: Retail Distribution and Local Regulations in Cities*, Erasmus Research Institute of Management (ERIM), Rotterdam.
Rodrigue, J.-P., Slack, B. and Comtois, C. (2001) "The Paradoxes of Green Logistics," the 9th World Conference on Transport Research, Seoul, 23-27 July, pp. 1-11.
Samuelsson, A. and Tilanus, B. (1997) "A framework efficiency model for goods transportation, with an application to regional less-than-truckload distribution," *Transport Logistics*, 1, 2, pp. 139-151.
Santén, V. and Blinge, M. (2010) "Actions for more sustainable freight transport - a comparison between theory and practice," the 12th World Conference on Transport Research, Lisbon, 11-15 July, p. 25.

Schonberger, R. J. (2007) "Japanese production management: An evolution - With mixed success," *Journal of Operations Management*, 25, 2, pp. 403-419.
SIKA Statistik (2009) "Lätta och tunga lastbilar 2008 (eng: LGV and HGV 2008),"Vägtrafik, Statens institut för kommunikationsanalys. In Swedish.
Small, K. and van Dender, K. (2007) "Long Run Trends in Transport Demand, Fuel Price Elasticities and Implications of the Oil Outlook for Transport Policy," OECD/International Transport Forum/Joint Transport Research Centre, Irvine/Paris.
START (2009) "Short Term Actions to Reorganize Transport of Goods," WSP, CIP, Gothenburg.
Stefansson, G. and Woxenius, J. (2007) "The concept of smart freight transport systems – the road haulier's perspective," The 19th NOFOMA conference, Reykjavik, 7-8 June, pp. 1-16.
Swedish Exhibit Center (2007) "Årsredovisning (Annual report)," Gothenburg. In Swedish.
Swedish Road Administration (2004) "Klimatstrategi för vägtransportsektorn (Climate strategy for the Road Transport Sector),"*Publication 2004:102*, Borlänge. In Swedish.
Timilsina, G. R. and Dulal, H. B. (2009) "Regulatory instruments to control environmental externalities from the transport sector," *European Transport\Trasporti Europei*, 41, pp. 80-112.
Uherek, E., Halenka, T., Borken-Kleefeld, J., Balkanski, Y., Berntsen, T., Borrego, C., Gauss, M., Hoor, P., Juda-Rezler, K., Lelieveld, J., Melas, D., Rypdal, K. and Schmid, S. (2010) "Transport impacts on atmosphere and climate: Land transport," *Atmospheric Environment*, 44, 37, pp. 4772-4816.
Whiteing, T., Browne, M. and Allen, J. (2007) "City logistics: the continuing search for sustainable solutions," In: Waters, D. (eds) *Global logistics and distribution planning: strategies for management*, Kogan Page, London, pp. 308-320.
Vierth, I. and Mellin, A. (2008) "Swedish goods study based on national and international literature,"*VTI Report 629*, VTI, Linköping.
Yang, B., Yang, Y. and Wijngaard, J. (2005) "Impact of postponement on transport: an environmental perspective," *International Journal of Logistics Management*, 16, 2, pp. 192-204.
Åkerman, J. and Höjer, M. (2006) "How much transport can the climate stand? - Sweden on a sustainable path in 2050," *Energy Policy*, 34, 14, pp. 1944-1957.

Paper 2

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NEW PERSPECTIVES ON SUSTAINABLE URBAN FREIGHT DISTRIBUTION: A POTENTIAL ZERO EMISSION CONCEPT USING ELECTRIC VEHICLES ON TRAMS

Niklas Arvidsson, University of Gothenburg, niklas.arvidsson@handels.gu.se

ABSTRACT

Purpose: This paper aims to analyse the potential use of trams and Electric distribution vehicles (EDVs) as cargo carriers in intermodal urban freight distribution. Transporting goods in urban areas, where most logistics chains start or end, is an activity that increasingly generates severe problems for all stakeholders, for instance, local authorities, the logistic industry, customers, as well as the society in general. New transport solutions are necessary in order to decrease traffic congestion, noise and traffic pollution, e.g., emissions of greenhouse gases and other pollutants in urban areas. Furthermore, distribution activities are not only the foundation of our society, but the cause of environmental and social problems as well. A possible solution to these problems is to transform the current freight distribution system within cities, for example by favouring the enhancement of intermodal transport alternatives, i.e. combining road and rail transport. Information has been collected through a literature review and interviews in Amsterdam and from these results a conceptual model is presented, as well as a potential zero emission scenario using electric vehicles on trams in Gothenburg.

Keywords: light rail, tram, electric distribution vehicles, EDV, transport efficiency, sustainability, urban freight distribution, intermodal city freight distribution, urban rail freight transport

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INTRODUCTION

The present configuration of freight distribution systems in urban areas is reaching unsustainable levels in terms of economic efficiency and the impact on quality of life, as stated by for instance the TADIRAM project (2006) and others. "Business as usual" simply does not make the cut anymore.

> The scientific evidence points to an increase risk of serious, irreversible impacts from climate change associated with business-as-usual (BAU) paths for emissions. (Stern report, 2006)

A Delphi study conducted by DHL (2009) provided us with some guidance about in what direction we are heading. According to the over 900 professionals and researchers interviewed many believe a proof of energy efficiency will be necessary to ensure a product's acceptance and marketability. Nevertheless, there are differing opinions regarding the extent to which "global warming" represents a genuine business opportunity, but the interviewees in the study also believe that "An enormous amount of money can be earned with the right answer**s** to 'global warming.'" (DHL, 2009 page 25).

With the focus on the manifold not singular; answers not the answer. As there is not yet a single renewable fuel that can replace oil, but many, as well as no one logistic solution that can replace current practice. In this paper, one suggestion is presented for urban freight distribution that would potentially help decreasing emissions significantly for parts of urban freight distribution, but also help the logistic companies to become more profitable.

Logistics companies that want to be green and stay in the 'green' race as well as to become or remain market leaders will need to constantly set new standards. It will not be enough to react; they will also need to adopt a proactive position. Only in this way will it be possible to operate profitably with their 'green' ideas – at least until these ideas become the legal standard. The timeframes during which it is possible to make a profit with sustainable efforts will become shorter, according to the DHL report. The report further states that the logistics company that offers the most intelligent low CO2 solutions will emerge as the market leader. However, it will only be able to maintain its market leadership if it constantly improves these solutions. Thus, logisticians need to continuously set new standards if they want to experience financial gains from the sustainability trend over the long term. It is presently truer than ever that merely reacting is not sufficient. Logistics companies must be actively involved in the formulation of standards and thus assume a leadership role in the economy.

An explicit definition of what is meant by light rail does not exist. In the literature many definitions are found. According to Priemus, (2001) a common feature seems to be that light rail is a rail associated transport system that can be positioned in the triangle between train, tram and metro.

To use the more general term *light rail* avoids incompatibilities in American and British English. The word *tram*, could mean aerial tramway in American English but streetcar in British English, whereas aerial tramway is called cable car (Merriam-Webster online dictionary, 2009-09-23). Cable car in North America usually refers to a trolley pulled along by subterranean cables. Trolley in American

English typically refers to streetcar, while in British English this word means a (shopping) cart (Merriam-Webster online dictionary, 2009-09-23).

Trams and street cars are commonly classified as a subtype of light rail, but this is not always true. There is a significant amount of overlap between these technologies. Light rail is mostly separated from other traffic with dedicated lanes and rights-of-way, passengers get on and off at stations rather than in the street, and the speeds are faster than for trams. In this paper, no distinction is made between *trams* and *light rail* for the sake of simplicity, variation and to facilitate keyword search.

According to Merriam-Webster online dictionary there is no significant difference between the use of *cargo* and *freight* anymore. Historically the use of cargo, from Spanish *cargar* used to refer to ships and later airplanes, but now also includes land-based vehicles. Freight, of mixed English, Dutch and German heritage, is somewhat more of a generic term, often attributive as in substituting transportation in transportation costs but also often referring to land based vehicles. The use of CarGoTram in Dresden is a pun, supplying car parts to the Volkswagen factory. In this paper, no distinction is made between *cargo* and *freight* for the sake of simplicity, as well as no distinction between *transportation* and *distribution*, for the same reasons as above.

The paper consists of five main parts. Firstly, the nomenclature of the terms appearing in the paper is discussed. Secondly, a comprehensive literature review was conducted on the previous projects using light rail in Europe followed by a literature review of the use of electric distribution vehicles in Europe. Thirdly, the four major projects using trams are presented. Information from Dresden, Vienna and Zurich is derived from a literature review and information from Amsterdam originates from empirical data from interviews. Fourthly, a discussion is held based on comparing differences and similarities between the cities. Lastly, barriers and recommendations are identified and an analysis of a possible future concept for the example city of Gothenburg is presented. The scope of this paper is to present where we are and lessons learnt from the Amsterdam case study together with the other cities presented and construct a fictive scenario for Gothenburg drawing on these lessons.

LIGHT RAIL FREIGHT AND CARGO TRAMS IN THE LITERATURE

In this section some of the most recent research focusing on urban freight distribution in relation to light rail is presented. The major projects in which this type of research has been evident are Bestufs, Civitas, Eltis and Sir-C. Goods have been carried on rail vehicles through the streets since the 19th century and the use of rail in urban freight has been the focus of researchers and practitioners for the last century. Projects aimed at using rail in urban freight in Europe have emerged over the last decades, some with the aim to partly eliminate road freight transport, like in Amsterdam, whilst others are of more limited application. The system in Dresden is a privately owned operation running between two points whereas Zurich and Vienna are non-commercial municipal services focusing on waste recycling and freight transport for the retail industry respectively.

According to Mortimer (2008), rail in urban freight has been on the decline in favor of better suited road transport, with regards to supply patterns, land use planning and regulations. Some of the known limitations of rail are the lack of door to door capability, difficulties in the integration of road and rail and the differences in economic mass. On the other hand, rail has a good weight/volume capacity, low energy and environmental impact, a good network linkage between cities and in some cities – trams and undergrounds. Today the vast majority of urban freight service is performed by trucks and vans on road and to a lesser extent through intermodal services. Transportation is a vital part of our society but at the same time considered to be a major contributor of emissions and thus also a major impact on the environment. This has triggered planning authorities all over the world to impose a variety of of restrictions and constraints on road transport, e.g. access times, weights, dwell times, noise limits and emissions etc. Light rail, much like rail and road, is considered to be conservative and the business model primarily focuses on passenger transport with generic constraints also with regards to coverage and access.

In the Italian TADIRAM project, ending in 2006, research activities have been performed with the aim to identify new organizational and technological solutions for the optimization of freight distribution process. One part of this project studied the cargo tram concept in a feasibility demonstration. The TADIRAM project partners demonstrated a new prototype designed for goods assembled onto load units. A new version of SIRIO Cargo Tram (light rail), the same type of tram ordered by Gothenburg municipality, has been studied. This type of tram is module-based and can also be coupled with passenger trams. Furthermore, the tram has a drop centre design, with a flatcar in the middle with 350 mm from the rail plane to the passenger floor.

The OLS-ASH project has generated knowhow on designing automated underground freight transportation systems that can be used for future UFT projects (Pielage, 2000). Royal Mail have been operating its own automated underground transport system called Mail Rail, with the aim to move mail across London very successfully since 1927 (Bliss, 2000). A few other researchers who have contributed to this area are; D. Bous, Reinhard Dorner, Monika Dönnhöfer, Axel Eisele, Peter Foyer, Mark Robinson and Dieter Wild.

ELECTRIC DISTRIBUTION VEHICLES IN THE LITERATURE

The electric vehicle is not a new concept; it actually precedes the internal combustion model. The deficient factors identified so far are: the same ability to accelerate and go fast, and to provide the same reach and ubiquity of the gasoline car. (Lesser, 2009; ELCIDIS, 2002). Henry Ford mentioned the electric car in his book “My life and World” in 1921:

> "Practically no one had the remotest notion of the future of the internal combustion engine, while we were just on the edge of the great electrical development. As with every comparatively new idea, electricity was expected to do much more than we even now have any indication that it can do. I did not see the use of experimenting with electricity for my purposes. A road car could not

> run on a trolley even if trolley wires had been less expensive; no storage battery was in sight of a weight that was practical. An electric car had of necessity to be limited in radius and to contain a large amount of motive machinery in proportion to the power exerted. That is not to say that I held or now hold electricity cheaply; we have not yet begun to use electricity. But it has its place, and the internal combustion engine has its place. Neither can substitute for the other--which is exceedingly fortunate." (Ford, 1921)

The ELCIDIS, 'Electric vehicle city distribution systems', project succeeded in verifying the principal advantages of using electric distribution vehicles (EDVs), hybrid as well as electric, in urban delivery concepts. ELCIDIS has provided proof that there are no predominant objections to the use of hybrid and electric vehicles in urban distribution, neither from company managers nor from drivers, and certainly not from local authorities (ELCIDIS, 2002). However, they stress the need for further development of the next generation of electric vehicles and hybrids. Furthermore, the project states the necessity of 'home-recharging' equipment close to the city centre for battery-run electric vehicles.

A study was carried out in the Brussels capital region by Van Mierlo *et al* (2003) and was also presented in Macharis et al (2007) that investigated the environmental benefits of electric heavy duty vehicles in which the Ecoscore or environmental damage rating was calculated. The methodology was based on a well-to-wheel analysis of emissions by calculating the impacts related to global warming, health, buildings and noise. The electric vehicle in the analyzed example was an electric bus and it had more than three times lower environmental impact compared to a diesel truck and twice as low as an LPG truck.

The study does however not describe how these figures were calculated. It would be interesting to know if the electricity was produced by coal, renewables (not likely) or a mix. Also, future research on the potential rebound effect of moving in the direction of smaller electrical vehicles is needed. The price of petrol is likely to drop since demand ought to be lowered? Will we ever manage the oil dependency?

LIGHT RAIL FREIGHT AND CARGO TRAMS IN EUROPE

At the dawn of the 21st century, transportation companies in the EU and around the world are trying to combine economic sustainability with finding green solutions for transport. As suggested by industry and researchers, one way of doing this is to apply transport efficiency, a set of measures to resource efficiently move goods, as a means to minimize externalities. One resource efficient way to move goods is by using tram systems with or without electronically driven vehicles. This paper will investigate the issue from a European perspective. One could argue that it could have a broad applicability in Europe, as carrying goods on rail (train) in Europe has its roots from the 19th century. The current known tram examples include Dresden which now has a regular Cargo tram service run by the world's longest train sets, 59.4 meters. Cities of Vienna and Zürich are using cargo trams as freight transport and mobile depots for recycling used goods respectively.

Amsterdam has developed this concept the furthest in the group, regarding the applicability of trams as freight movers, including a wide variety of consumer goods and the sheer economic size of the project is well exceeding the economic size of the other three projects combined. That is the main reason why Amsterdam was chosen as case in this study. In the following sections a short description of three of these projects precedes the results from the analysis of the Amsterdam case. Strengths and weaknesses of the experience from these cities may help if the stakeholders in the city of Gothenburg would decide on developing a feasible concept and sustainable implementation.

1. DRESDEN – VOLKSWAGEN PROJECT

Volkswagen planned to build an eye catching transparent factory in the city centre of Dresden in the late 1990s. A prerequisite of the Dresden municipality, as the city centre is small and sensitive to heavy trucks, Volkswagen needed to seek another solution of the goods flow, if the factory was to be built at this site (P Hendriks, 2010).

Volkswagen together with Transportation Services of Dresden came up with an idea to utilize cargo trams. At the new factory access to a local tram line was possible as well as for the distribution centre four km away, this made the cost for additional infrastructure low with only short connection tracks needed. The project with the Cargo Trams started in Dresden on 16 November 2000 and made its first test run in January, 2001.

The trains run every hour on a fixed route that is five km long (this can be increased to every 40 min). It takes approximately 15 min for each trip and the cargo is unloaded in 20 min by forklifts at the factory. DVB´s operations system is controlling all public trams and the Cargo trams takes advantage of gaps in the regular schedule of the passenger trams. One trip of the 'CarGoTram' eliminates three truck rides through the city center. The project 'CarGoTram' is unique in Germany (Civitas, 2005). Every day transports equal of 60 trucks is sent by the Cargo tram to the Volkswagen factory. Over the year this is the same as 200 000 km by road, according to VW AG's own calculations. The environmental impact is accordingly reduced drastically.

The CarGoTram have been successful since the start in 2000 but it is a purpose-built project with very specific conditions, the project facilitates one customer on one route only at this point. DVB is looking for further applications for their cargo trams; one is to serve a newly built city center shopping mall with over a hundred stores (ptua.org, 2008).

2. VIENNA – 'GÜTERBIM' PROJECT.

The project considered as a modern solution to urban logistics for transporting goods within the city using the existing rail network, 'GüterBim', examined the basic infrastructure required for operating a cargo tram in Vienna. The aim was to use the existing, well developed public transport network to switch goods traffic from the roads to rail. (Vienna Consult, 2006). The project investigated

potential applications, e.g. hospital or waste disposal logistics, and a pilot operation on a selected route. In 2004, the project started and was finally implemented in the context of a demonstration event.

Moreover, in 2005, possible combination of rail and tram freight transport (container transshipment) was tested, in order to introduce a rail bound city logistics solution for densely populated areas. The municipal public transport operator of Vienna carried out freight transport for its own internal purposes. The 'GüterBim' transports spare parts between the main workshop and its satellites. These initial demonstrations across the city of Vienna in 2005 had the intention of exploring options for further traffic applications, and study the needs for designing a feasible telematics system under an open interoperable based platform.

In normal circumstances, the transport would have been carried out by special road equipment causing considerable traffic congestion, pollution, and noise, on the inner-city road network.

In 2005, representing the government, the Austrian Ministry of Transport, Innovation and Technology proposed a joint-venture called 'GüterBim', composed by key players, such as, the Wiener Linien, the railway undertaking Wiener Lokalbahnen (WLB) and the two consulting companies TINA Vienna Transport Strategies and Vienna Consult, to carry out the respective research, and subsequently led the project team to develop follow-up projects (web22.wien.gv.at, 2004).

Lately, tests have been performed within the supply chain of different retail companies, to find low-cost solutions for a reliable delivery of their stores and sales points in the City of Vienna, for instance, developing techniques for fast handling.

3. ZURICH PROJECT

The Cargo tram in Zurich is a project that took only a few months to be converted into a pilot after its conception. It was the CEO of "Entsorgung und Recycling Zürich" ERZ (municipal public waste disposal and recycling company Zurich), Mr. Gottfried Neuhold, who initiated this innovative project in April 2003. Along with its future implementation in a daily operating basis, starting with four stops, and by 2004 extending them to eight. The initial approach was to collect bulky waste from households along the city´s outskirts, near the trams' turn around points. Afterwards in 2005, the collection of disposal electronic home and industrial equipment followed. According to Bestufs (2005), the way Cargo tram started to operate was based upon the collection of waste in two standard refuse containers, but the normal containers turned out to have an insufficient capacity for bulky goods. Therefore, a new container was developed, incorporated with a press for bulky goods, which in turn were carried on flat wagons, pulled by a converted tram.

ERZ jointly with the tram company VBZ used the actual infrastructure and the surplus tram units. They started by investing 32.000 Euros, in order to convert old trams and wagons into a functional unit, by adding standard parts. It is necessary to realize that Zurich has a broad tram network

serving the majority of the city areas. There are also many sidings not used by regular services which could be suitable. An equivalent road vehicle would have been harder to purchase due to initial funding and environmental constraints (proaktiva.ch, 2005). By strictly following the pre-condition of the system, which is neither disturbing nor slowing down the public transport for passengers, the Cargo tram serves, nowadays, nine different tram stations in the city area of Zurich. Hence, the positioning of Cargo tram is at those stations where additional tracks already exist, mostly turning points at the end of a tram line, where residents can leave bulky items for free. It has been estimated that collecting the same amount of waste by road transport equals 5 020 kilometers covered by lorries (which need about three times longer to move across the heavily congested city during peak hours) which in turn equals 960 running-time hours, hence 37 500 liters of diesel per year. (Bestufs, 2005). According to these calculations, the solution of disposing waste by Cargo tram has achieved a reduction of 37 500 liters of diesel annually, thus, avoiding equivalent emissions of harmful substances.

In short, Cargo tram not only makes a contribution towards reducing traffic congestion, traffic pollution and noise, it also provides a valuable service to Zurich' residents, offering a low cost service, but faster, moving commodities of low or null intrinsic value that commonly is not time sensitive.

RESULTS FROM CASE STUDY

4. AMSTERDAM – CITY CARGO PROJECT

The Amsterdam City cargo tram project is by far the biggest of the four investigated projects. The following Amsterdam section is based on a literature review as well as five interviews in Holland conducted in January 2010 with Peter Hendriks (2010-01-15), CEO Cargo tram, Michael Hendriks (2010-01-19), Financial Manager Cargo Tram, Jan Dijstelbloem (2010-01-18), Municipality Project Manager, Jupijn Haffmans (2010-01-18), Public affairs Cargo Tram and Stefan Saalmink (2010-01-18), MindsinMotion.net.

Description of the city center

The city of Amsterdam has been significantly important in the history of Europe. As for many European cities the construction of the city centre with its narrow streets during the seventeenth century did not provide a favourable situation for the modern day vehicles. At the dawn of the twentieth century the city was adapted to the needs of motor vehicles by filling in many canals of the city. However during the process major canals still remained intact. All administrative officials in all cities follow the same agenda in formulating development plans for a city; pollution and noise caused by the traffic ought to be reduced, traffic safety ought to increase and quality of space available for general public ought to be enhanced. This emphasizes the need to develop measures in order to reduce traffic congestions and reduce the effect of cargo transport on the environment.

However, in doing so maintenance of a smooth flow of goods and securing economic profits is also a considerable concern.

Process

Cargo trams in Amsterdam were expected to start their operations in 2008. The rationale of these trams was to shift the traffic load from trucks on the road to the trams for distribution of goods among the various stores and restaurants in the city. Also the restrictions on truck access would pave the way to implement the operations of cargo trams. The trams would provide service to the small distribution centers to reduce traffic load on the roads and would help improve the environmental aspects of the city transport. The door to door service could be maintained by the carrying of goods from the stations through the use of EDVs. In the month of March 2007 the test phase of this project included running of the cargo trams without loads from Osdrop to central Amsterdam. The trams used for this test phase belonged to GVB trams and after this test phase the trams were planned to be running with goods (Technisch Weekblad, 2007; P Hendriks interview, 2010).

Amsterdam's project regarding the Cargo trams is becoming a reality with the accomplishment of the test phase as it was carried out in March 2007. During this test phase the trams ran without goods but from 19th March they were supposed to run with cargoes from De Aker to the city. Cargoes included Heineken beer for pubs in the city and clothing for the Mexx store. During the last week of the phase waste paper was also carried in the opposite direction. (Cargotrams Yahoo group, 2007)

According to M Hendriks, the city council of Amsterdam allowed City Cargo to carry out trial operations whereas the full scale operations were expected to start in 2012. The trams were responsible for delivering goods to the city business companies. These cargo tram operations were restricted to the lines which have enough capacity to avoid problems with passenger trams. The operations were also limited within the time frame of 07:00-23:00 to avoid noise disturbances during the night. This project could result in the reduction of 2500 lorry movements within the city per year and the particle pollution in the air by 15 percent according to calculations made by the company. The trams used for these initial trials belong to GVB trams whereas in the later stages of the project City Cargo would use its own designs (M Hendriks, 2010). The economics of the operations were calculated to save almost 15 percent compared to a conventional set up with trucks (Haffmans interview, 2010).

Operations

According to a press release of Amsterdam tourist information dated 17 July, 2007, a joint venture of City Cargo BV with Amsterdam municipality, signing a 10 year contract to launch a cargo transport project employing freight trams running on the existing tram tracks used for public transport. According to P Hendriks (2010), ten cargo tram units were planned to start working by mid 2008. To ensure that the freight trams did not disrupt or alter the existing passenger tram schedule, a pilot was tested in March.

Jupijn Haffmans, City Cargo spokesman told the press after the test that this was the municipality's main concern and they demonstrated that by using 'follow mode' with the passenger trams, hindering the existing passenger tram schedule could be avoided. The 'follow mode' could easily be performed since the cargo trams did not have to stop to pick up passengers. The contract requires close collaboration between Amsterdam tram company GVB and City Cargo which uses GVB's schedule to establish when and where they can operate.

As the central Amsterdam is still reminiscent of its medieval times having only narrow streets and canals, the municipality allows heavy vehicles only between the hours of 7:00-11:00 hence stores and businesses are in need of a quicker and efficient supply system (M Hendricks interview, 2010).

Haffmans (interview, 2010) also highlighted the future plans of expansion, City Cargo did aim to increase its number of trams from ten to fifty in the next four years. This was expected to half the daily truck load in the inner city.

The project employs a system of a number of strategically located distribution centers or cross docks situated in western suburbs near the Schiphol airport. Therefore the inbound goods arriving at Schiphol airport could also be transported onboard the freight trams. At cross dock locations goods would be transferred from trucks to trams, after being sorted in the delivery area, and transported to inner city transhipment hubs.

Sophisticated networks of electric distribution vehicles were to deliver the goods to their final destination. Although the cargo trams took fifteen minutes extra compared to direct transport trucks, the City Cargo claimed that it cuts the cost by fifteen percent (P Hendriks interview, 2010) and accordingly being significantly more useful for small businesses like restaurants and boutiques.

Peter van der Sterre, policy consultant of EVO, a Dutch organization of companies dealing with cargo transport, as part of their core business acknowledged and appreciated City Cargo's initiative and its usefulness to small companies but at the same time pointed out the limitation of its use for larger companies like supermarkets. EVO, have lent only conditional support to City Cargo so as to make sure those companies are not forced into using the tram system and still have the freedom to choose between the two.

Meanwhile, Haffmans unfazed by Peter Van Der Sterre's cautious approach told the media that City Cargo has received encouraging feedback from around the world. Tokyo and San Francisco showed an interest in addition to many European states like the Netherlands and Germany to mention a few. He also stressed the need of expanding the tram network to all the metropolitan areas of Amsterdam in order to be truly successful. While for smaller cities like Utrecht or Rotterdam a single company may be enough. He went on to quote the examples of some other European cities employing the cargo trams, like Dresden (DPA, 2007; Haffmans interview, 2010).

After the successful trial, the company faced a problem with financial stability. The company board admitted they were not yet stable. As Peter Hendricks pointed out "almost no company is profitable from the start", similarly City Cargo would have needed at least three years to be profitable

according to Hendricks. According to Driessen (2007).and Dijstelbloem (2010), the municipality gave the City Cargo a three weeks' notice to come up with a bank guarantee in November 2008. Having failed to meet the 1st December deadline, City Cargo was declared bankrupt.

ANALYSIS OF CASE STUDY – REASONS FOR FAILURE

The people at Cargo Tram they identified two reasons for failure; inability to acquire adequate finance for investments and politics. Cargo Tram, through Peter and Michael Hendriks, focused on receiving finance from major banks. The timing with the financial crisis was, to put it mildly, not working in favour of the project. Furthermore, the banks would much rather invest in bigger projects according to Mr P Hendriks, thus one of the reasons for the project not starting out small scale and then scaling up. The business plan estimated the project costs to 70 million Euro, ten percent of this amount was Peter's private money (M Hendriks interview, 2010). The investment included trams, EDVs, new infrastructure, tracks and a cross dock central.

Others additionally identified a lack of understanding between Alderman[1] Marijke Vos and Peter Hendricks, two people at the opposite ends of the political spectrum. It was 'unfortunate' that Mr Hendriks went to the meetings with Mrs Vos in a big car with a personal driver, while Mrs Vos herself chose the bicycle.

The municipality, through Jan Dijstelbloem, identified finance as the main reason for failure, the lack of finance led up to the bankruptcy of this start up at the end of 2008.Up to the end of 2008 the municipality, through Aldermen, had helped Cargo tram by allocating a project group working with the company as well as fast tracking many of the necessary adjustments and changes in regulations, all in all, much more than normally provided for a new private company. City Cargo was amongst the projects the City embraced. One of the things the City did was extending the concession from the usual six years to ten years to give the company more time to become profitable. In addition, the municipality seriously considered the question of City Cargo to financially partake in the project. In the end the City made a proposal for City Cargo in what way the City would participate (financially) in the project. This proposition was never realised as City Cargo went bankrupt during these discussions (Dijstelbloem interview, 2010).

This was one of the reasons for the city refusing to contribute to the construction of extra tracks that were going to be needed. The city administration was interested in the project without including any additional subsidy. On the other hand, according to Mr Hendriks, City Cargo had already collected 69 million Euros from various companies like Nuon and Rabobank and had asked the city administration for a contribution of 6 million Euros for the construction of extra tracks (Dutchnews.nl and Railway Gazette, 2009).

The cargo trams use the passenger tram lines for transport and the no longer used tramways, called 'dead tracks', were used as parking lanes and loading and unloading bays. Being electrically

[1] An alderman is a member of a municipal assembly or council.

run they have the added advantage of low carbon emissions and replacing the trucks on the roads and reducing the city congestion, especially at the motorways to and from the city. City council also admits to this benefit, pursuing a policy of adopting measures to reduce air pollution (Dijstelbloem interview, 2010). Dijstelbloem stressed that the municipality took this project onboard and really supported the company with an extended concession mentioned above and the support of a project group to help City Cargo in all their affairs with the municipality.

The company director Peter Hendriks revealed that the municipal transport company GVB has objected to the use of dead tracks by City Cargo. The GVB claimed these tracks to be 'calamity tracks' and therefore could not be provided to City Cargo (P Hendriks interview, 2010). He continued by stating that this meant that City Cargo had to build its own parking track which is an expensive ordeal with a cost around one million euro per kilometre, *ibid* (2010). The extra tracks were difficult to finance for City Cargo since, by law, all tracks being built were owned by the municipality and a privatization of the trams or its tracks was not on the agenda at this point.

CONCLUDING DISCUSSION

An electric vehicle has more than three times lower environmental impact compared to a diesel truck and twice as low impact compared to an LPG truck according to Van Mierlo *et al* (2003).

One way to summarize is to present a table with differences and similarities between the cities presented in the paper. From the table one could argue that an evident conclusion on a business plan that works in all cases is quite hard to identify. Comparing the only two ongoing projects at the moment one comes to the conclusion that **starting small** seems to be the only common denominator between the two projects. The sample could be argued to be too small and the context, e.g. size of city and logistics character, is different from case to case making it difficult to compare the different cities.

City / **Key factors**	Amsterdam	Dresden	Wien	Zurich
Project owner	Private (City Cargo)	Private (VW)	Municipality	Municipality
Funding	Banks/Private	VW	Municipality	Municipality
Size of project	Large	Medium	Small demonstration	Small
Type of goods	Commercial, parcels etc	Automotive parts	Commercial, mainly retail	Electronic Waste
Type of customers	Commercial	Private (VW)	Commercial/Public	Public
Logistics character	Logistic service provider	Internal Logistics	Commercial/Recycling Logistics	Recycling Logistics
Infrastructure investments	Large	Small	Small	Small
Current status	On hold, bankrupt late 2008	Ongoing	On hold	Ongoing

Table 2 – Cargo tram projects in Europe

Other barriers identified are not to interfere with personal traffic (all), high initial investments (Amsterdam, Dresden), limitations in battery technology (Amsterdam), resistance to try something not tried before (initially all), number of actors cooperating (Amsterdam). It is important to repeat that the two identified reasons for failure of the Amsterdam project were: inability to acquire adequate finance for investments (supported from interviews by both Cargo Tram and the municipality) and, to a lesser extent, politics (supported only by Cargo Tram).

Cost calculations for any type of set up need to be conducted before any new projects are considered. The business plan for the Amsterdam operations were calculated to save almost 15 percent on an operational basis compared to a conventional set up with trucks according to Haffmans interview, (2010). Unfortunately the author of this paper did not get the opportunity to have a look at these numbers. The "15 percent" is thus **secondary information**. Let us end by stating some things that might be useful to bear in mind when conducting potential future calculations:

Tram costs are higher than truck cost when one considers distance. Tram and truck costs are usually calculated in cost/km but for a city distribution scenario one of the advantages of an all day delivery tram is to partly avoid the busy hours in the morning and in the afternoon, which a delivery truck cannot since it usually makes one round trip per day[2]. It is therefore suggested that both cost for trucks and trams are calculated in hours instead of km. Also, the cost for trams is divided on a set of 2-3 wagons and that some of the variable costs, if one tram is used, ought be adjusted accordingly. Lastly, and possibly most importantly, a discussion and an awareness of the risk of pricing this type of set up cheaper than the current set up. This ought to be avoided; possibly

[2] Interviews with Schenker and DHL

resulting in an increase of attractiveness for and use of urban freight transport in general by the laws governed by the rebound effect. It is thus important that the solution is priced in pair with or even higher compared to current solution with trucks.

Future research: According to Zunder (2004) trucks produce over 40 percent of pollution (congestion) and noise in cities although only accounting for 10 percent of operations in urban areas. What are the reasons behind this congestion? How much of the truck's contribution to congestion can be deduced from size? How would a decrease in size and increase in numbers of distribution vehicles effect congestion?

In the appendix a comparison between Gothenburg drawn mainly from the results from Amsterdam due to its close realization of implementation, business orientation and because of these two cities many geographical and political similarities is presented. The barriers and obstacles are manifold and the success of a cargo tram project is ambiguous. The author of this paper is optimistic to the idea of trying out a small scale test, for the simple reason that it has never been tried out commercially before.

APPENDIX – SCOPE FOR A NEW PROJECT?

Some do claim that one part of research is to investigate and compare projects and concepts and see if it is possible to learn from potential mistakes or change some of the parameters in order to acquire a different result? In the following appendix the author will therefore try to do this in the case of Cargo Tram moved to a new setting. One might ask why Gothenburg is chosen as a possible arena for future implementation, apart from being the author's hometown. The city of Gothenburg is almost the same size as Amsterdam, according to "Research and statistics", 500 thousand inhabitants versus 760 thousand. Gothenburg city is with its 450 km2 bigger than Amsterdam, 219 km2. A coincidental fact is that the city was heavily influenced by the Dutch. Dutch city planners had the necessary skills to build in the marshy areas around the city and were contracted to build the city to have canals, using Amsterdam as a blue print, according to Henriksson *et al* (1994). The tram system in Gothenburg is extensive covering an area of 3700 km2 (Amsterdam 1800 km2) and dates back to 1879. One could argue that the tram is synonymous with Gothenburg but also with its culture. Many of the tram tracks in Gothenburg are integrated with the street around the tracks, unlike for instance train tracks. This would literary pave the way for the RoRo technique presented in the next section.

Willy Nicklasson (2009), a technical manager at the Gothenburg tram company, revealed that a great number of old tram models but fully functional trams, known as M28 and M29[3], are available to a fraction of the price for a new tram. And as identified from Amsterdam, the cost of the trams together with the cost of new infrastructure, tracks and cross dock centrals, are by far the most

[3] *M28 and M29, are high floor trams, which makes it harder for older people to board than the newer dropcentre design. But on the other hand the floor is flat on the inside allowing for up to three electric distribution vehicles no wider than 2600 mm to fit.*

expensive investments in a cargo tram project. The low cost of trams would support a low cost and small scale approach.

From the four cities presented, even though different from one another in many respects, a set of barriers has been identified, and together a concept for Gothenburg is derived.

The most important feature of a future concept is that in order for it to work it cannot hinder personal traffic or, as learnt from Amsterdam; not to interfere too much with the daily city picture of urban space and life – **Barrier 1**.

Building add-ons, or sidings, to tracks for loading and unloading in the city center are very costly as learnt from Amsterdam, according to Peter Hendriks one million Euros per kilometer. Partly, also one reason to why City Cargo started filing for bankruptcy in the end of 2008, see section on Amsterdam. The funding of the project was estimated at an impressive 70 million €, not a small scale endeavor – **Barrier 2**.

"An electric car had of necessity to be limited in radius..." (Ford, 1921) – **Barrier 3**.

From the interviews some agreement was received, but not from all, on a potential opposition from the other logistics competitors of the new, now bankrupt, company: City Cargo. The transportation industry is argued, for example, by Behrends *et al.* (2008), to be particularly resistant to change. In a report on Intermodal City Distribution from WSP (2008) a great concern was the lack of interest and motivation among the stakeholders – **Barrier 4**.

The number of actors involved in the decision process is greater in light rail freight than traditional freight by truck set-up, thus making the implementation and cost-benefit division amongst the actors more complex. Unfortunately, excerpts from conducted interviews with the logistics industry in general do portray a similar picture. Phrases like "we were forced to cooperate" have been recorded – **Barrier 5**.

One proposed recommendation to the barriers presented in this paper could be to use the same distribution strategy as used in Amsterdam, but with three fundamental differences identified through the study of the four cities in this paper: RoRo technique, small scale and open source:

In order to minimize the building of sidings and maximize the use of existing infrastructure the EDVs could catch a ride, 'piggy-back', on a rebuilt tram from the tram end point into the cities, rather than waiting in the city centre and re-loading from tram to EDVs. This way one would decrease the risk of **barriers 1-2**. By using a rebuilt distribution wagon, type M28 or M29, in 'follow mode'[4] the time for rolling off and on the trams in the city centre and at the tram end stations would be the time between the existing trams in the system, varying between twelve to twenty minutes depending on route and time of day (Nicklasson. 2009). This would also mean no necessary investments in infrastructure. So, why did Amsterdam not use this method? The trams in

[4] See Amsterdam section

Amsterdam are quite narrow because of the narrow streets of the city. They are about thirty centimeters more narrow than in Gothenburg, and the design of the trams are not suited for a roll on and roll off scenario. The old versions have a drop center design meaning that the middle wagon is lower than the other two and the new ones are built for disabled people with low entrance possibilities throughout the entire tram, requiring the wheels to be built in and sticking up in the compartment. Thus making it impractical to drive EDVs on and off without a complete rebuild of the tram. The floor of a M28/M29 on the other hand is flat from the back to the front and fifteen meters long.

Barrier 2 is potentially the most important lesson from Amsterdam; to try this concept in a more small scale fashion, allowing for test and necessary changes before a possible scale up. Lessons learnt from Dresden and Zurich, the only ongoing projects at the moment, it seems sound to start small scale and gradually scale up. Furthermore, a test could be carried out for a limited time period with normal express diesel or renewable fuel vehicles commonly used today, like MB Sprinter, instead of EDVs. This could be an inexpensive way of trying out the concept in a real life situation before investing large amounts of money on EDVs.

By using RoRo technique, where the EDVs drive onto the tram on a ramp in the back, also means that the EDVs could charge their batteries inside the tram on their way to the city centre, thus resolving **barrier 3**. Allowing for these EDVs to drive onto the trams would also mean that they are not obstructing traffic on the motorways to and from the city.

Rather than creating a new competitor and in order to increase the chances of the recommendations to be implemented in Gothenburg by decreasing initial investments and to tackle **barrier 4**, the recommendations ought to be presented to the already existing distribution companies, as well as the municipality and tram operator after a thorough cost-benefit analysis has been made. By doing this, additional competition in an already competitive industry as well as a 'not invented here' mentality is avoided. An "open source" mentality, with its origin from the internet, would be preferable until falsified.

Unfortunately, there is no other way of resolving **barrier 5** other than to call for an increase in cooperation between the logistical actors, municipality and the Gothenburg tram company.

REFERENCES (FOR INTERNET REFERENCES; SEE NEXT CAPTION)

Behrends, S., Lindholm, M., Woxenius, J. (2008), 'The impact of urban freight transport: a definition of sustainability from an actor's perspective', Transportation Planning and Technology. Vol. 31, No. 6, pp. 693-713.

Bliss, D; (2000), Mail Rail : 70 Years of Automated Underground Freight Transport, Compass Logistics Ltd, 2nd International Symposium on Underground Freight Transportation by Capsule Pipelines and Other Tube/Tunnel Systems: September 28-29, Delft, The Netherlands

DELIVERING TOMORROW, (2009), Customer Needs in 2020 and Beyond, A Global Delphi Study

DfT 2004, Road freight transport survey 2004; central statistics office (CSO); www.rws.avv.nl/goederenvervoer2003/index)

Driessen, A., (July 9, 2007) "Amsterdam cargo tram in desperation" Amsterdam News, DPA

ELCIDIS, (2002), Electric Vehicle City Distribution, FINAL REPORT, European Commission

Ford, H; (1922) My Life and Work, The Project Gutenberg EBook

Genta, S; Marangon, F; Messina, M G; Valentini, M P; (2006) TADIRAM project: Organizational and technical proposals for Freight Distribution in the Sustainable City, co-funded by the Italian Ministry of Research

Gregory L. Thompson (2003), Defining an Alternative Future: Birth of the Light Rail Movement in North America, Transportation Research Board, http://trb.org/publications/circulars/ec058/03_01_Thompson.pdf

Henriksson, Dick and Älveby, Rustan. (1994). *Vårt Levebröd - Göteborgregionens näringsliv Igår, I dag och I morgon*. Publisher: Akademiförlaget. Page 5.

Lesser, K; No Stopping the Gravy Train of Car Support?, (2009), World Transport Policy & Practice, Volume 15, Number 1

Macharis, Cathy, Van Mierlo, Joeri and Bossche, Peter Van Den, (2007), 'Combining Intermodal Transport With Electric Vehicles: Towards More Sustainable Solutions', Transportation Planning and Technology, 30:2, 311 - 323

Mortimer, P; (2008), BESTUFS, UK Seminar 2008, New rail

Pielage, BJ; Underground Freight Transportation. A new development for automated freight

transportation systems in the Netherlands, 2nd International Symposium on Underground Freight Transportation by Capsule Pipelines and Other Tube/Tunnel Systems: September 28-29, Delft, The Netherlands Technisch Weekblad, This news item is from the 2007 newslog)

Priemus, H; Konings, R, (2001), Light rail in urban regions: what Dutch policymakers could learn from experience in France, Germany and Japan, Journal of Transport Geography 9, p 187-198

Smiler, S; "Trams, Streetcars and Light Rail Vehicles", pdf, Retrieved 2007-07-18.

Van Mierlo, J., Maggetto, G., Vereecken, L., Favrel, V., Meyer, S. & Hecq, W. (2003) Comparison of the environmental damage caused by vehicles with different alternative fuels and drive trains in a Brussels context, In: Proceedings of the Institution of Mechanical Engineers Part D _ Journal of Automobile Engineering, I MECH E, SAE and IEE, isnn 0954-4070, 2003, Vol. 217, No. D7.

WSP, RAPPORT, Intermodal stadsdistribution, Slutrapport 2008-11-19
Zunder, T; Ibanez, N; (2004), Urban freight logistics in the European Union, European Transport \ Trasporti Europei n. 28 77-84

INTERNET REFERENCES

"Area, population density, dwelling density and average dwelling occupation". www.os.amsterdam.nl. Research and Statistics Service, City of Amsterdam. 2006-01-01. Retrieved 2008-08-13.

http://www.absoluteastronomy.com/topics/CarGoTram#encyclopedia

http://www.bestufs.net/cgi-bin/projectdb/project_db.pl?init=shwprodescr&id=161

http://www.bestufs.net/download/conferences/Amsterdam_Jun05/BESTUFS_Amsterdam_June05_Neuhold_ERZ.pdf

Cargotrams Yahoo group, citycargo.nla pictorial website on Amsterdam's cargo tram. This news item is from the 2007 newslog.)

http://www.proaktiva.ch/tram/zurich/CarGo Tram.html Retrieved 2009-09-20

http://www.bestufs.net/download/BESTUFS_II/national_seminar/2008-04-21_uk/BESTUFS_UK_Seminar_2008_Phil_Mortimer.pdf 2009-09-20

http://www.civitas-initiative.org/docs1/CIVITAS_Award_2005_nondemonstration_city_Dresden.pdf

http://www.eurailtelematics.com/fileadmin/eurailtelematics.com/abstracts/2_10.pdf

dutchnews.nl and Railway Gazette. This news item is from the 2009 newslog.

"Kerncijfers voor Amsterdam en de stadsdelen". www.os.amsterdam.nl. Research and Statistics Service, City of Amsterdam. Retrieved 2009-04-04

"Light Rail Transit - Encyclopedia Britannica". Retrieved 2009-07-18.

Merriam-Webster online dictionary, Retrieved 2009-09-23 – cargo

Merriam-Webster online dictionary, Retrieved 2009-09-23 – freight

Merriam-Webster online dictionary, Retrieved 2009-09-23 – tram

Merriam-Webster online dictionary, Retrieved 2009-09-23 – trolley

www.nieuwsuitamsterdam.nl/2006/061124_goederentram.htm, this news item is from the 2006 newslog.) Retrieved 2007-05-04

http://www.ptua.org.au/files/2008/PTUA_EWLNA_submission_20080715.pdf

http://www.tinavienna.at/service/upload/Newsletter_September_2004.pdf

http://www.tinavienna.at/index.php?p_id=1139227810&last_id=1139227810&l_id=en&sid=181192404dd165190f869fcabfbcc0e4 Retrieved 2009-05-04

"Tätorternas landareal, folkmängd och invånare per km2 2000 och 2005" (in Swedish) (xls). Statistics Sweden. Retrieved 2009-05-10.

http://www.viennaconsult.com/Homepage%20Englisch/n_GB1_e.htm 2009-05-04

http://www.viennaconsult.com/Homepage%20Englisch/n_GB2_e.htm 2009-05-04

http://www.volkswagenag.com/vwag/vwcorp/content/en/sustainability_and_responsibility.-bin.acq/qual-DownloadFileList.Single.DownloadFile.0002.File/csr_en.pdf

http://www-web22.wien.gv.at/umweltschutz/umweltbericht/pdf/mobil-engl-04.pdf Retrieved 2009-09-20

Stern, N. (2006). "Short Executive Summary. Stern Review Report on the Economics of Climate Change, pre-publication edition." HM Treasury. http://www.hm-treasury.gov.uk/d/CLOSED_SHORT_executive_summary.pdf. Retrieved 2009-09-20.

INTERVIEWS

Willy Nicklasson (2009-06-12), Gothenburg Tram Company

Peter Hendriks (2010-01-15), CEO Cargo tram

Michael Hendriks (2010-01-19), Financial Manager Cargo Tram

Jan Dijstelbloem (2010-01-18), Municipality Project Manager

Jupijn Haffmans (2010-01-18), Public affairs Cargo Tram

Stefan Saalmink (2010-01-18), MindsinMotion.net

Paper 3

Paper 3: Santén, V., Arvidsson, N., (2011), Road freight transport efficiency and less environmental impact – the perspectives of transport buyers and operators, Published in the proceedings and presented at Nofoma, Harstad, Norway, June 9-10, 2011.

Road freight transport efficiency and less environmental impact – the perspectives of transport buyers and operators

Vendela Santén*

Niklas Arvidsson**

*) Chalmers University of Technology, Department of Technology Management and Economics, 412 96, Gothenburg, Sweden

E-mail: vendela.santen@chalmers.se, Tel: +46 31 772 13 32

**) University of Gothenburg, School of Business, Economics and Law, 405 30, Gothenburg, Sweden

E-mail: niklas.arvidsson@handels.gu.se, Tel: +46 31 786 64 37

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ABSTRACT

Purpose of this paper

The purpose of this article is to describe and compare the transport buyers' and transport providers' views of challenges when improving transports efficiency and reducing environmental impact from freight transport. By investigating perspectives of the actor groups, an increased understanding of different viewpoints is made and factors that are of importance for improving transport efficiency and reducing environmental impact are identified. The role of the actors and especially what could be expected from each actor is discussed.

Design/methodology/approach

The empirical findings have been collected through semi-structured interviews and two focus groups. The target groups have been two main actors in the logistics system; transport providers and transport buyers in Sweden. Grounded theory has been used for analyzing the data. The focus is road transports and its interface to other transport modes. Both long distance transports and short distance distribution have been included.

Findings

Competence and resources, Knowledge and information, Demands, Service and offers, Follow up environmental goals and Priority of transport are identified as important factors. The transport buyers need to raise the focus of transport and environment in order to better understand the effects of transport in the system while the transport providers need to be innovative and proactive in order to find business models that steer towards both efficient and sustainable transports.

What is original/value of paper

The interface between transport buyer and transport provider has shown to be poorly studied before. This article provides input to a more holistic approach when improving the logistics system towards an efficient and environmentally preferable direction.

Keywords: actors, environment, factors, perspectives, road freight transport efficiency

1 INTRODUCTION

That transportation is an important sector for society is undisputed. According to the European commission the transport sector is the "the backbone of European economy" (EC, 2009a). However, there is an increased focus on social and environmental impacts from transportation in the political as well as the societal debate due to e.g., large amount of emitted greenhouse gas emissions from the sector, congestion problems and accidents. The trends are clear; there is an increased share of road transport in Europe as well as longer transport distances in a steadily growing international market. The transport sector alone is today the largest sector still increasing its share of greenhouse gas emissions in society (EC, 2009a). Looking into the societal goals, e.g., reducing greenhouse gas emissions by 20 % by 2020 (EC, 2009b), makes it obvious there is a large gap between societal goals and current trends.

Within logistics, transportation is the major function contributing to environmental impact (Wu and Dunn, 1995). There are a number of logistical actions suggested in literature in order to reduce environmental impact from freight transportation, such as more efficient technology, modal shift, better logistical planning, consolidation and changes in logistical structures, e.g. Skinner et al (2010), De Jong (2010) and Piecyk and McKinnon (2010). However, even if the vehicles in operation are becoming more and more efficient, the transport demand tend to increase along with the requirements on service level from the transport buyers which may limit the improvements (McKinnon, 2003). In addition, the interest for environmental issues in logistics are lacking in favor for traditional logistical performances such as cost and service (Vachon and Klassen, 2008), which may hinder implementation of environmentally preferable actions in the transport sector. From a transport providers perspective, Léonardi and Baumgartner (2004) show that to a large extent, the measures aimed at improving transport efficiency have been poorly implemented. Drewes Nielsen et al. (2003) argue in line with this statement, that "the transport buyer do not display a great interest in an environmentally based change of transport demand and the transport companies only seem willing to supply new transport concepts if demand exists.".

There are a number of actors in the logistics system that potentially could take action, alone or in co-operation with others, e.g. transport providers, freight forwarders, third party logistics providers and transport buyers. Today, most manufacturing companies outsource their transportation and/or logistical activities to a transport provider or a third party logistics provider, which makes the responsibility for improvements being more focused on the transport provider. Björklund (2011) investigates drivers and hinders when purchasing green transportation services from a transport buyer's perspective. Her study shows that transport buyers' view the transport providers as playing an important role in the greening of transportation services. Their knowledge, ambitions, equipment and the relationship between the transport buyer and transport provider has a great positive influence when purchasing green transportation services. Blinge (2005) explores the transport buyers view on transport related environmental issues. He describes some important future focus areas in the interface between the transport buyer and freight forwarders, such as lack of incentives from the forwarders and raises the question, who is actually responsible for the emissions produced from transport activities? However, both of these studies highlight the need for more knowledge about the improvement potentials, especially in the interface between transport buyer and provider. Also, both studies raise these statements from a transport buyer's perspective only.

Few studies exist where comparing several actors' perspectives on acting towards more efficient and environmentally preferable freight transport solutions. Wolf and Seuring (2010) is one such study however, examining how environmental issues is taken into account by transport buying companies, studying cases of both buyers and suppliers of logistical services. These cases shows that, in order to reduce CO_2 emissions, one of the main challenges is to change business practice along supply chains, e.g. improving cooperation, trust and information change in between actors. There is a need for a more holistic approach, widening the scope towards suppliers', customers' and competitors' environment in order to find the factors that are of importance for improving the logistics system further in an efficient and environmentally preferable way.

The purpose with this article is to describe and compare the transport buyers' and transport provider's perspectives when improving transports efficiency and reducing environmental impact from freight transport. By investigating the views of the two actor groups an increased understanding of the different perspectives could be made and factors that are of importance for improving transport efficiency and reducing environmental impact are identified. The following research questions are answered in this study:

RQ 1: What factors are of importance when improving transport efficiency and reducing environmental impact from freight transport from a transport buyer and operator's perspective respectively and how are they related?

RQ 2: What differences and similarities can be identified when comparing transport buyers' and transport providers' perspectives?

This paper is distributed as follows: first, the method is explained. Second, an introduction to the concept of freight transport efficiency and its correlation to less environmental impact is made. Third, a general overview of the actors' perspectives concerning what may obstruct transport efficiency and reduce environmental impact is described. Finally, a concluding discussion compares the factors identified as important for the actors and a discussion of the implications of the coinciding and differing views takes place.

2 RESEARCH METHOD AND DATA COLLECTION

Interviews and the results from two focus groups form the basis for the empirical data collection in this study. As introduced earlier, there is a lack of research that investigates more than one actor's view when analyzing ways to improve transport efficiency as well as reducing environmental impact from transport systems. How different actors, such as transport providers and transport buyers, view the system is fairly new and unexplored. Therefore the data collection has been performed in an explorative way, aiming at describing the system and forming hypotheses and suggestions for further research based on empirical data.

The two studied actor groups were transport providers and transport buyers. Transport providers included actors offering logistics and transport services and operations; third-party logistics service providers, freight forwarders and hauliers. Transport buyers included actors that have a large goods flow and purchase the transport service from a third part, i.e. they do not have their own vehicle fleet. The transport providers were both medium sized trucking terminals operating on a regional level, rail providers and third party logistics providers

operating at a national and international level. The transport buyers were large international companies having a large goods flow. All of them originate from different branches including food, pulp, agriculture, construction, vehicle production, clothing and personal care. They all have their base in Sweden.

A combination of interviews and focus groups were complementing each other. Semi-structured interviews were conducted since it was important to understand the specific respondent's context, being able to include open questions as well as to include different follow up questions. In addition, semi-structured interviews allow you to be flexible about the order of questions as well as to be able to include questions of interest dependent on the specific respondent (Bryman and Bell, 2007). An interview guide was used as a base for all interviews. The respondents were included from both actor groups; transport providers and transport buyers. Interviews were performed with 5 transport providers and 3 transport buying companies. Two researchers conducted the interviews, lasting about 1 to 2 hours each. The interviews were recorded and later transcribed.

Since we wanted to both identify factors of importance and comparing the viewpoints between the two actor groups, focus groups were chosen as a method to collect data. The interviews contributed to forming subject areas that were discussed in two full day focus group seminars, one for each actor group respectively. Focus groups were chosen for its advantages of capturing the dynamics in viewpoints from several participants in the groups (Kvale and Brinkman, 2009). Also, focus groups are useful for e.g., orienting oneself in a new field, generating hypotheses based on informants' insights and evaluating different study populations (Morgan, 1988), which is in line with the aim of our study. The focus groups included 8 and 10 participants respectively. The researchers were moderating the focus group discussions with the aim to create informality in the discussions in order to get all members to speak openly while at the same time keeping the discussion within the different subject areas. During the focus groups notes were taken continuously by the authors of this article. The notes were thereafter summarized and sent out to the participants for their comments.

The analysis of data has been performed in line with grounded theory (as described in Bryman and Bell (2007)). The key process of coding has been performed; data were analyzed and compared from the interviews forming subject areas that were included in the discussions in the focus groups. Open coding has been carried out, which is "the process of braking down, examining, comparing, conceptualizing and categorizing data" (Strauss and Corbin, 1990). The outcome from the process was the identified common factors. Also relationships between these factors were explored, by presenting a model in which the factors are connected to each perspectives and its influence on the actors.

3 FREIGHT TRANSPORT EFFICIENCY AND ENVIRONMENT

This section serves as an introduction to the area of freight transport efficiency and environment, and aims at explaining some of the complexities when dealing with these concepts, based on literature. The review of the concepts is meant as a short reference guide for the reader of the paper in order to help out in the understanding of the different factors identified that affect transport efficiency and environmental impact.

Efficiency of transport systems is of most importance for reducing environmental impact from freight transport while also staying competitive. However, the terminology of transport

efficiency is used with no common definition, which makes it important to highlight its significance and relation to reducing environmental impact from freight transport as a part of a sustainable freight transport system. From the literature at least two aspects in trying to define transport efficiency can be identified: 1) Several types of measures; smart, economically and environmentally sustainable or "optimal" use of "resources". 2) Clear trade-offs and different meanings for various actors.

Caplice and Sheffi (1994) propose a series of ratios as logistical KPI for performance measurement in logistics: Utilisation, Productivity and Effectiveness. These logistics metrics is later reworked by McKinnon and Ge (2004) and suggested to serve as a base for transport efficiency measures, leading to a series of KPIs: vehicle loading, empty running, fuel efficiency, vehicle time utilization and deviations from schedule. The first three KPIs are utilization measures, the fourth is a productivity measure and the last assessed the effectiveness of the delivery operation. In another report, transport efficiency in terms of reducing CO_2 emissions from a macro perspective is presented (Piecyk and McKinnon, 2010). The used framework maps the linkages between determinants, key variables and output. All these measures combined with fuel efficiency result in an analytical tool to reduce environmental impact in terms of CO_2.

Rodrigue et al. (2001) focuses more on the paradoxes of green logistics such as; environmental costs are often externalized, modes used are the least environmentally efficient: trucks and air, and inventory shifted in part to roads contributing to congestion and space consumption with the argument that reducing logistics costs does not necessarily reduce environmental impacts and also stresses the importance of integrating logistics with other fields of research. McIntyre et al. (1998) highlight the trade-off between reducing environmental impact and decreasing financial costs. Most KPIs used have been found to be time and cost focused. This approach tends to promote a short term perspective and work on greening the supply chain benefits from a more long term perspective. The suggestion presented by McIntyre et al. (1998) is to amalgamate both perspectives so that the long term is represented in the performance measurement.

There are, obviously, different levels of efficiency in transport and logistical systems. Reducing costs is naturally of more importance on a micro level. Literature focusing on reducing environmental impact takes to a larger extent the macro level dimension. The indicators that measure efficiency on these levels may differ. Literature shows that a number of measures are necessary in order to present the broad picture of efficiency as such and level of environmental impact in particular. In the interviews and focus groups undertaken in this study a common definition of transport efficiency or what kind of environmental impact that is to be reduced was not presented or brought up. Rather a focus has been on what factors impacting a reduction of environmental impact while improving competitiveness on a general level spring boarding from each actor's perspective.

4 PERSPECTIVES OF DIFFERERENT ACTORS

Factors that affect the level of transport efficiency and environmental impact from freight transport have been identified. Every factor below is described according to both transport providers' and transport buyers' perspectives, respectively. Some factors are more important for one actor group, while others are important for both, sometimes in contrasting ways. The factors are the outcome from the study, based on the different viewpoints that were brought

up from the two actor groups, both in the performed interviews and the undertaken focus groups.

4.1 Competence and resources

The transport providers in both the interviews and focus group raised the issue of lack of competence as a factor affecting their environmental work and ability to make more efficient transport solutions. One small provider highlighted that they do not have the economic conditions for hiring specialists in all areas, especially environmental. Furthermore they have limited possibilities to invest in other technical improvements that might be better off for environment and efficiency, such as information systems or new vehicles. Another provider raised the point that employees responsible for environmental issues may not have enough knowledge about how to actually work with these issues or that there is a large work load and not time for reflecting and analyzing possible new projects. In the focus group, how to attract new and young professionals to the transport sector in general was another issue of concern for the providers. There is a growing lack of truck drivers and competent business people in transportation. The transport providers believe that their business is not attractive enough, especially for women. Two reasons mentioned in the focus group was the unpleasant working hours which may limit the co-ordination of family life, such as picking up kids at day care, but also the general reputation of the branch as such with myths about overbalance of male employees and a “rough” working environment.

4.2 Knowledge and information

The transport buyers in the focus group stated challenges concerning knowledge about their transport systems. In both the interviews and the focus group, companies painted a picture of lack of knowledge regarding their purchased transports. This concerns knowledge of the amount of purchased transport as well as the amount of environmental impact from the purchased transport. There were a number of the transport buying companies that experienced they have not full control of their own transport flows. One company mentioned that about 80 percent of its transport flows are known while the rest is unknown for the company; "a lot of people in the company buy transport services". Another company stated in the interview that because of new company structures and a large expansion in the company the first aim is to actually get control of its own flows, i.e. to identify what transport structures exist in the company at the moment.

When it comes to environmental issues, there are different views about the level of knowledge. In the focus group there were examples of transport buying companies who experience they have knowledge about their environmental impacts from transportation, but also the opposite. From the focus group, the impression was that there is an issue concerning detail level. To base an environmental measurement on very general assumptions, such as on transport mode and distances mentioned as a possibility, while being more detailed was stated as more difficult. Another issue mentioned in the focus group was the lack of knowledge concerning how important the transport service is for society.

4.3 Demands

According to the transport providers in the focus group, the transport buyers traditionally dictate the terms while purchasing the service from the transport providers by setting different

kind of demands. In order to improve the efficiency or reduce the environmental impact of freight transportation demands from the transport buyers can constrain this work. In both the interviews and the focus group the transport providers agreed on that to save cost is traditionally one important focus of the transport buyers. However, the larger part of the discussion concerned the stricter time constraints that were partly seen as limiting the ability to act efficient from a transport providers' point of view.

Time demands are connected to several different issues; point for ordering the transport, point for picking up goods, point for delivery and also the total time in between these points. From both the interviews and the focus group this issue was mentioned in different ways, but it was also clear that it was not a completely uniform picture within the transport providers regarding time. The transport providers highlighted that in order to stay competitive it is of importance to focus on time, the goods need to be delivered quickly and just in time. One reason for this development is that the competitors also are offering fast deliveries and that the customers (the transport buyers) demand it. Furthermore, a trend was recognized from the transport providers, that the transport buyers are making the order later and requiring the delivery earlier. This trend was mentioned to be negative for optimizing the transport system, since it shortens the time for planning the transport in an efficient way and also leaves less room for error and flexibility. Also greater time windows at delivery were viewed as something that would improve the possibilities for increasing the efficiency in the system. However, other transport providers stated that they already have their time table to which the transport buyers do have to adapt to. The important issues in order to make a transport efficient are to consolidate a large goods flow.

Also, there were examples raised of when the delivery requirements in terms of time would increase the environmental impact, e.g. intermodal transport. A provider transporting goods between the Swedish west coast and Stockholm had a customer requiring delivery at 7 am in the Stockholm area; which was impossible using rail. Instead road transport had to be used in this example.

Several transport providers in the focus group suppose that it is not always that the demands regarding time need to be stressed as hard as firstly perceived. In general, some of the transport providers clearly express the need for having better knowledge in terms of the actual need from the transport buyer. The transport providers believe that the transport buyers often are not really aware of what they want. The reasons for this, according to the transport providers in the focus group, can be that the person responsible for purchasing transport does not have enough detailed knowledge about the actual operations in the company. Demands are framed in a traditional way - and a change of that (if not to a better service level) may be seen as lowering the service even if it may lead to a better total efficiency of the system. The perception from the transport provider's point of view was that transport providers today are generally bad at questioning the transport buyers' demands and starting a dialogue about the different options that are actually available. The transport buyers may fear that these type of questions can be seen as a way to reduce service - when it is actually about finding ways to make the transport more efficient by delivering the service that is satisfying their needs. One transport provider mentioned the importance of information in the dialogue when meeting the demands from the transport buyer: "It is important to deliver facts to the buyer; to be able to say that your decision A will have the following effects. But if we do B, this is what we will save". In this dialogue it is important to have information about the operations, tools for calculating environmental effects and know potential cost savings. Additionally, the environmental demands are often not included in the original discussion, but are later added,

sometimes by the environmental department. The transport providers would like to see the buyers ask how they could best use the provider's network, instead of stating how and when a transport should be performed. A more extensive dialogue with the transport buyers regarding their actual needs was of major concern among the transport providers.

In the focus group, it was obvious that a robust transport chain is a necessity for the transport buyers' business. The transport buyers stated several aspects concerning demands that are important for their efficiency of their transports; such as cost, time and robustness. Concerning environmental demands, in the interviews, all transport buyers did state that they put environmental demands on their transport providers, where the majority using Q3 as a guideline[1]. However, in the focus groups, the most concern regarding demands was about cost and time.

The transport buyers in the focus group did say that price is an important factor in the choice of transport supplier, but expressed that they would like to see the transport providers to sell services on other aspects than price, like flexibility and adaptation. They agree on that if all qualitative factors are equal between the transport providers, price is an order winner, but it was also identified that an open dialogue, and an understanding from the transport provider about the transport buyers' logistics system, is important. It is however of main concern for the buyer to keep prices low.

In addition, strict lead times can also be a deal breakers according to the majority of the transport buyers. If the robustness in the transport chain is disturbed, leading to e.g. delivery delays, serious effects in terms of costs for the transport buying companies might occur. One example, mentioned by one transport buyer, was the problems in Rotterdam harbor last year which lead to extensive delays on their shipping on products. This forced the transport buyer to ship by air instead, which of course generated higher transport costs.

Most participating transport buyers in the focus group identified robustness and smaller time windows at delivery as important. The transport buyers agreed on that "just in time" was very important, by that meaning "just in delivery time". However, some transport buyers recognized that they did plan and book transport quite late in the process, which was mentioned to be possible to be made earlier. Furthermore, the question was raised whether the transport providers could handle order information that was sent out a couple of days earlier than customary. Some of the transport buyers were in doubt.

4.4 Service and offers

In order to offer an attractive service to the transport buyers, price of transport is perceived as an important factor, as identified in section 0 and 4.6. The market for transport providers are tough, with low margins and fierce competition. One reason for this, which was mentioned by the transport providers, is the growing availability of inexpensive hauliers from low cost countries, such as Poland. This issue worries the Swedish transport providers from a perspective of competition on equal terms. Furthermore, the entry levels to start a trucking firm and to invest in a truck within Sweden are low, which contributes to an over-capacity of

1 Q3 is a non-profit-making association assisting transport buyers when setting demands in the areas of safety, working conditions and environment. For more information see their webpage: www.q3.se.

transport providers on the market, according to some transport providers in the work shop. However, some of the transport providers mentioned a change in trends, where the larger transport providers are growing, collaborating with or taking over smaller hauliers in the surrounding area, in order to get a higher goods flow and better profitability.

A suggestion mentioned by the transport providers in order to both raise the profitability in offers and efficiency in the system was differentiated time requirements. In the offer this meant to vary the price with different services connected to time of transports, e.g., more expensive express transports and cheaper price for non-urgent transports. To differentiate between the regular and "slow" goods, would make it possible to leave some goods waiting for the next day which would make only full vehicles to leave the terminal. The idea was brought up to identify the goods that actually do not have the strict time requirements. However, as discussed by the transport providers in the focus group, this is not only a positive arrangement for the transport providers, since it would require another type of terminal handling including more storage - which in turn raises the cost.

One problem that was raised by a large transport provider concerned keeping the promised service level when delivering goods to a receiver which is not prepared to receive the goods. The problem was concerning the common situation whereby the transport provider makes an attempt to deliver the goods, but the receiver is not available, or the timing of delivery is not right. This in turn generates many unnecessary transports. Approximately five percent (estimation by the transport provider) of the transport provider's deliveries cannot be finalized due to that the receiver does not know about the details of the delivery and are therefore not prepared to receive the goods. The reason for this to happen, according to the transport provider, was that the dialogue between the transport buyer and receiver were lacking. Major improvement possibilities were identified within the area of planning in this respect, where the transport providers expressed a need for the transport buyer to take a larger responsibility of the supply chain in order to plan the goods flow all the way from pick up to delivery.

As discussed in section 0, the transport providers stated clearly that transport buyers in a too large extent dictate the demands, what service level must be kept and indirectly then also the conditions in the offer. The transport providers wanted to have a more open discussion in terms of how they can create a better transportation offer and service for the buyer, instead of just reacting to demands.

The transport buyers in turn, state that transport providers must elevate their gaze in order to offer an attractive product, where cooperation and a dialogue in between the two actors are very important. Some transport buyers did mention that they think the transport providers are too passive regarding offering new solutions that may be more efficient and environmentally preferable. One transport buyer expressed it as: "The confidence of transport providers is low -- they do as they are told". The transport buyer meant that their experience was that all initiatives were taken by themselves – not by the transport provider.

On the other hand, regarding offerings including environmental improvements, some of the transport buyers questioned if the transport providers had a hidden agenda in terms of selling an "environmental product" and wondered if they did package an environmental service to make money or actually lessen the environmental impact. The transport buyers mentioned that there can be suspiciousness towards the transport providers when they are "packaging" an environmental service. There is a feeling from the transport buyers that the transport providers

do offer environmentally preferable services in a way to make more money rather than improving the transport itself.

To differentiate prices was also mentioned as an option from the transport buyers; such as a book early discount or different price levels dependent on if return flow exist or not.

4.5 Follow up environmental goals

The transport providers in both the focus group and interviews described that they are setting environmental goals; most of them concretizing the goals into numerical emission reductions. The most common goals among the respondents were to decrease CO_2 emissions. Some goals are more ambitious than others, such as reducing CO_2 emissions / tonkm with 50 percent to 2020. These goals were set on a voluntary basis only and no discussion of potential retributions of non-compliance took place. Other issues brought up in regard to environmental goals were; to increase the use of higher euro classes, to use alternative transport modes, and to use longer vehicles.

One transport provider stated “As long as you do not follow-up, nothing happens”, which was representing the view from the transport providers about the importance of follow up and measuring the fulfillment of environmental goals. However, there was no deeper discussion held on how these measurements could be realized. Although, one point mentioned was the need for standardizing the use of telematics for both increasing efficiency and facilitate measure of transport data.

The transport buyers gave a picture of a situation where it is very difficult to get an overview of transportation and emissions. Far from all transport buyers do have a clear picture of their emissions from transport and their transport flows in general. However, several of the transport buyers do calculate the CO_2 emissions, but not at a detailed level. The idea is to start “somewhere”, as one participant put it. Most transport buyers have information regarding used transport mode, distance between origin and destination and amount of goods to be delivered. The exact route is difficult to get hold of, as well as detailed information about vehicle size, load factor etc. On the other hand, there are examples of companies using different calculation tools or models for their estimations.

One important problem raised by the transport buyers was that the “normal” key performance indicators in transport buying companies are not including environmental issues, they are primarily connected to pure costs. So the need for differentiated price settings on environmental issues are mentioned as important by the transport buyers in order to actually make something happen in line with the environmental goals. Goals exist, but more incentives are needed, steering towards these goals, as concluded by another participant. Furthermore, to make an environmental analysis of the transportation when making decisions in the transport buying companies seems very rare, no one of the transport buying companies had made such an analysis.

Some concrete suggestions were raised by the transport buyers. These include; enforcing stricter demands on how the transport providers should declare the emissions. One idea is to declare specific emissions per consignment, another to declare the whole transport chain in detail. Although the transport buyers doubt that the transport provider can deliver this type of information. To have a standard for measuring emissions is seen as important from the

transport buyers' point of view. Or as one participant concluded; maybe such a model needs to be in place before setting such demands?

From a transport buyer's perspective, the concern about where to draw the line of the system and what to include in their responsibility area was raised. For example, a change from a supplier in China to a supplier in Sweden may result in less transport in total, thus fewer emissions as well. However, the supplier itself may supply from China or have an inefficiency transport system which makes, in total, the first solution better. How to handle these issues when follow up transport and using the material for decision making are issues of importance, as mentioned by one of the transport buyers.

4.6 Priority of transport and low transport price

For the transport providers transportation is, naturally, their main business focus. However, one of the most important factors influencing the transport efficiency and environmental action mentioned by the transport providers in the focus group was the need for a higher priority of transports among the transport buyers. A number of reasons were mentioned; the view that the transport buyer are not taking enough responsibility for its supply chain and its transport, the view of the low willingness to pay for transport in itself (too low transport price) and especially more efficient and environmentally preferable solutions. Even though, the common view in the focus group was that economical and environmental goals are not contradicting each other, which means that a more efficient solution is also more environmentally preferable, it was mentioned that the low willingness to pay by the transport buyers is a problem for introducing more efficient and environmentally preferable solutions. On the other hand, there were other examples raised when the goals are contradicting, e.g., the investment and use of trucks using technology for alternative fuels (such as bio gas) are more costly than the conventional alternatives; both regarding the investment, but also when it comes to time consuming operational difficulties due to lack of gas stations.

In the focus group, the transport buyers agreed on that the transport issue is not as high a priority within the transport buying companies as it should be. Several of the transport buyers stated that there is a common view of transportation as something that "is", somehow taken for granted, and not prioritized in the top management team or board rooms. One transport buyer raised this specific topic by saying: "More transports are created because of globalization and too cheap transport prices. One may have a transport flow all the world around without any significant costs". However, it is clear from the transport buyers that if the robustness in the transport chain gets disturbed, it is a critical issue for the whole company and its performance which also leads to extra costs. In the focus group it was discussed if the location of transport or logistics organization within the organization as a whole can be a hint of its priority. Also, how large part of the total costs arises from transport and logistics is another sign of its priority. In the interviews, the transport buyers showed a difference of total transport costs' share of total production costs, ranging from a few percent to around 20 percent, the latter a paper mill, which was also related to the companies' focus in logistics activities. In order to increase the focus on transports within the transport buying companies it was raised that it was essential to communicating the importance and cost of transportation to the top management and also raise the awareness and control of the company´s transportation activities in general.

In line with the transport providers, the common perspective raised in the focus group was that economical and environmental goals do go along and are not contradicting. One transport

buyer mentioned examples of successful purchasing that lead to both cheaper and more efficient transportation. However, the willingness to pay more for a more efficient or environmentally preferable transport is not obvious among the transport buyers. One transport buyer in the focus group stated that "to pay more is probably not going to happen".

5 CONCLUDING DISCUSSION

The two actor groups, transport providers and transport buyers, show both similar and dissimilar views concerning challenges when aiming for a more efficient and environmentally preferable transport system. The concluding discussion includes a comparison of the actors perspectives as well a description of the identified factors' relation.

5.1 Comparing perspectives

The major differences from the viewpoints of the actors can be seen from the table 5.1.

Table 5.1: Summary of the factors identified as most important when improving transport efficiency and reducing environmental impact from freight transport based on the transport providers' and transport buyers' perspectives.

Important factors	Perspective of the transport provider	Perspective of the transport buyer
Competence and resources	Lack of competence and resources to work with environmental issues within the organization.	Knowledge and information were discussed rather than competence and resources
Knowledge and information	Competence and resources were discussed rather than knowledge and information	Lack of knowledge about all their transport operations and its environmental impact.
Demands	Demands, like cost and time can sometimes be viewed as a limiting factor. Greater time windows at delivery are needed and more flexible solutions.	To keep the time, i.e. JIT, and robustness in deliveries is a prerequisite.
Priority of transports	Notice the low willingness from the transport buyers to pay extra for environmental better solutions.	Low priority of transport in transport buying companies. Agrees on the low willingness to pay for environmentally better solutions.
Service and offers	Would like the buyers to be more open in discussions about possible solutions.	Would like the operators to offer more environmental services and being more proactive.
Follow up environmental goals	Raises the need for measuring the fulfillment of the goals.	Raises many challenges in the area of measuring environmental impact, difficult to measure in detail. More information from the transport provider is needed.

Regarding **competence, resources, knowledge and information** the actors highlighted different challenges. The transport providers mainly discussed the challenge of finding enough competence within their own organizations, such as personnel and knowledge in areas dealing with e.g. environmental issues as well as economical resources for investments. The

transport buyers' challenge is about not having full knowledge and information about their transportation flows, especially on a detailed level.

The transport buyers and transport providers in our study discussed mainly around the importance of two types of **demands**; time requirements and price of transport, not environmental demands. The transport buyers highlighted the need for getting the goods on time (JIT), while the transport providers gave a more differentiated picture around the theme: that greater time windows at delivery or receive orders about the transport well in advance for planning purposes would benefit the efficiency in the system. This was not mentioned by the transport buyers themselves. The issue of how demands are prioritized in the transport purchasing process, such as shorter lead time, delivery requirements, costs and environmental issues, has been discussed by e.g. Crum and Allen (1997), Menon et al., (1998), Lammgård (2007). Lammgård (2007) concludes from her investigation that *"price is important when basic requirements are fulfilled"* which is in line with the view from the transport buyers in our study. The seemingly low priority of environmental demands from a transport buyer has been shown in earlier studies as well, e.g. Wolf and Seuring (2010) state that there is *"limited evidence of environmental issues constituting a buying criteria for 3PL services"*. How the low priority of environmental demands affect the actual outcome in terms of action has been scarcely discussed in earlier research. Rogerson (2011) do mention that the transport providers' ability to respond to environmental demands will affect the transport buyers' interest for them as a supplier. The transport providers in our study however, were most concerned about how the high prioritized demands on especially time issues impede more efficient transport solutions. In literature (e.g. McKinnon (2003), Halldórsson and Kovács (2010)) it has been questioned if the trends towards e.g., shorter lead times, more frequent shipments and smaller delivery windows really reduces environmental impact. But examples in practice showing these relations and the actual effects are lacking. In order to influence these requirements it will be of outmost importance for transport providers to communicate in what way a change will lead to both environmental and economical improvements for the transport buyers.

While the transport providers see themselves as a low margin branch with high competition, struggling for survival to make more profitable business steered by the transport buyer's demands, the transport buyers give an impression of viewing transport as a given service. This service is commonly lacking in priority in top management in the transport buying companies even if uncertainties in the transport services, such as interruptions, delays etc. may give raise to huge negative impacts for transport buying companies. Both actors recognized that the price of transport is generally very low and that the will to pay more for better solutions from an environmental perspective seems to be low, or even non-existing. The difference in **priority of transport** issues in the two actors systems might be explained by how efficiency is perceived. It is not always the case that efficiency from a transport buyers' perspective is the same as efficiency from a transport provider's perspective, where efficiency gains from a transport buyer is also about e.g., production, inventory and marketing strategies at times experienced by the provider to be restrictive in their effort of making a more efficient transport system.

It was apparent that the actors today experienced hierarchies in relation to each other, where both the transport providers and transport buyers were aware of the unbalance in the purchasing dialogue. The challenge seems to be to meet the demands from the transport buyer, turn these demands into a more sustainable offering and getting paid for it. A few transport buyers voiced a concern, accordingly, that the transport providers do package

environmentally better offers in a way to make more money rather than improving a transport service. The providers would like to have greater impact in the transport purchasing process instead of just reacting to demands. In terms of **service and offers**, the transport providers were asking for more openness and flexibility from the transport buyers in the discussion about new business solutions and the transport buyers would like to see the transport providers more proactive in the way they offer new solutions. Also, Wolf and Seuring (2010) recognize a superior-subordinate relationship in between 3PLs and transport buying companies in their study: *"Almost inevitably and despite all efforts and shiny visions, 3PL rather remain in a "henchman's" position towards their customers, with few exceptions from this rule"*. On the other hand, since the transport buyers state a need for more initiatives from the transport providers themselves, it is an indication of that the transport providers can front the transport buyers much more proactively in the future than what is done today without venture their position as a supplier – rather the opposite. A closer dialogue and co-operation in between these two actors might then be a necessity.

Both actors identified to **follow up environmental goals** as an important factor. However, the problem was mainly discussed among the transport buyers. Many of the transport buyers do not have a clear picture of their emissions from transport flows, even though many transport buyers do measure their CO_2 emissions, it is mainly on a rough detail level. To have a standard for measuring emissions is seen as important from the transport buyers' point of view, where in turn there is a need for information from the transport provider about the performed transport. Other studies also discuss the issue of measuring environmental impact and why it is important to communicate effects from decisions both within a transport buying company, as well as between the transport buyer and transport provider. Blinge (2005) highlight several challenges from a transport buyers perspective; the need for information so that decision makers could understand the consequences from their decisions and the need for common methodologies for calculating on environmental effects from transports. Wolf and Seuring (2010) concluded that most of their investigated companies, transport buyers and 3PLs, have started to measure their environmental impact from transport activities, but with "*limited knowledge on how results of these measurements impact the company's economy*". The many challenges of measuring freight transport trends on a macro level scale have been pointed out by McKinnon (2010) which also could be applied in a micro level environment. Examples of such challenges concerns how accurate distances have been measured or if weight measures includes the loading units or not. When follow up goals and measuring effects it is important to know what the information is used for. There is little doubt that more information concerning freight transports is needed and it can be seen as a prerequisite for raising the awareness about cause and effects from decisions in both actors environment, motivating changes in the system, raising the priority of freight transport and also to increase the willingness to pay for efficiency and environmental improvements. In order to know if it is profitable to change your pattern or make investments it is important to know what you actually pay for and this might in turn generate concrete action by both actors.

5.2 The relation between factors

In figure 5.1, the different factors are summarized and their relations to each other are highlighted.

Figure 5.1 Factors of importance for the actors

Figure 5.1 is a model of how the factors affect the different actors and what actor could be argued to take the lead in a change towards a more efficient and environmental system, at least from the factors identified in this study. Transport buyers highlighted the importance of knowledge about their transport systems through better information about their transportation flow internally. Transport providers on the other hand lack resources in terms of money and personnel within their companies. In order to provide better internal conditions for both actors, they are both dependent on each other's co-operation and dialogue. Openness for what demands are important as well as an increase of priority of transport must be instigated by the transport buyers in order to open up for a dialogue about efficient and environmentally preferable services and offers from the transport providers. This in turn may be induced by being provided the necessary information from the transport providers in order to motivate the purchasing of efficient and environmentally preferable services and offers or to follow-up environmental goals. Each actor is dependent on the other actor's acting. A better understanding of both systems will be a necessity in order to generate a change from today's situation. Then an open dialogue, information sharing and to be proactive are suggested to be essential.

REFERENCES

Björklund, M. 2011. Influence from the business environment on environmental purchasing -- Drivers and hinders of purchasing green transportation services. *Journal of Purchasing and Supply Management,* 17**,** 11-22.

Blinge, M. 2005. Transport purchasers view upon environmental issues. Göteborg, Sweden: CPM - Centre for Environmental Assessment of Product and Material Systems

Bryman, A. & Bell, E. 2007. *Business Research Methods,* New York, Oxford University Press.

Caplice, C. & Sheffi, Y. 1994. A Review and Evaluation of Logistics Metrics. *International Journal of Logistics Management,* Vol. 5**,** pp.11 - 28.

Crum, M. R. & Allen, B. J. 1997. A longitudinal assessement of motor carrier-shipper relationship trends: 1990 vs. 1996. *Transportation Journal,* 37**,** 5-17.

De Jong, G., Schroten, A., Van Essen, H., Otten, M. & Bucci, P. 2010. Price sensitivity of European road freight transport - towards a better understanding of existing results. A report for Transport and Environment, report 9012-1.

Drewes Nielsen, L., Homann Jespersen, P., Petersen, T. & Gjesing Hansen, L. 2003. Freight transport growth - A theoretical and methodological framework. *European Journal of Operational Research,* 144**,** 295-305.

EC 2009a. EU Energy and Transport in Figures - Statistical Pocketbook 2009. Belgium: European Communities.

EC. 2009b. *European Commission Homepage - Climate Change.* http://ec.europa.eu/environment/climat/home_en.htm [Online]. European Commission. [Accessed 2009-01-28 2009].

Halldórsson, A. & Kovács, G. 2010. The sustainable agenda and energy efficiency: Logistics solutions and supply chains in times of climate change. *International Journal of Physical Distribution and Logistics Management,* 40**,** 5-13.

Kvale, S. & Brinkman, S. 2009. *Interviews - Learning the Craft of Qualitative Research Interviewing*, SAGE.

Lammgård, C. 2007. Environmental Perspectives on Marketing of Freight Transports. Göteborg: School of Business, Economics and Law, Göteborg University.

Léonardi, J. & Baumgartner, M. 2004. CO2 efficiency in road freight transportation: Status quo, measures and potential. *Transportation Research Part D: Transport and Environment,* 9**,** 451-464.

McIntyre, K., Smith, H., Henham, A. & Pretlove, J. 1998. Environmental performance indicators for integrated supply chains: The case of Xerox Ltd. *Supply Chain Management,* 3**,** 149-156.

McKinnon, A. 2003. Logistics and the environment. *In:* Hensher, D. A. & Button, K. J. (eds.) *Handbook of Transport and the Environment.* London, UK: Elsevier Ltd.

McKinnon, A. 2010. European Freight Transport Statistics: Limitations, Misinterpretations and Aspirations. Brussels: ACEA 15th SAG meeting.

McKinnon, A. & Ge, Y. 2004. Use of a synchronised vehicle audit to determine opportunities for improving transport efficiency in a supply chain. *International Journal of Logistics,* 7**,** 219-238.

Morgan, D. L. 1988. *Focus Groups as Qualitative Research*, Newbury Park, SAGE.

Piecyk, M. I. & McKinnon, A. C. 2010. Forecasting the carbon footprint of road freight transport in 2020. *International Journal of Production Economics,* 128**,** 31-42.

Rodrigue, J. P., Slack, B. & Comtois, C. Year. The paradoxes of green logistics. *In:* Proceedings of the 9th World Conference on Transport Research, 2001 Seoul.

Rogerson, S., Andersson, D. & Johansson, M. I. Year. Context influencing freight purchasing. *In:* IPSERA, 2011 Maastricht.

Skinner, I., van Essen, H., Smokers, R. & Hill, N. 2010. Towards the decarbonisation of the EU's transprt sector by 2050. Final report produced under the contract ENV.C.3/SER/2008/0053 between European Commission Directorate-General Environment and AEA Technology plc, see www.eutransportghg2050.eu.

Strauss, A. & Corbin, J. M. 1990. *Basics of Qualitative Research: Techniques and Procedures for Developing Grounded Theory,* Thousand Oaks, Calif, SAGE.

Vachon, S. & Klassen, R. D. 2008. Environmental management and manufacturing performance: The role of collaboration in the supply chain. *International Journal of Production Economics,* 111**,** 299-315.

Wolf, C. & Seuring, S. 2010. Environmental impact as buying criteria for third party logistical services. *International Journal of Physical Distribution & Logistics Management,* 40**,** 84-102.

Wu, H.-J. & Dunn, S. C. 1995. Environmentally responsible logistics systems. *International Journal of Physical Distribution and Logistics Management,* 25**,** 20-38.