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Reducing transportation emissions: Company intentions, barriers and discriminating factors

Henrik Pålsson Ola Johansson

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Henrik Pålsson
Department of Packaging Logistics, Lund University, Lund, Sweden, and
Ola Johansson
Department of Design and Data Science, Kristianstad University, Kristianstad, Sweden

Abstract

Purpose – The purpose of this paper is to examine the intention of companies to reduce transportation emissions by 2020 and the barriers and the discriminating factors that affect the reduction.

Design/methodology/approach – A literature review identified potential logistical and technical actions and their barriers, and discriminating factors for reducing transportation emissions. A survey of freight transport-intensive industries in Sweden examined the effects of, intention for implementation of and barriers to 12 actions to reduce CO_2 emissions from freight transportation. In total, 172 logistics managers responded, representing a response rate of 40.3 per cent.

Findings – Logistics service providers (LSPs) and freight owners are likely to reduce a considerable amount of CO_2 emissions from freight transportation by 2020 using a combination of actions. The lowest level of confidence was for reducing CO_2 emissions by changing logistics structures, while there was greater confidence by means of operational changes. The actions have few barriers, but there is often a combination of barriers to overcome. Three discriminating factors influence the intention of a firm to reduce transportation emissions: perceived potential, company size and LSP/freight owner. The industrial sector of a freight owner has minor influence. Companies that are particularly likely to reduce emissions are LSPs, large companies, and those that perceive a large reduction potential.

Research limitations/implications – Logistical and technical barriers appear to hinder companies from implementing actions, while organisational barriers and external prerequisites do not. Barriers cannot be used to predict companies' intentions to reduce transportation emissions. The authors examined the impact of three discriminating factors on reduction of transportation emissions. The research is based on perceptions of well-informed managers and on companies in Sweden.

Practical implications – The findings can be used by managers to identify firms for benchmarking initiatives and emissions-reducing strategies.

Originality/value – The study provides insights into intended CO_2 reductions in transportation by 2020. It presents new knowledge regarding barriers and discriminating factors for implementing actions to reduce transportation emissions.

Keywords Sustainability, Survey, Logistics, Supply chain management, Transport, Emissions

Paper type Research paper

1. Introduction

Due to growing public awareness of the effects of transportion on global warming and increasing pressure from legislation, companies need to become more environmentally sustainable. Transportation accounts for 15 per cent of the total greenhouse gas emissions globally (OECD, 2010), and the current trends clearly point in the direction of increased freight transport work (in terms of tonne-km) and reduced resource utilisation of road freight vehicles (European Commission, 2010). In a global perspective, transportation of goods is expected to continue increasing in step with the GDP.

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This trend contrasts sharply with the climate targets set by the EU, which require substantial reductions in emissions; by 2020 the EU should cut its emissions by 20 per cent, and by 2030 by 40 per cent below the 1990 levels (EU, 2011).

To curb this negative trend of CO_2 emissions from freight transportation and to reach long-term targets, companies need to incorporate environmentally sustainable processes in their organisations (Seuring and Muller, 2008). This should be attainable, since research has identified great technological and organisational improvement potentials in transportation emissions efficiency (Leonardi and Baumgartner, 2004). Research has also found that such greening of the supply chain may lead to improved competitiveness and better economic performance (Rao and Holt, 2005). However, despite these potentials, company actions are lacking that can solve the challenges of environmental and energy use in the supply chain (Meixell and Norbis, 2008, p. 206). Though the need for corporate sustainability and the potential benefits of green logistics were identified more than 15 years ago (Greene and Wegener, 1997; Murphy and Poist, 1995; Rao, 2004), the environmental impact of freight transportation has continued to increase. Thus, even though transportation emission reduction has advanced, it has not been sufficient.

One explanation is that logistics structures and company decision making have not favoured CO_2 efficient freight transportation. On the contrary, they have in general developed in favour of road transportation, which is fairly inefficient in terms of transportation emissions (European Commission, 2010). Logistics structures and decision making influenced freight transport by centralisation of inventory (Matthews and Hendrickson, 2002), just-in-time replenishment (Rao *et al.*, 1991), globalisation of suppliers (Paxton, 1994) and time and flexibility constraints (Kamakate and Schipper, 2009).

However, the extent to which companies reduce transportation emissions depends on the fact that strategies, barriers and other discriminating factors vary between companies (Pålsson and Kovács, 2014). The company strategy determines the direction for greening transportation because the approach taken by top management in environmental issues is essential for this matter (Banerjee *et al.*, 2003). Barriers for greening transportation can affect the level of reduction. The barriers can be both company-specific and industry-specific regarding, for instance, costs, regulations or internal legitimacy (Walker *et al.*, 2008). Discriminating factors can also affect the level of reduction, for instance, both the industry type (Banerjee *et al.*, 2003) and company size (Gonzaléz-Benito and González-Benito, 2006) affect how companies address and adopt environmental issues and practices in general. Such effects are likely to apply to greening transportation, but these need to be confirmed.

In short, there is a growing need for greening transportation, which has not been obtained despite the identified potentials for emission reduction and monetary savings. Instead, transportation emissions have grown steadily. The previous discussion showed that companies reduces transportation emissions to various extents depending on varying barriers and discriminating factors. Research is needed to understand how companies will behave in the near future regarding environmental challenges of transportation in supply chains (Meixell and Norbis, 2008, p. 206). One study on this topic conducted by Tacken *et al.* (2014) examined carbon reduction initiatives in the logistics sector in Germany. The results confirmed the drivers, barriers and initiatives described in the literature. The majority of the companies surveyed had implemented several green logistics initiatives, but there was still a sufficient amount of improvement to be made. To extend the research, and thus increase knowledge about initiatives and barriers of green logistics, Tacken *et al.* (2014) call for new studies in other geographical regions with a wider scale in order to gain more generalisable results. This paper addresses this issue by benchmarking future intentions, barriers and discriminating factors for greening transportation for different type of companies. The purpose is to examine the intention of companies to reduce transportation emissions by 2020, and determine which barriers and discriminating factors affect the reduction. This will help to understand whether the negative trend described above is likely to continue, or if companies intend to embrace the economic and strategic opportunities of reducing transportation emissions in the coming years. It will also help to understand the barriers and the discriminating factors that can help companies finding ways to overcome them, as well as assist policy makers in developing policy measures to support such approaches.

The paper is organised as follows: Section 2 presents a literature review examining actions companies can take to reduce transportation emissions. It also examines barriers and discriminating factors. Section 3, methodology, describes the research we carried out based on a survey of nine freight transport-intensive industries in Sweden. The results are presented in Section 4 and discussed in Section 5. Conclusions are drawn and future research proposed in Section 6.

2. Literature review

The literature review was carried out to identify and review potential logistical and technical actions and their barriers, and discriminating factors for reducing transportation emissions. To do this, we first clarified the relationship between the actors involved in generating freight transport emissions: logistics service providers (LSPs) and freight owners. We then identified six factors that describe the causes of transportation emissions on the macro level. Thereafter, we reviewed green transportation practices and linked these to four of the six macro-level factors to ensure that the wide spectra of potential causes of transportation emissions were covered in the logistical and technical actions. Finally, barriers and discriminating factors for green logistics practices were reviewed.

2.1 Macro- and micro-level actions

Most current freight transport research uses a macro perspective and does not consider the constraints on companies to actually obtain CO_2 reductions (Aronsson and Huge Brodin, 2006). The impact of such micro-level constraints on the actual reduction potential is well illustrated in a retrospective analysis for reducing empty running (McKinnon and Ge, 2006). The analysis shows that great aggregated potential on the macro level is unachievable on the micro level when considering vehicle compatibility, vehicle capacity and time constraints. Unless logistical requirements or structures are changed, the opportunity for reducing empty running is only minor. Put differently, the company perspective is interesting because the level of transportion emissions depends on the logistical decisions made by freight owners (shippers) regarding material flow (e.g. location of production plants and warehouses, and packaging design), and the decisions made by the LSPs (transportation providers) regarding transportation flow (e.g. choice of vehicles and route planning) (Figure 1). LSPs have a direct impact on the freight transportation system because they bear the operational responsibility for the freight transport emissions, while the freight owners have an indirect impact through their logistical decisions. In Sweden, 95 per cent of the manufacturing companies outsource transportation to LSPs, but 36 per cent also organise their own transportation (Lammgård, 2007). To explore transportation emissions, the potential actions of both actors need to be analysed.

A structured approach to map the causes of CO_2 emissions on the macro level is to decompose CO_2 emissions from freight transportation into six factors: economic activity, value density, transportation intensity, traffic intensity, energy intensity and emissions intensity (McKinnon, 2003; Woxenius, 2005) (Figure 2).

Changes in these factors lead to changes in CO_2 emissions from freight transportation. From the perspectives of logistics and freight transport, economic activity and value density are usually unaffected. From a macro perspective, CO_2 emissions can thus be reduced by decreasing one or more of the intensities of transport, traffic, energy and emissions. The actual reduction is carried out by the actors in Figure 1. Since a company's economic activity and the tonnage to be transported are unchanged, transportation intensity can be reduced through shorter transport distances. To reduce total traffic intensity in a given logistical structure, the total number of vehicle kilometres can be reduced through either shorter transport distances or improved vehicle load factors. Energy intensity can be reduced by changing mode of transport or increasing the fuel efficiency through ecodriving, for instance. Emissions intensity, which describes emissions produced per kWh of fuel consumed, is related to types of fuel and vehicle technology.

2.2 Green transportation practices

Freight transport is the largest source of environmental impact related to the logistics system (Wu and Dunn, 1995). Table I summarises logistical and technical actions for reducing the environmental impact from freight transportation. The actions are grouped under the four macro factors identified above. The table also shows whether the studies use a macro or a micro perspective, the method employed and the content of the study. For each macro factor there are a number of logistical and technical actions, which are reviewed in the following sub-sections.

2.2.1 Logistical and technical actions. To reduce the transportation intensity factor, companies should restructure their supply chains to shorten transport distances (Aronsson and Huge Brodin, 2006; Lemoine and Skjoett-Larsen, 2004; Piecyk and McKinnon, 2010). Restructuring can be achieved through relocation of manufacturing plants and warehouses and switching to closer suppliers (Doherty and Hoyle, 2009;

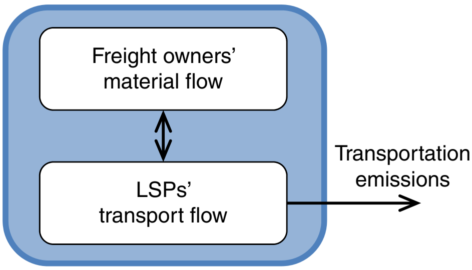

Figure 1. Actors involved in decisions affecting transportation emissions

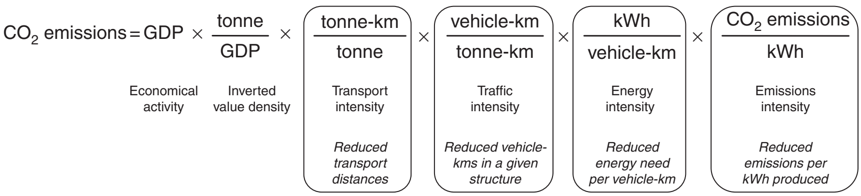

Figure 2. Factors affecting CO_2 emissions from freight transport

Author	Perspective	Method	Content	1. Transport intensity	2. Traffic intensity	3. Energy intensity	4. Emissions intensity
Aronsson and Huge Brodin (2006)	Micro	Case study	To link logistics decision making to environmental impact. Identify and explain situations where both the environment and the operational effectiveness are improved	Restructure supply chains	Consolidation	IT solutions	
Arvidsson *et al.* (2013)	Micro	Case study	To review improvement and efficiency measures suitable for urban distribution and comment on their effects		Packaging efficiency consolidation transport planning load factor Backhaul management	Ecodriving Modal shift	
Baumgartner *et al.* (2008)	Macro	Qualitative survey	To identify areas suspected of having the greatest potential for saving CO_2 when combining today's CRS with vehicle telematics systems and through specific technical developments to positively impact on the CO_2 efficiency and the utilisation of trucking companies			Telematics	
Colicchia *et al.* (2013)	Micro	Literature review Case study	To provide an analysis of environmental sustainability with a particular focus on the logistics industry. It aims to examine		Packaging management Reverse logistics Transport planning	Modal shift Ecodriving	Alternative fuels Clean vehicle technology
Doherty and Hoyle (2009)	Macro	Modelling, interviews	Based on official statistics and perceptions of representatives from industry and non-governmental	Low carbon sourcing Nearshoring Increased home delivery	Improve network planning Packaging design initiatives Increase load	Ecodriving Modal shift Traffic management techniques	Clean vehicle technology

Table I. Relationships between actions dealt with in the current literature and four macro factors

(*continued*)

Author	Perspective	Method	Content	1. Transport intensity	2. Traffic intensity	3. Energy intensity	4. Emissions intensity
			organisations, opportunities to reduce CO_2 emissions across a product lifecycle are estimated		fill Reverse logistics		
Heaps *et al.* (2009)	Macro	Scenario analysis	Present a detailed sector-by-sector mitigation scenario for all 27 EU countries that can achieve GHG emissions reductions of 40 per cent in 2020 and 90 per cent in 2050 relative to 1990 levels			More rail transport	Electrified vehicles Clean vehicle technologies
Helmreich *et al.* (2010)	Macro	4 workshops	Based on backcasting, an action plan with policy recommendation on how to reach CO_2 targets for 2020, 2035 and 2050 is developed		Larger trucks Load factor Consolidation Empty running	Ecodriving Intermodal transport	Electrified road vehicles Biofuels Clean vehicle technology
Islam *et al.* (2013)	Micro	Interviews	To assess the performance of an online benchmarking tool developed for logistics service users and providers to provide alternative service option in Europe			Intermodal transport	
Kamakaté and Schipper (2009)	Macro	Macro analyses of national data	Look at the trends in and decompose energy and carbon intensity of truck freight transportation in Australia, France, Japan, the UK and the USA. Discuss considerations for policy makers	Logistics structures	Transport planning		Clean vehicle technology

(*continued*)

Table I.

Author	Perspective	Method	Content	1. Transport intensity	2. Traffic intensity	3. Energy intensity	4. Emissions intensity
Kohn and Huge Brodin (2008)	Micro	Case study	To discuss and illustrate the circumstances for centralisation under which it is possible to achieve simultaneous improvements in cost, service and environmental performance of a distribution system	Centralisation			
Lemoine and Skjoett-Larsen (2004)	Micro/ macro	Survey, case study	To illustrate the implications of reconfiguration supply chains on transport by using empirical data from Denmark	Restructure supply chains	Load factor		
Leonardi and Baumgartner (2004)	Micro/ macro	Survey	Quantifying the CO_2 emissions of German truck transport companies under normal working conditions before and after implementation of IT scheduling systems		Load factor Vehicle usage Empty running	Telematics	Vehicle selection Lightweight vehicles
Ljungberg and Gebresenbet (2004)	Micro/ macro	Survey, interviews	Investigate the potential for coordinated goods distribution in cities		Consolidation		
McKinnon (2007)	Macro	Statistical	Examine 12 possible causes of the observed decoupling in the UK	Centralisation Relocate manufacturing		Intermodal transport	
McKinnon (2005)	Macro	Historical review	To assess the impact of the increase in maximum truck weight in the UK in 2001 on traffic levels, road haulage costs and emissions		Max. truck weight		

Table I. (*continued*)

Author	Perspective	Method	Content	1. Transport intensity	2. Traffic intensity	3. Energy intensity	4. Emissions intensity
McKinnon (1996)	Micro	Survey	Examine possible reasons for the trend that empty running decreased between 1982 and 1993 in the UK		Load matching Reverse flow management		
McKinnon and Ge (2006)	Micro/ macro	Survey	To examine the recent trend in empty running by trucks in the UK and assess the potential for a further reduction in empty running in the food supply chain		Empty running		
Piecyk and McKinnon (2010)	Micro	Focus group, Delphi study	Assess three scenarios of CO_2 emissions from road freight transport in the UK until 2020	Sourcing Logistics structures	Transport planning Product scheduling Packaging design	Telematics	Carbon intensity of fuel Cleaner vehicle technologies
Tacken *et al.* (2014)	Micro	Multiple case study	To assess the extent to which the measures outlined in frameworks for guiding CO_2 emissions reduction in road	Network design	Consolidation Backhaul management Transport planning	Modal shift Ecodriving	Cleaner vehicle technologies Alternative fuels
Wu and Dunn (1995)	Micro	Conceptual	Examine environmental logistics issues and discuss measures that can be undertaken to achieve a proactive environmental management focus	Vendor selection Vendor location Network design	Packaging design Backhaul management Reverse logistics	Mode selection	

Table I.

McKinnon, 2007; Piecyk and McKinnon, 2010; Tacken *et al.*, 2014; Wu and Dunn, 1995). Centralisation is one method of restructuring warehouses (Kohn and Huge Brodin, 2008). Dependent on context and the current logistics structure, centralisation can either increase or decrease transportation emissions. The centralisation of manufacturing and warehouses often increases transportation work (McKinnon, 1994), but due to consolidation and modal shift opportunities, as well as reduced emergency deliveries in centralised setups, it can still have a positive impact on CO_2 emissions (Kohn and Huge Brodin, 2008). In addition to relocating manufacturing plants and warehouses, Doherty and Hoyle (2009) suggest increased home delivery initiatives. However, in their analysis they believe this has a minimal effect on transportation emissions reduction.

To reduce the traffic intensity factor, the vehicle-kms in a given logistical structure should be reduced. The literature review distinguishes among three logistical actions: improved transport planning, improved packaging and load carrier design and increased vehicle loading capacity. First, companies can improve transport planning (Colicchia *et al.*, 2013; Doherty and Hoyle, 2009; Kamakate and Schipper, 2009; Piecyk and McKinnon, 2010; Tacken *et al.*, 2014) by consolidating goods (Aronsson and Huge Brodin, 2006; Arvidsson *et al.*, 2013; Helmreich *et al.*, 2010; Ljungberg and Gebresenbet, 2004; Tacken *et al.*, 2014), increasing load fill (Arvidsson *et al.*, 2013; Doherty and Hoyle, 2009; Helmreich *et al.*, 2010; Lemoine and Skjoett-Larsen, 2004; Leonardi and Baumgartner, 2004), reducing empty running (Arvidsson *et al.*, 2013; Helmreich *et al.*, 2010; Leonardi and Baumgartner, 2004; McKinnon and Ge, 2006; Wu and Dunn, 1995) and reverse flow management (Colicchia *et al.*, 2013; Doherty and Hoyle, 2009; McKinnon, 1996; Tacken *et al.*, 2014; Wu and Dunn, 1995). Second, companies can work with packaging and load carrier design to improve weight and volume efficiency (Arvidsson *et al.*, 2013; Colicchia *et al.*, 2013; Doherty and Hoyle, 2009; Piecyk and McKinnon, 2010; Wu and Dunn, 1995). Finally, the loading capacity in vehicles can be increased by using larger vehicles (Helmreich *et al.*, 2010; McKinnon, 2005).

To reduce the need for energy per vehicle-km (energy intensity), the literature suggests implementation of traffic management solutions (Doherty and Hoyle, 2009) based on information technology (IT) (Aronsson and Huge Brodin, 2006) and telematics (Baumgartner *et al.*, 2008; Leonardi and Baumgartner, 2004; Piecyk and McKinnon, 2010). It also suggests utilisation of ecodriving (Arvidsson *et al.*, 2013; Colicchia *et al.*, 2013; Doherty and Hoyle, 2009; Helmreich *et al.*, 2010; Tacken *et al.*, 2014), which is the practice of driving in a fuel-efficient manner. Finally, it is suggested that energy intensity can be reduced through modal shift (Arvidsson *et al.*, 2013; Colicchia *et al.*, 2013; Doherty and Hoyle, 2009; Tacken *et al.*, 2014; Wu and Dunn, 1995), which means to utilise modes of transport with less energy need per vehicle-km, such as changing from road and air freight to rail and sea. In particular, the literature suggests intermodal transportation (Heaps *et al.*, 2009; Helmreich *et al.*, 2010; Islam *et al.*, 2013; McKinnon, 2007), often related to combining rail and road transportation.

Emissions intensity can be reduced through technical actions. The literature review shows two basic actions: cleaner vehicle technology and non-fossil fuel. Cleaner vehicle technology (Colicchia *et al.*, 2013; Doherty and Hoyle, 2009; Heaps *et al.*, 2009; Helmreich *et al.*, 2010; Piecyk and McKinnon, 2010; Tacken *et al.*, 2014) refers to technologies that are efficient in terms of emissions per produced kWh. This includes more electric vehicles, lightweight vehicles and tyres with less friction (Heaps *et al.*, 2009; Helmreich *et al.*, 2010; Leonardi and Baumgartner, 2004). Increased use of non-fossil fuels refers to carbon intensity of fuels in general (Piecyk and McKinnon, 2010) and specific alternative fuels, such as biofuel (Colicchia *et al.*, 2013; Helmreich *et al.*, 2010; Tacken *et al.*, 2014).

2.2.2 Summary of logistical and technical actions and their relation to macro factors. Some literature evaluates the potential of different actions. Doherty and Hoyle (2009) stress that the greatest potentials, which are also judged to be highly feasible, are related to clean vehicle technologies, vehicle utilisation (from improved transport planning and reduced delivery time requirements), logistics structures (expressed as optimised networks) and packaging design. Based on the analyses of national data in five OECD countries, Kamakaté and Schipper (2009) claim that "future emissions savings can arise both from better truck and engine technologies as well as better handling of truck freight, and improvements in traffic conditions" (p. 3750) and that "the most obvious gains will come from logistics, the improved handling of goods and utilisation of lorries as average loading is still well below average lorry capacity" (p. 3750). They particularly point out opportunities to better match lorry size and capacity to cargo load and type, optimisation of logistics structures and improvements in vehicle technology. A modal shift from lorry to rail is, however, judged to provide little opportunity for gains.

The green transportation practices proposed for reducing emissions in the current literature were linked to the four macro-level factors in Table I. The literature expresses similar actions in slightly different ways and on different levels of detail. Thus, this literature review describes and aggregates the practices into 12 functions (Table II).

2.3 Barriers

Though environmental practices can lead to a competitive advantage and reduced costs (Porter and van der Linde, 1995; Rao and Holt, 2005), the level of implementation of actions for reducing freight transport emissions is limited (Leonardi and Baumgartner, 2004; Perotti *et al.*, 2012). This limited level of implementation is influenced by a number of barriers or constraints. Our literature review of barriers for reducing transportation emissions revealed four general types of barriers: logistical, organisational, external prerequisites and technical barriers. Most of the literature only considers individual or some barriers from each type. In green supply chain management literature, the barriers for green transportation include costs, lack of internal legitimacy, regulations and industry-specific barriers, for example, in oligopolistic industries or in industries where environmental considerations are a low priority (Walker *et al.*, 2008). In literature regarding sustainable supply chains, barriers for greening transportation are related to increased costs, the working environment and motivational aspects (Abbasi and Nilsson, 2012). Increased costs are highlighted as it is stated that companies often have to pay to become green. A certain type of cost barrier is highlighted by Arvidsson *et al.* (2013) who conclude that efficiency gains are not always shared between supply chain actors in a fair way. They state that most cost reductions by the road hauliers "have been fully passed onto the forwarder and much of that further to the shipper" (p. 124). The working environment is exemplified by the fact that there is a reliance on motorised road transportation in some contexts, and a lack of environmentally sensitive behaviour in others. The motivational barriers are exemplified by the importance of considering the motivational factors of employees towards greening transportation. Transportation plays

1. Transportation intensity	2. Traffic intensity	3. Energy intensity	4. Emissions intensity
Using closer suppliers	Improved transport planning	Changing mode of transport from air to other	Non-fossil fuels
Relocating production plants and warehouses	Packaging design		Cleaner vehicle technologies
	Load carrier design	Changing mode of transport from road to other	
	Increased loading capacity in vehicles	Implementing traffic control technologies	
		Ecodriving	

Table II. Actions to be used from the survey an important role in fulfilling logistics performance measures in deliveries. Thus, barriers for reducing transportation emissions related to logistics performance measures need to be considered. Such measures can be defined in terms of delivery time, flexibility, costs and quality of logistics management (Neely *et al.*, 1995). The emission levels can also be influenced in the process of purchasing transportation where transportation requirements are defined. In the transportation purchasing process, organisational and technical barriers are considered in terms of the non-environmental demands of customers and a potential lack of knowledge, ambition and equipment of the LSPs (Björklund, 2011). External prerequisites are addressed by Murphy *et al.* (1995) as they discuss the nature and the uncertainty of long-term development of government regulations, which may hinder companies from daring to green their transportation. Colicchia *et al.* (2013) discuss that there is heterogeneities among countries and within different sectors in the same country, which makes the adoption of environmental initiatives more difficult. Technical barriers are highlighted by Rogers *et al.* (2007) as they review alternative non-fossil fuels. In their analysis, they conclude that it will be challenging to implement infrastructures and technologies for alternative fuels. Commercial solutions for alternative fuels will take time to implement. Another dimension of technical barriers is infrastructure, the importance of which, for environmentally efficient transportation, is discussed by Wu and Dunn (1995). A lack of infrastructure can be seen as a barrier for green transportation (e.g. lack of harbours, rail infrastructure or bad roads). The authors also discuss the importance of IT for increasing the operational efficiency and reducing the environmental impact of transportation (e.g. through freight matching). Thus, lack of IT can restrain greening of transportation. All barriers are summarised in Table III.

2.4 Discriminating factors

In addition to the barriers, previous research indicates that other factors, such as company size and industry type, may also influence the implementation of green transportation initiatives. We identified three such factors that may discriminate between companies regarding their intention to reduce transportation emissions. One is whether companies

Type of barrier	Barrier	Source
Logistical	Costs	Abbasi and Nilsson (2012), Arvidsson *et al.* (2013), Neely *et al.* (1995), Walker *et al.* (2008)
	Delivery time	Arvidsson *et al.* (2013), Neely *et al.* (1995)
	Delivery flexibility	Arvidsson *et al.* (2013), Neely *et al.* (1995)
	Delivery quality	Neely *et al.* (1995)
Organisational	Lack of competence	Björklund (2011)
	Lack of IT	Arvidsson *et al.* (2013), Wu and Dunn (1995)
	Lack of motivation	Abbasi and Nilsson (2012), Björklund (2011), Walker *et al.* (2008)
External prerequisites	Contradictory laws and regulations	Arvidsson *et al.* (2013), Colicchia *et al.* (2013), Murphy *et al.* (1995), Walker *et al.* (2008)
	Working environment	Abbasi and Nilsson (2012)
Technical	Lack of infrastructure	Wu and Dunn (1995)
	Lack of technical know-how	Björklund (2011)
	Lack of commercial solutions	Björklund (2011), Rogers *et al.* (2007)

Table III.
Barriers for greening transportation

realise a potential to reduce emissions from an action. The aggregated data shows that there is a potential to reduce transportation emissions (Leonardi and Baumgartner, 2004). As described above, our aim is to examine whether companies realise such potential for different actions. If they do, does it affect their intention to reduce transportation emissions? This emerging view, that the intention to reduce transportation emissions may be related to the perceived potential, is a logical assumption. It is in line with a literature review that showed a critical element for implementation of supply chain initiatives is the perceived value of the initiative (Power, 2005).

Another possible discriminating factor is industry type. From an overall corporate perspective, Oberhofer and Fürst (2013) state that industry type has great influence on companies' actual environmental performance. Banerjee *et al.* (2003) found that industry type affects the way companies view the importance of environmental issues and how they integrate those issues into their strategic plans. The volume of transportation and mode of transport used, and thus transportation emissions, varies among industries. For instance, the food industry is likely to differ from ore and metal in terms of transportation characteristics. A special difference is the one between LSPs and freight owners. For LSPs, freight transportation is the core activity, while it is not for freight owners. Thus, LSPs may have a greater focus on reducing fuel consumption and empty running, and obtaining efficient routing. Such actions would also reduce transportation emissions. This indicates that industry type may affect the intention to reduce transportation emissions.

A third discriminating factor may be company size. Existing studies have shown that company size often influences the intention of adopting sustainability practices (Pagell *et al.*, 2004; Sharma and Henriques, 2005). Larger companies often face greater public scrutiny (Pfeffer and Salancik, 1978), have greater resources (Russo and Fouts, 1997) and receive more governmental stakeholder pressure than small- and medium-sized enterprises (SMEs) (Gonzaléz-Benito and González-Benito, 2010). However, Sharma and Henriques (2005) found a difference between the earlier phases of sustainability performance and later ones. In the earlier phases (e.g. pollution control and savings through material and energy conservation), company size matters but in more advanced phases (e.g. eco-design and business redefinition) it does not. In other words, company size is often seen as a discriminating factor for greening, but not necessarily in more advanced phases of greening. For the intention to reduce transportation emissions, company size can be a discriminating factor.

3. Methodology

To examine the intention of companies to reduce transportation emissions by 2020, we used an exploratory survey of freight transportation-intensive industries in Sweden. The survey focused on the disposition of these industries to reduce CO_2 emissions from freight transportation. The choice of research design was motivated by a lack of research on what is to be done from a company perspective to reduce transportation emissions in the near future, even though it is a contemporary and highly relevant topic. The choice was further motivated by a need for a broad overview of companies in different industries as emissions are generated from a variety of industries. The research design was considered to offer valuable insights into barriers and discriminating factors.

3.1 Survey instrument

Based on the theoretical foundations described in Section 2, the survey included two essential areas: first, logistical and technical actions and their barriers for CO_2

reduction from freight transportation; and second, the company features of industry type, company size and data regarding firm location, turnover, profit and type of products manufactured.

The development process of the survey instrument incorporated three steps. First, the content areas were defined as described above. The list of actions to reduce CO_2 emissions (Table II) and their barriers (Table III) are described in Section 2. For each action, its perceived potential for the firm, the intention of its being implemented at the responding firm, and its barriers were rated on a five-point Likert scale ranging from very low to very high. Second, a draft survey was developed and tested in a pre-study as suggested by Flynn *et al.* (1990). The testing phase facilitated the generation of easy-to-understand wording and format, which, according to Trost (2007), usually results in high reliability of survey studies. To gain feedback about the structure and clarity of the survey, it was pre-tested on eight logistics academics. Modifications were made based on their feedback: a few questions were rephrased for clarity or deleted, followed by discussion with the respondents. The revised survey was then tested on five industry representatives, again resulting in minor modifications in structure and some rephrasing of questions.

3.2 Sampling strategy

To achieve internal and external validity, homogeneous groups were selected (Judd *et al.*, 1991; Kerlinger, 1986) and a probability sample from a well-defined population was used (Sudman and Blair, 1998). The survey was directed at firms in freight transportation-intensive industries in Sweden (Table III). Sweden was selected because the authors have in-depth knowledge of trade and industry in this country and because Sweden is in the forefront of environmental logistics (among the ten strongest environmental performers globally, Yale, 2012) and logistics performance (number 3 on the global LPI ranking, World Bank, 2012). In addition, several large industries in Sweden, such as ore, forestry, retail and manufacturing, are freight transport intensive. The span of logistical demands in these industries covers a variety of requirements in terms of costs, flexibility, delivery time and quality.

The population was defined as all companies in nine industries in Sweden (Table III) accounting for the majority of the country's freight transport emissions (Trafikanalys, 2010). Companies with fewer than 50 employees were not considered. The remaining sample included 1,095 companies. Companies of different size were also represented. The general idea was that the larger the firm, the more transportation it potentially generates. Large companies were defined as those with 500 or more employees, and SMEs were defined below this limit (OECD, 1997). A stratified sample was used to avoid an imbalance among the groups of companies with regard to size. First, all large companies (142) were included in the sample. Then, three equally large groups of SMEs with 50-99 (97), 100-199 (94) and 200-499 (94) employees were systematically selected. The SME division was made to capture potential variance among this large group of companies. The resulting sample size was 427 companies.

The pre-test indicated that corporate heads of logistics could be relevant respondents, but to identify key informants at each firm, we were guided by the recommendations provided by Bagozzi *et al.* (1991). The process of choosing the most suitable respondent started with a switchboard contact. To reach the respondents knowledgeable about the current and future logistics decision-making procedures, logistics structure and transportation solutions of the companies, we called all 427 companies, explained the purpose of the survey and particularly the criteria for the respondents. This either resulted in a name and address of the respondent or in further contact with different people in the logistics departments to eventually identify the appropriate person. They corresponded mostly with the corporate head of logistics (hereafter referred to as "logistics managers"), but in a few cases the company deemed another respondent, such as the transportation manager, to be more suitable.

3.3 Data collection and analysis

Data collection took place in November-December 2010. The logistics managers of the sample were e-mailed an explanatory covering letter accompanied by a link to a web-based survey. The covering letter explained the research, asked for their help to complete the survey, promised a prompt copy of the results of the study to encourage participation (Frohlich, 2002), and emphasised confidentiality. Reminders were sent to non-respondents weekly for three weeks after the first e-mail. Follow-up telephone calls were made three weeks after the initial e-mail to obtain additional responses. The 172 responses represent a response rate of 40.3 per cent, evenly distributed across industries.

In total, 11 responses were removed due to incomplete data. Table IV provides the frequency distributions of number of the employees and industries. Several non-respondents were contacted by phone in the follow-up calls. The reason most often cited for non-response was lack of time, followed by company policy. To check for non-response bias, respondents and non-respondents were compared on characteristics known as *a priori* (Wagner and Kemmerling, 2010). No significant differences were found between respondents and non-respondents in terms of geographical location (the first digit in the postcode was used as a geographic divider), or in terms of company size, which again points to the lack of non-response bias. Another test for non-response bias was to compare early responses from the first group of surveys sent by e-mail to late responses obtained after follow-up calls. No statistically significant differences or trends were found, indicating the absence of non-response bias.

The data were analysed in several consecutive steps. For orientation and basic insights into the data, the entire sample was first analysed using descriptive statistics. To identify dominating barriers, *t*-tests were applied. These tests determined which barriers had a statistically significant average impact greater than three (moderate) on the Likert scale meaning that they are perceived as strong to very strong. To complement the average values for intentions and barriers, companies with an intended level of implementation from moderate to very high were analysed. This analysis highlighted the main barriers for those companies that are most likely to implement an

	No. of employees				
Industry	50-99	100-199	200-499	> 499	Total
Agriculture/forestry	1	7	2	1	11
Chemical	6	4	4	5	19
Food and drinks	10	7	5	8	30
Manufacturing		5	6	8	19
Manufacturing other			4	5	9
Ore/metal	2	6	10	12	30
Pulp, paper and paper articles		3	5	7	15
Wholesale trade	7	1	1	13	22
Logistics service providers	1	8	6	2	17
Total	27	41	43	61	172

Table IV. Frequency distributions of industry and number of employees action. In the analysis, *t*-tests were used for each action to investigate if the barriers differed between companies which are most likely to implement an action (intention is moderate to very strong), compared to those who have responded that their intention is low or very low. Finally, the impact of the three discriminating factors was analysed to detect first, whether the perceived potential of an action was correlated to the intention of implementing it, second, differences between industries and third, whether company size has an impact on the intention of implementing the different actions. Pearson's product-moment coefficient and *t*-tests were used to test whether the discriminating factors could statistically explain any differences found in the data material.

4. Results

The results of the survey first present the average values of the perceived potentials, the intended reductions and the barriers for implementation. Then, the impact of the three discriminating factors on the intended implementation of actions are presented.

4.1 Descriptive statistics for potential effect, intention and barriers

The survey results are summarised in Table V. The average values for the perceived potential and the intended implementation range from slightly more than weak to slightly less than strong for the different actions. However, the frequency distributions of the data are well spread from very weak to very strong for all actions (Figure 3). The actions with the greatest potential effect are improved transport planning, changing mode of transport from road to rail or sea and using non-fossil fuels. The transport planning action is also the one that is most likely to be implemented. This action stands out when it comes to intended implementation. The next most likely actions – ecodriving, cleaner vehicle technologies and using non-fossil fuels – are perceived as considerably less likely. It is noticeable that these three are behavioural or technological changes. Thus, only one of the four actions that are most likely to be implemented are related to logistics.

To complement the average values in Table V, Table VI shows the share of companies that are most likely to implement the different actions. We see that almost 50 per cent of the companies have an intention from moderate to very high to implement the top seven actions. Even for the five less likely actions, about a third of the companies have an intention ranging from moderate to very high.

The unique combination of barriers for each action is presented in Table V. It is evident that the majority of the barriers are not particularly strong. For most of the actions, only one or a few are perceived as moderate or strong. The strongest barriers to each action for the companies with a moderate intention for implementation are presented in Table VI. Costs are a main barrier for seven of the actions, but only for one action is it perceived as strong; otherwise it is considered as a moderate barrier. For technical actions (cleaner vehicle technology, non-fossil fuels and traffic control technologies), lack of technical solutions and technical know-how and lack of IT are perceived as main barriers. The main barriers for changing mode of transport and transport planning are flexibility and delivery time.

4.2 Discriminating factors for a company's intention to reduce CO_2 emissions

The survey tested a number of discriminating factors: the impacts of perceived potential, industry and company size on a company's intention to reduce CO_2 emissions.

4.2.1 Perceived potential vs a company's intention to reduce CO_2 emissions. The survey results were tested to see if the perceived potential to reduce CO_2 emissions

Table V. The potential effect, intention and main barriers to the implementation of actions investigated

	Potential effect	Intention to implement	Barriers[a] Costs	Delivery time	Flexibility	Quality	Lack of competence	Lack of IT	Contradictory laws and regulations	Lack of infrastructure	Working environment	Lack of motivation	Lack of technical know-how	Lack of commercial solutions
Using closer suppliers	2.90	2.36	*3.27*	2.48	2.80	*2.64*	*2.74*	2.21	1.96	n/a	n/a	n/a	n/a	n/a
Relocate production plants and warehouses	2.82	2.19	**3.77**	*2.52*	*2.65*	2.25	2.36	2.03	2.01	n/a	n/a	n/a	n/a	n/a
Transport planning	3.26	3.28	2.40	*2.93*	*3.08*	1.85	2.05	2.39	1.76	n/a	n/a	n/a	n/a	n/a
Packaging design	2.51	2.27	*2.88*	1.95	2.02	2.21	2.01	1.70	1.66	n/a	n/a	n/a	n/a	n/a
Load carrier design	2.61	2.25	*3.01*	2.15	2.35	1.93	2.11	1.81	1.79	n/a	n/a	n/a	n/a	n/a
Increased loading capacity in vehicles	3.09	2.51	2.19	2.14	2.34	1.69	1.79	1.66	2.42	*2.51*	n/a	n/a	n/a	n/a
Changing mode of transport from air to other[b]	3.01	2.46	1.70	**3.85**	**3.65**	1.86	1.76	1.70	1.67	2.49	n/a	n/a	n/a	n/a
Changing mode of transport from road to other	3.53	2.48	*3.01*	**3.92**	**3.99**	2.29	2.16	2.05	1.90	3.75	n/a	n/a	n/a	n/a
Traffic control technologies	2.60	2.39	2.47	1.94	2.01	1.59	2.14	*2.50*	1.80	n/a	2.30	n/a	n/a	n/a
Ecodriving	3.08	2.81	2.11	1.76	n/a	n/a	2.21	n/a	n/a	n/a	n/a	2.38	n/a	n/a
Non-fossil fuels	3.44	2.60	*3.13*	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	*2.93*	**3.53**
Cleaner vehicle technologies	2.92	2.72	*3.00*	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	*2.76*	*2.83*

Notes: [a]Barriers in the range 2.5-3.5 are classified as moderate (in italic), while barriers in the range 3.5-4.5 are classified as strong (in bold); [b]only companies that use air freight are listed

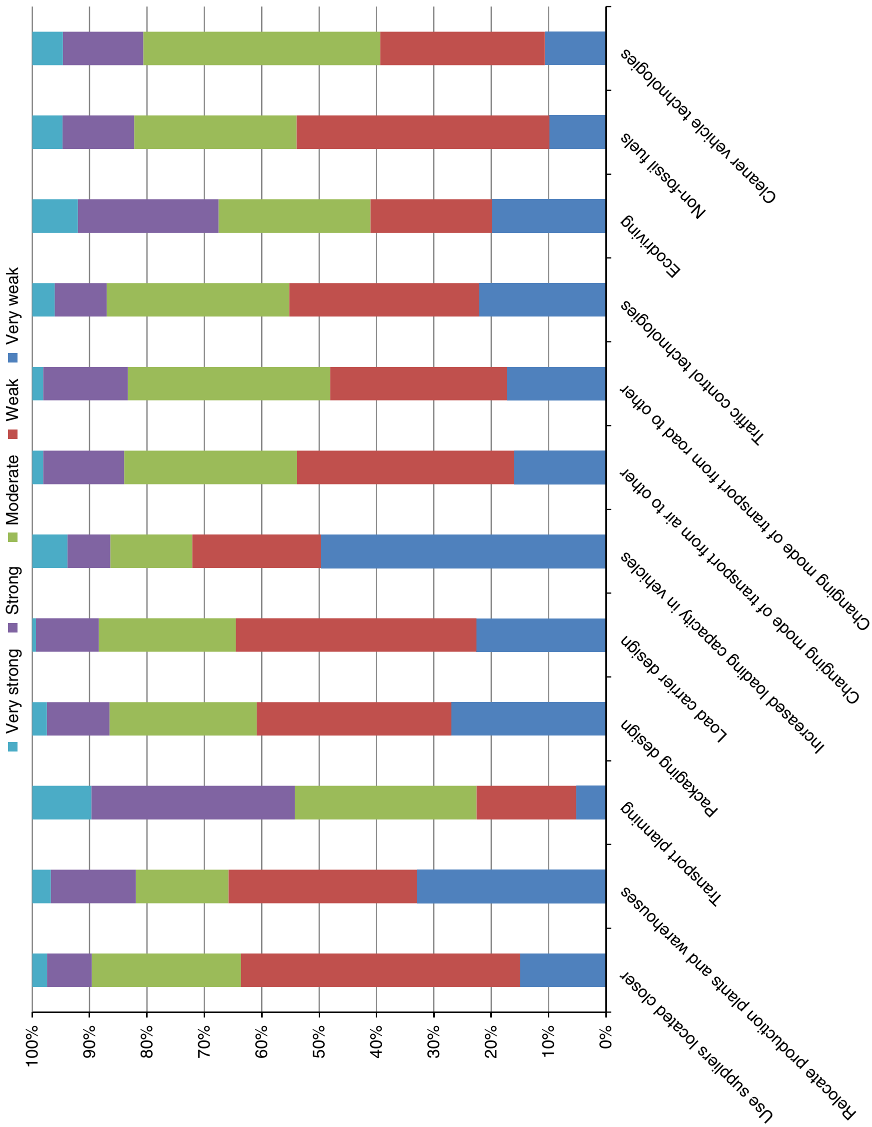

Figure 3.
Percentage of the frequency distribution of the 12 actions examined

Action	Moderate – very high intention (% of companies)	Main barriers and their scope[a]
Transport planning	77	Moderate: flexibility, delivery time
Cleaner vehicle technologies	61	Moderate: costs, lack of commercial solutions, lack of technical know-how
Ecodriving	59	Only weak barriers
Increased loading capacity in vehicles	52	Moderate: infrastructure
Non-fossil fuels	46	Strong: lack of commercial solutions Moderate: costs, lack of technical know-how
Changing mode of transport from road to other	46	Strong: flexibility, delivery time, infrastructure Moderate: costs
Traffic control technologies	45	Moderate: lack of IT
Using closer suppliers	36	Moderate: costs, flexibility, lack of competence, quality
Packaging design	39	Moderate: costs
Load carrier design	36	Moderate: costs
Relocating production plants and warehouses	34	Strong: costs Moderate: flexibility, delivery time
Changing mode of transport from air to other	28	Strong: flexibility, delivery time

Notes: [a]The barrier are listed in descending order. Only barriers classified as strong and moderate are included

Table VI. Share of companies with moderate to very high intention to implement the different actions

from freight transportation had an impact on the perceived intention to reduce these emissions, based on the supposition that the implementation of an action is likely to reduce CO_2 emissions. Pearson's correlation coefficient test showed that they are highly correlated (Table VII). Thus, the more potential a company perceives in an action, the higher it ranks its intention of implementing that specific action.

4.2.2 Industry vs a company's intention to reduce CO_2 emissions. Several *t*-tests were conducted to explore the differences between different industries on the intention to reduce CO_2 emissions by actions. Few statistically significant differences among the industries were detected (Table VIII). An exception was the LSPs, which stand out compared to freight owners regarding six actions. They state they are significantly more likely to improve transport planning, increase loading capacity in vehicles, change mode of transport both from road to rail and sea, and from air to other modes of transport. They also report a significantly higher intention for the technical actions: switch to non-fossil fuels and use cleaner vehicle technologies.

Other significant differences were that the manufacturing other and agriculture/forestry industries expressed a greater intention to change load carrier design to reduce CO_2 emissions. Companies in the chemical industry rate the intention for implementing traffic control technologies and ecodriving higher than other companies and companies in the food and drinks industry as well as in the wholesale trade industry rate the use of closer suppliers higher than companies in other industries. The ore/metal industry regards increased loading capacity in vehicles and traffic control technologies as more likely to be implemented than other industries. Finally, companies in the pulp, paper and paper articles industry state that they are more likely to change mode of transport from road to rail or sea.

Table VII. Correlations between perceived potential and the intention of implementing actions

	Using closer suppliers	Relocating production plants and warehouses	Transport planning	Packaging design	Load carrier design	Increased loading capacity in vehicles	Changing mode of transport from air to other	Changing mode of transport from road to other	Traffic control technologies	Ecodriving	Non-fossil fuels	Cleaner vehicle technologies
Pearson corr.	0.210*	0.376**	0.589**	0.713**	0.664**	0.603**	0.803**	0.464**	0.660**	0.449**	0.484**	0.537**
Sig. (2-tailed)	0.011	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Note: *,**Correlation is significant at the 0.05 and 0.01 levels (two-tailed), respectively

Table VIII.
t-Tests of the intention to implement actions in one industry vs the other industries

	p-value								
Action	Manufacturing	Manufacturing other	Agriculture/ forestry	Chemical	Food and drinks	Ore/ metal	Pulp, paper and paper articles	Wholesale trade	LSPs
Using closer suppliers	0.930	0.596	0.206	0.156	*0.033**	0.103	0.427	*0.047**	0.942
Relocating production plants and warehouses	0.880	0.307	0.420	0.698	0.231	0.238	0.292	0.532	0.890
Transport planning	0.507	0.320	0.332	0.382	0.570	0.047	0.910	0.359	*0.019**
Packaging design	0.497	0.804	0.317	0.723	0.736	0.091	0.832	0.401	0.903
Load carrier design	0.737	*0.003***	*0.005***	0.540	0.425	0.903	0.301	0.109	0.600
Increased loading capacity in vehicles	0.264	0.775	0.144	0.791	0.303	*0.035**	0.879	0.345	*0.000***
Changing mode of transport from air to other	0.652	0.976	0.038	0.102	0.107	0.325	*0.006***	0.739	*0.011**
Changing mode of transport from road to other	0.617	0.601	0.342	0.179	0.395	0.914	*0.001***	0.062	*0.000***
Traffic control technologies	0.240	0.112	0.815	*0.032**	0.886	*0.007***	0.346	0.081	0.058
Ecodriving	0.318	0.429	0.045	*0.038**	0.614	0.868	0.185	0.859	0.325
Non-fossil fuels	0.417	0.406	0.063	0.241	0.249	0.479	0.844	0.162	*0.006***
Cleaner vehicle technologies	0.550	0.545	0.227	0.086	0.346	0.426	0.286	0.843	*0.016**

Note: *,**Correlation is significant at the 0.05 and 0.01 levels (two-tailed), respectively

4.2.3 Company size vs a company's intention to reduce CO_2 emissions. Company size is a potential discriminating factor for greening transportation. To explore the impact of company size on the intention to reduce CO_2 emissions, *t*-tests comparing SMEs (< 500 employees, see OECD definition) with large companies ($\geqslant 500$ employees) were conducted for each action (Table IX). The table shows that large companies are significantly more likely to implement six of the actions than SMEs are. These actions include those related to logistics: relocating production plants and warehouses, improving transport planning, changing the mode of transport from road to other and implementing traffic control technologies. It also includes behavioural and technical actions: ecodriving and using non-fossil fuels.

5. Discussion

The discussion addresses the intention to implement logistical and technical actions for reducing transportation emissions by 2020, barriers that impede implementation and factors that discriminate between companies.

5.1 Intentions to reduce transportation emissions

Two of the actions are related to logistics structures: increased use of local suppliers, and relocating production plants and warehouses. Both actions have low intention of being implemented, indicating that they are unlikely to have a high impact on CO_2 emissions by 2020. A similar opinion was expressed by a focus group in the UK: the group did not expect any significant changes in supply chain structures by 2020 (Piecyk and McKinnon, 2010). The positive effects of shortening transport distances seem to be mainly overshadowed by a cost barrier, which can be explained by the fact that cost reduction has been a major reason for sourcing in low-wage countries.

Improved transport planning is the most likely action to be implemented. This is also in line with results from the focus group study in the UK suggesting considerable improvements in vehicle utilisation through increased loading factors and reduced empty running by 2020 (Piecyk and McKinnon, 2010). A possible reason for the perceived potential of transport planning can be related to IT application potential, as better use and integration of IT systems will help companies better match spare

Table IX. *t*-Tests for the impact of company size on the intent to implement actions

Action	Sig. (2-tailed)
Using closer suppliers	0.090
Relocating production plants and warehouses	0.002**
Transport planning	0.02*
Packaging design	0.570
Load carrier design	0.101
Increased loading capacity in vehicles	0.982
Changing mode of transport from air to other	0.323
Changing mode of transport from road to other	0.05*
Traffic control technologies	0.007**
Ecodriving	0.001**
Non-fossil fuels	0.021*
Cleaner vehicle technologies	0.319

Note: *,**Significant at the 0.05 and 0.01 levels (two-tailed), respectively capacity in vehicles with freight located in the vicinity, reduce empty running and locate vehicles close to a loading point. Thus, unused capacity due to empty running on roads, which is apparent in most countries, is addressed.

The intention to increase loading capacity is rather low compared to the perceived potential, which is surprising as the barriers are low. Experiences from the UK would also support a greater intention. It shows that increasing maximum lorry weight led to significant economic and environmental benefits (McKinnon, 2005). Both this action and improved packaging and load carrier design could address the challenge that many vehicles are not used to their full capacity. However, the results indicate that the companies do not intend to take this opportunity due to increased costs. Colicchia *et al.* (2013) came to similar results for the current adoption rate. They found that packaging initiatives seem to be quite neglected in industry. Compared to analytical studies (e.g. Doherty and Hoyle, 2009; Kalkowski, 2007; Murphy *et al.*, 1994), the intentions to implement packaging and load carrier design in our study are quite low. Potential reasons could be a lack of actual potential or, more likely, lack of knowledge among the companies. Thus, to reach the full potential of reducing empty running and improving fill rates, packaging and load carrier design initiatives probably need greater acceptance among companies in general.

The intentions to change mode of transport from road and air freight to more emissions-efficient modes of transport are ranked quite low. Both actions are mainly hindered by delivery time and flexibility constraints (and an infrastructure constraint for rail), which seem logical as such features are important reasons for choosing road and air freight. However, almost half of the companies have a medium to very high intention to transfer goods from road to rail, and such a process has already started in Sweden. Between 1996 and 2009 it increased by 22 per cent in tonne-kilometres (Vierth, 2011). One explanation for the rather low overall ranking may be related to limitations in rail infrastructure, which hinders major transfer from road to rail.

The rather low ranking of the intention to implement traffic control technologies is in line with one previous study (O'Reilly, 2008), but differs slightly from the results of two other studies (Baumgartner *et al.*, 2008; Piecyk and McKinnon, 2010). In a survey in the USA, a similar result was obtained as 42 per cent of the respondents planned to use vehicle re-routing to reduce mileage (O'Reilly, 2008). A Delphi study in the UK, however, estimated that such actions were to be widely applied by 2020 (Piecyk and McKinnon, 2010) and expert surveys in Germany concluded that different technologies ranged from low to high impact on CO_2 emissions (Baumgartner *et al.*, 2008). Load factor information, route optimisation and on-board monitoring are judged to be highly CO_2 relevant, while eight other dimensions are ranked as having medium or low CO_2 relevance. A possible explanation for these differences could be that companies actually using these technologies might prefer alternative ways to improve load factors; for instance, by improving transport planning, which is highly ranked in our survey, instead of using traffic control technologies for this purpose. A combination with traffic control technologies might be the optimum, so that both planning and changes in execution are considered for load factors/fill rate.

The intentions to implement technical and behavioural actions are ranked high. On average, the companies in the study perceive significant effects on reducing transportation emissions by implementing non-fossil fuel, but due to a disbelief in commercial solutions available by 2020 they are slightly sceptical of its implementation. The current situation seem to be similar. Tacken *et al.* (2014), for instance, found that alternative fuels have had little success in the operations of LSPs in

Germany. Six of ten companies have moderate to very high intentions of implementing cleaner vehicle technologies and ecodriving. Cleaner vehicle technologies are hindered by costs and a lack of commercial solutions and technical know-how. The freight owners are dependent on technical companies for both this action and using non-fossil fuel, meaning that such actions are quite easy to implement for freight owners. However, it may mean that they put too much faith in technical solutions. The barriers for ecodriving are low and could be overcome by training and motivating drivers.

5.2 Barriers and discriminating factors for reducing transportation emissions

The study examined the effect of a number of barriers and three differentiating factors (perceived potential, industry, company size) on the intention to reduce transportation emissions. Barriers related to each action were presented in Section 4, Tables V and VI, and then discussed in the previous section. Here, a more general discussion of barriers is provided followed by the differentiating factors. In general, the barriers are logical in relation to each action, but also quite weak. The empirical evidence clearly shows that only three actions have strong barriers. Increased delivery time and reduced flexibility are strong barriers for changing mode of transport from both road and air, which is logical as the advantages of road and air transport are typically shorter delivery times and higher flexibility. Lack of infrastructure is also a strong barrier for changing mode of transport from road, which can be explained by the current capacity limitation in Swedish Rail.

Overall, the companies seem to be hindered by logistical and technical barriers, but organisational barriers and external prerequisites are rarely viewed as problematic. Particularly, it is worth noting that contradictory laws and regulations, as well as lack of IT, are not seen as problematic for reducing transportation emissions. Of the logistical barriers, cost is one of the main barriers for seven of the actions, but for only one action (relocating production plants and warehouses) is it perceived as strong. Otherwise, it is perceived as a moderate barrier, which is noticeable as costs often have been argued to be a major hurdle for greening (see e.g. Abbasi and Nilsson, 2012). Delivery time and flexibility are also clear barriers for some actions, while delivery quality is not perceived as an important barrier for any action. The technical barriers are perceived as moderate or slightly above, which indicates that they are perceived as surmountable.

The barriers do not seem to be related to the intentions to reduce transportation emissions, i.e. it is not possible to predict companies' intention to reduce transportation emissions by knowing how they perceive the strength of the barriers. However, the perceived potential of an action is highly correlated to the intention of it being implemented. Thus, the more potential a company perceives, the more likely it seem to be that the action will be implemented. This means that it is the perceived potential rather than overcoming barriers that differentiates companies' intentions to reduce transportation emissions. Our study does not show whether this is a causative relationship, but previous studies (e.g. Murphy *et al.*, 1995; Rao and Holt, 2005) have shown that when companies see a potential to reduce CO_2, they may also see opportunities for economic gains and for strengthening their green image.

Our results show that the industrial sector of a company affects transportation emissions reduction between LSPs and freight owners, but hardly between different freight owner industries. The few differences found between different freight owner industries in Table VIII seem logical. For instance, the food and drinks industry stands out, which is an industry where local sourcing to reduce transportation has been on the agenda. This action is also perceived as more likely for the wholesale trade industry. Both of these industries interact with consumers, a reason for which this action is concrete and quite easy to communicate. Thus, companies in these industries might gain goodwill among consumers for such actions. It may also be easier for these industries to find alternative suppliers than for companies in industries such as ore/metal, chemical, pulp, paper and paper products. Another logical example is that the ore/metal industry perceives it is more likely to increase the loading capacity in vehicles as their goods are heavy.

These results related to industry can be linked to Banerjee *et al.* (2003), who found that the industrial sector helps explain differences in environmental behaviour for companies. The fact that our results are in line with Banerjee *et al.* (2003) when it comes to LSP vs freight owner is coherent with the fact that transportation is the core of LSPs, but not for freight owners. Regarding LSPs vs freight owners, the difference could be explained by the fact that "many of the major global 3PL service providers have made important commitments to environmental sustainability improvements during the past several years" (Lieb and Lieb, 2010, p. 532). Regarding different freight owner industries, the role of transportation in business models does not seem to be industry specific. Pålsson and Kovács (2014) highlight the need of integrating sustainable transport issues into the company strategy. In a similar manner, future research could examine whether the intention could be explained by company strategy. For instance, the intention could vary between companies focusing on minimising costs and those focusing on a large product assortment. Even though the general pollution potential of industrial sectors varies, thus being "subject to different controls and scrutiny from institutions, social groups and consumers" (Gonzaléz-Benito and González-Benito, 2010), the intention to reduce transportation emissions does not seem to be reflected in these differences. Thus, the industrial sector of freight owners does not provide an explanation of intention to reduce transportation emissions. However, whether a company is a freight owner or an LSP represents an important variable to explain divergences.

Our study also shows that company size is a discriminating factor as to why companies embrace greening of their transportation. Large companies in particular have greater intentions of implementing actions than do SMEs. Similar results have been found for greening in general, which can be explained by the fact that regulations target large companies differently than they do SMEs. Generally, large companies receive more governmental stakeholder pressure for greening than smaller ones (Gonzaléz-Benito and González-Benito, 2006).

6. Conclusions and future research

This study examined the intention of companies to reduce transportation emissions by 2020, which helps to understand whether the current trend of increased transportation emissions is likely to change in the coming years. The study also determined which barriers and discriminating factors affect the reduction, which can help companies finding ways to overcome them and policy makers to develop policy measures to support such approaches. The applied company perspective addressed calls for research regarding new knowledge in the area of greening transportation (Meixell and Norbis, 2008; Tacken *et al.*, 2014). Most of the previous studies consider long-term actions on an aggregated macro level.

The survey shows that LSPs and freight owners are likely to reduce a considerable amount of CO_2 emissions from freight transportation in the coming years. The perceived reduction will come from a combination of actions, which are summarised in Table V. The respondents have the lowest level of confidence in CO_2 reductions related to changing logistics structures to shorten transport distances, while they perceive greater CO_2 reductions from operational changes, such as improved transport planning, increased loading capacity and ecodriving. In terms of emission reduction factors on the macro level (Table II), the lowest CO_2 reductions can be expected from transportation intensity. For actions related to traffic intensity, energy intensity and emissions intensity, the companies have higher levels of confidence; exceptions are design of packaging and load carriers, and traffic control technologies. Still, the share of companies optimistic about these actions is about 50 per cent.

The study identified barriers to each action and discriminating factors of green transportation initiatives. The main barriers to implementing different actions are presented in Table V. Cost is one of the main barriers to all actions except those that are related to changing mode of transport, where the main barriers are flexibility, delivery time and lack of infrastructure. However, in general the actions we investigated have quite low barriers. Often the problem is that a combination of barriers need to be overcome before an action is to be implemented. The barriers are important to consider for a company's intention to reduce transportation emissions, but they do not seem to distinguish whether a certain company intends to reduce transportation emissions. It should be noticed that the level of increase for individual companies cannot be predicted based on the level of a barrier. Three discriminating factors (perceived potential, company size and whether the company is an LSP or a freight owner) influence the intention of a firm to reduce transportation emissions. Notably, the industrial sector of a freight owner only has a minor influence on the intention of a firm to reduce transportation emissions.

Theoretically, this paper contributes to the area of greening transportation. It presents new knowledge regarding intentions and barriers for implementing actions for CO_2 reduction. First, it shows that logistical and technical barriers seem to hinder companies from implementing actions, while organisational barriers and external prerequisites are less obstructive. Second, the levels of the barriers are not linked to the intended reductions. Thus, barriers cannot be used to predict companies' intentions to reduce transportation emissions. Further, the paper clarifies the impact of three discriminating factors on reduction of transportation emissions. Whether a company is a freight owner or an LSP is an important factor to explain divergences, while the industry sector of freight owners does not seem to matter. Another discriminating factor is the size of a company; larger companies embrace greening of their transportation to a greater extent than smaller ones. Finally, for all investigated actions, the potential effect is significantly higher than and correlated to the intention for it to be implemented.

Practically, logistics managers should review the potential of various actions for reduced transportation emissions in their supply chains. This study has shown that barriers are perceived to be quite low for most actions and possible to overcome. Companies need to address logistical and technical barriers in particular. Doing so could lead to realised reduced transportation emissions, which would position the company as green leading to long-term gains in terms of marketing advantage (Carbone and Moatti, 2011) and attracting talented employees (Jackson *et al.*, 2011). Further, since large companies and LSPs are more likely to reduce transportation emissions, logistics managers in SMEs and in freight owners could benchmark against these firms to learn how to address these issues. Another insight for companies is that the industry sector is not a major differentiator. Thus, companies could benchmark initiatives and emissions-reducing strategies to companies in both their own and other manufacturing industries. This could be done by being involved in research activities, national or international green programmes, environmental workshops and seminars and transportation associations. To benchmark transportation emission reduction initiatives, managers could identify firms with the greatest intention to reduce transportation emissions. Based on our research, the typical profile of such firms is a large firm, preferably an LSP, but also large freight owners that perceives a high-reduction potential.

Policy makers can also use the findings presented in this paper. The findings can provide a basis for benchmarking tools, set up forums where practices and ideas can be exchanged, and support research. The purpose of such initiatives would be to first, make the CO_2 reduction potential transparent between high performers and those firms that are lacking, and second, raise the general level of the perceived potential and thus encourage implementation.

This study has some limitations. First, it is based on perceptions. Even though they are from well-informed managers, future research should verify the perceptions by investigating alternative sources of information. Second, it focuses on firms in Sweden. Future research should consider investigating other countries as well. This would address the fact that supply chains and freight transportation are largely global and there are both national and international CO_2 targets. Third, due to the scope of our study, three discriminating factors were addressed, but company strategy also matters for environmental initiatives (Sarkis, 1998). To extend the results of our study, future research should address the role of company strategy for greening transportation, thus also gaining insights into why there are more variations of intended reductions within an industry than between industries.

References

Abbasi, M. and Nilsson, F. (2012), "Themes and challenges in making supply chains environmentally sustainable", *Supply Chain Management: An International Journal*, Vol. 17 No. 5, pp. 517-530.

Aronsson, H. and Huge Brodin, M. (2006), "The environmental impact of changing logistics structures", *International Journal of Logistics Management*, Vol. 17 No. 3, pp. 394-415.

Arvidsson, N., Woxenius, J. and Lammgård, C. (2013), "Review of road hauliers' measures for increasing transport efficiency and sustainability in urban freight distribution", *Transport Reviews*, Vol. 33 No. 1, pp. 107-127.

Bagozzi, R.P., Yi, Y. and Phillips, L.W. (1991), "Assessing construct validity in organizational research", *Administrative Science Quarterly*, Vol. 36 No. 3, pp. 421-458.

Banerjee, S.B., Iyer, E.S. and Kashyap, R.K. (2003), "Corporate environmentalism: antecedents and influence of industry type", *Journal of Marketing*, Vol. 67 No. 2, pp. 106-122.

Baumgartner, M., Leonardi, J. and Krusch, O. (2008), "Improving computerized routing and scheduling and vehicle telematics: a qualitative survey", *Transportation Research Part D: Transport and Environment*, Vol. 13 No. 6, pp. 377-382.

Björklund, M. (2011), "Influence from the business environment on environmental purchasing – drivers and hinders of purchasing green transportation services", *Journal of Purchasing & Supply Management*, Vol. 17 No. 1, pp. 11-22.

Carbone, V. and Moatti, V. (2011), "Towards greener supply chains: an institutional perspective", *International Journal of logistics: Research and Applications*, Vol. 14 No. 3, pp. 179-197.

Colicchia, C., Marchet, G., Melacini, M. and Perotti, S. (2013), "Building environmental sustainability: empirical evidence from logistics service providers", *Journal of Cleaner Production*, Vol. 59, pp. 197-209.

Doherty, S. and Hoyle, S. (2009), *Supply Chain Decarbonization – The Role of Logistics and Transport in Reducing Supply Chain Carbon Emissions*, World Economic Forum, Geneva.

EU (2011), "A roadmap for moving to a competitive low carbon economy in 2050", available at: http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52011DC0112&from=EN (accessed 1 March 2016).

European Commission (2010), *EU Energy and Transport in Figures*, Publications Office of the European Union, Luxembourg.

Flynn, B.B., Sakakibara, S., Schroeder, R.G., Bates, K.A. and Flynn, E.J. (1990), "Empirical research methods in operations management", *Journal of Operations Management*, Vol. 9 No. 2, pp. 250-284.

Frohlich, M.T. (2002), "Techniques for improving response rates in OM survey research", *Journal of Operations Management*, Vol. 20 No. 1, pp. 53-62.

Gonzaléz-Benito, J. and González-Benito, Ó. (2006), "A review of determinant factors of environmental proactivity", *Business Strategy and the Environment*, Vol. 15 No. 2, pp. 87-102.

Gonzaléz-Benito, J. and González-Benito, Ó. (2010), "A study of determinant factors of stakeholder environmental pressure perceived by industrial companies", *Business Strategy and the Environment*, Vol. 19 No. 3, pp. 164-181.

Greene, D.L. and Wegener, M. (1997), "Sustainable transport", *Journal of Transport Geography*, Vol. 5 No. 3, pp. 177-190.

Heaps, C., Erickson, P., Kartha, S. and Kemp-Benedict, E. (2009), *Europe's Share of the Climate Challenge – Domestic Actions and International Obligations to Protect the Planet*, Stockholm Environmental Institute, Stockholm.

Helmreich, S., Bonilla, D., Akyelken, N., Duh, J. and Weiss, L. (2010), "Freightvision – management summary IV revised version", Freightvision, AustriaTech, Vienna.

Islam, D.M.Z., Zunder, T.H. and Jorna, R. (2013), "Performance evaluation of an online benchmarking tool for European freight transport chains", *Benchmarking: An International Journal*, Vol. 20 No. 2, pp. 233-250.

Jackson, S.E., Renwick, D.W.S., Jabbour, C.J.C. and Muller-Camen, M. (2011), "State-of-the-art and future directions for green human resource management: introduction to the special issue", *Zeitschrift für Personalforschung*, Vol. 25 No. 2, pp. 99-116.

Judd, C.M., Smith, E.R. and Kidder, L.H. (1991), *Research Methods in Social Research*, 6th ed., Harcourt Brace Jovanovich College Publishers, New York, NY.

Kalkowski, J. (2007), "State of 'green packaging' ", *Packaging Digest*, Vol. 44 No. 12, pp. 40-42.

Kamakate, F. and Schipper, L. (2009), "Trends in truck freight energy use and carbon emissions in selected OECD countries from 1973 to 2005", *Energy Policy*, Vol. 37 No. 10, pp. 3743-3751.

Kerlinger, F.N. (1986), *Foundations of Behavioural Research*, 3rd ed., Holt, Rinehart and Winston, New York, NY.

Kohn, C. and Huge Brodin, M. (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*, Vol. 11 No. 3, pp. 229-245.

Lammgård, C. (2007), "Environmental perspectives on marketing of freight transport – the intermodal road-rail case", doctoral disseration, School of Business, Economics and Law, University of Gothenburg, Gothenburg.

Lemoine, O. and Skjoett-Larsen, T. (2004), "Reconfiguration of supply chains and implications for transport: a Danish study", *International Journal of Physical Distribution and Logistics Management*, Vol. 34 No. 10, pp. 793-810.

Leonardi, J. and Baumgartner, M. (2004), "CO_2 efficiency in road freight transportation: status quo, measures and potential", *Transportation Research Part D: Transport and Environment*, Vol. 9 No. 6, pp. 451-464.

Lieb, K.J. and Lieb, R.C. (2010), "Environmental sustainability in the third-party logistics (3PL) industry", *International Journal of Physical Distribution & Logistics Management*, Vol. 40 No. 7, pp. 524-533.

Ljungberg, D. and Gebresenbet, G. (2004), "Mapping out the potential for coordinated goods distribution in city centres – the case of Uppsala", *International Journal of Transport Management*, Vol. 2 Nos 3-4, pp. 161-172.

McKinnon, A.C. (1994), *Logistics and the Environment*, Heriot-Watt University Business School, Edinburgh.

McKinnon, A.C. (1996), "The empty running and return loading of road goods vehicles", *Transport Logistics*, Vol. 1 No. 1, pp. 1-20.

McKinnon, A.C. (2003), "Logistics and the environment", in Hensher, D.A. and Button, K.J. (Eds), *Handbook of Transport and the Environment*, Elsevier Ltd, Oxford, pp. 665-683.

McKinnon, A.C. (2005), "The economic and environmental benefits of increasing maximum truck weight: the British experience", *Transportation Research Part D: Transport and Environment*, Vol. 10 No. 1, pp. 77-95.

McKinnon, A.C. (2007), "Decoupling of road freight transport and economic growth trends in the UK: an exploratory analysis", *Transport Reviews*, Vol. 27 No. 1, pp. 37-65.

McKinnon, A.C. and Ge, Y. (2006), "The potential for reducing empty running by trucks: a retrospective analysis", *International Journal of Physical Distribution and Logistics Management*, Vol. 36 No. 5, pp. 391-410.

Matthews, H.S. and Hendrickson, C.T. (2002), "The economic and environmental implications of centralized stock keeping", *Journal of Industrial Ecology*, Vol. 6 No. 2, pp. 71-82.

Meixell, M.J. and Norbis, M. (2008), "A review of the transportation mode choice and carrier selection literature", *International Journal of Logistics Management*, Vol. 19 No. 2, pp. 183-211.

Murphy, P.R. and Poist, R.F. (1995), "Role and relevance of logistics to corporate environmentalism", *International Journal of Physical Distribution and Logistics Management*, Vol. 25 No. 2, pp. 5-20.

Murphy, P.R., Poist, R.F. and Braunschwieg, C.D. (1994), "Management of environmental issues in logistics: current status and future potential", *Transportation Journal*, Vol. 34 No. 1, pp. 48-57.

Murphy, P.R., Poist, R.F. and Braunschwieg, C.D. (1995), "Role and relevance of logistics to corporate environmentalism: an empirical assessment", *International Journal of Physical Distribution and Logistics Management*, Vol. 25 No. 2, pp. 5-19.

Neely, A., Gregory, M. and Platts, K. (1995), "Performance measurement system design: a literature review and research agenda", *International Journal of Operations and Production Management*, Vol. 15 No. 4, pp. 80-116.

Oberhofer, P. and Fürst, E. (2013), "Sustainable development in the transport sector: influencing environmental behaviour and performance", *Business Strategy and the Environment*, Vol. 22 No. 6, pp. 374-389.

OECD (1997), *Globalisation and Small and Medium-Sized Enterprises (SMEs)*, OECD Publication, Paris.

OECD (2010), "Moving freight with better trucks – summary document", Transport Research Centre of the OECD and the International Transport Forum, Paris.

O'Reilly, K. (2008), "Green transportation and logistics", Eyefortransport, available at: http://businessassurance.com/downloads/2008/07/eye_for_transport_report.pdf (accessed 10 November 2013).

Pagell, M., Yang, C.L., Krumwiede, D.W. and Sheu, C. (2004), "Does the competitive environment influence the efficacy of investments in environmental management?", *Journal of Supply Chain Management*, Vol. 40 No. 2, pp. 30-39.

Pålsson, H. and Kovács, G. (2014), "Reducing transportation emissions – a reaction to stakeholder pressure or a strategy to increase competitive advantage", *International Journal of Physical Distribution and Logistics Management*, Vol. 44 No. 4, pp. 283-304.

Paxton, A. (1994), *The Food Miles Report: the Dangers of Long Distance Transport of Food*, Safe Alliance, London.

Perotti, S., Zorzini, M., Cagno, E. and Micheli, G.J.L. (2012), "Green supply chain practices and company performance: the case of 3PLs in Italy", *International Journal of Physical Distribution and Logistics Management*, Vol. 42 No. 7, pp. 640-672.

Pfeffer, J. and Salancik, G.R. (1978), *The External Control of Organizations*, Harper and Row, New York, NY.

Piecyk, M.I. and McKinnon, A.C. (2010), "Forecasting the carbon footprint of road freight transport in 2020", *International Journal of Production Economics*, Vol. 128 No. 1, pp. 31-42.

Porter, M.E. and van der Linde, C. (1995), "Toward a new conception of the environment-competitiveness relationship", *The Journal of Economic Perspectives*, Vol. 9 No. 4, pp. 97-118.

Power, D. (2005), "Supply chain management integration and implementation: a literature review", *Supply Chain Management*, Vol. 10 Nos 3-4, pp. 252-263.

Rao, K., Grenoble, W. and Young, R. (1991), "Traffic congestion and JIT", *Journal of Business Logistics*, Vol. 12 No. 1, pp. 105-122.

Rao, P. (2004), "Greening production: a South-East Asian experience", *International Journal of Operations and Production Management*, Vol. 24 No. 3, pp. 289-320.

Rao, P. and Holt, D. (2005), "Do green supply chains lead to competitiveness and economic performance?", *International Journal of Operations and Production Management*, Vol. 25 No. 9, pp. 898-916.

Rogers, Z., Kelly, T.G., Rogers, D.S. and Carter, C.R. (2007), "Alternative fuels: are they achievable?", *International Journal of Logistics Research and Applications*, Vol. 10 No. 3, pp. 269-282.

Russo, M.V. and Fouts, P.A. (1997), "A resource-based perspective on corporate environmental performance and profitability", *Academy of Management Journal*, Vol. 40 No. 3, pp. 534-559.

Sarkis, J. (1998), "Evaluating environmentally conscious business practices", *European Journal of Operational Research*, Vol. 107 No. 1, pp. 159-174.

Seuring, S. and Muller, M. (2008), "From a literature review to a conceptual framework for sustainable supply chain management", *Journal of Cleaner Production*, Vol. 16 No. 15, pp. 1699-1710.

Sharma, S. and Henriques, I. (2005), "Stakeholder influences on sustainability practices in the Canadian forest products industry", *Strategic Management Journal*, Vol. 26 No. 2, pp. 159-180.

Sudman, S. and Blair, E. (1998), *Marketing Research*, McGraw-Hill, New York, NY.

Tacken, J., Rodrigues, V.S. and Mason, R. (2014), "Examining CO_2e reduction within the German logistics sector", *International Journal of Logistics Management*, Vol. 25 No. 1, pp. 54-84.

Trafikanalys (2010), "Commodity flow survey 2009", available at: http://trafa.se/PageDocuments/Varufloedesundersoekningen_2009.pdf (accessed 17 August 2012).

Trost, J. (2007), *Enkätboken*, 3rd ed., Studentlitteratur, Lund.

Vierth, I. (2011), "Uppföljning av konkurrensutsättningen av godstransporter på järnväg i Sverige", Transportforum, available at: www.vti.se/templates/Page____15471.aspx (accessed 10 December 2011).

Wagner, S.M. and Kemmerling, R. (2010), "Handling nonresponse in logistics research", *Journal of Business Logistics*, Vol. 31 No. 2, pp. 357-381.

Walker, H., Di Sisto, L. and McBain, D. (2008), "Drivers and barriers to environmental supply chain management practices: lessons from the public and private sectors", *Journal of Purchasing and Supply Management*, Vol. 14 No. 1, pp. 69-85.

World Bank (2012), "Logistics performance index", available at: www1.worldbank.org/PREM/LPI/tradesurvey/mode1b.asp#ranking (accessed 17 August 2012).

Woxenius, J. (2005), "Koldioxid – en ödesfråga för godstransporterna", *Transport & Hantering*, Vol. 21, p. 10.

Wu, H.J. and Dunn, S.C. (1995), "Environmentally responsible logistics systems", *International Journal of Physical Distribution and Logistics Management*, Vol. 25 No. 2, pp. 20-38.

Yale (2012), "Environmental performance index", available at: http://epi.yale.edu/epi2012/rankings (accessed 17 August 2012).

Corresponding author
Henrik Pålsson can be contacted at: henrik.palsson@plog.lth.se