UNIVERSITY OF GOTHENBURG

This is an author produced version of a paper published in Transport reviews

This paper has been peer-reviewed but does not include the final publisher proof-corrections or journal pagination.

Citation for the published paper:

Niklas Arvidsson, Johan Woxenius, Catrin Lammgård

Review of road hauliers' measures for increasing transport efficiency and sustainability in urban freight distribution

Transport Reviews, 33(1) , pp. 107-127

http://dx.doi.org/10.1080/01441647.2013.763866

Access to the published version may require subscription. Published with permission from: **Taylor & Francis**

GUP

Gothenburg University Publications

http://gup.ub.gu.se/gup/

Author accepted manuscript version of:
Arvidsson, N., Woxenius, J., Lammgård, C. (2013) Review of road hauliers' measures for increasing transport efficiency and sustainability in urban freight distribution, *Transport Reviews*, **33**(1), pp. 107-127. doi:10.1080/01441647.2013.763866.

Review of road hauliers' measures for increasing transport efficiency and sustainability in urban freight distribution

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 analyses 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 the number of actors involved in the decision. The third part presents results from interviews with the CEOs of two road hauliers regarding their opinions of the transport efficiency measures. Finally, the conclusions about transport efficiency measures are summarised in a matrix, 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 transport, road haulier.*

1 Introduction

Freight transport is important in today's society, creating economic and social benefits. Ships, aircraft, trains and lorries support globalisation and distribute commodities to locations near us. We cannot do without these services, but we pay a cost in the negative side effects in terms of emissions, accidents, visual and audio nuisance, barrier effects and not least, time loss because of congestion. With the recent downturn in the global economy, there is growing concern that environmental issues are being neglected in favour of economic aspects. However, it could be argued that there are no alternatives to the redirection of transport systems towards economic, social and environmental sustainability.

Urban freight distribution is often provided in inefficient ways, and the industry is particularly resistant to change (see, e.g., Behrends *et al.*, 2008). A French study (discussed in Ülkü, In press) finds that the marginal external congestion costs of urban traffic are ten times higher than inter-urban traffic. Moreover, there is no lack of ideas for improvements and development projects, but rather a lack of persistence in continuing tests into a steady state and learning from earlier pilot tests. 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). Access to and understanding of these measures and their effects is particularly important for Europe's hundreds of thousands of small and medium road hauliers lacking their own budget and departments for R&D, negotiation power and, at times, the vision of how to operate in a better way.

The purpose of this paper is to review improvement and efficiency measures suitable for urban distribution and comment on their effects. This is examined from the perspective of road hauliers and illustrated in a case study of the two dominant pick-up and delivery hauliers in Gothenburg. The analysis of potential measures is structured along the actor categories that need to be involved, starting with the measures road hauliers can implement themselves followed by measures involving shippers, forwarders, other transport operators and policy makers.

The paper is divided into four parts. The first part of the paper is a literature review in the field of operational transport efficiency, which is not exhaustive. The second part reviews potential transport efficiency measures with implications for the environmental performance of road haulage. The third part is a case study presenting empirical findings from structured interviews with two CEOs of pick-up and delivery hauliers in the parcel and general cargo segment. The fourth part summarises the transport efficiency measures in a matrix, taking into account whether they are mainly costs or benefits for the involved actors.

After the initial literature review, the identification and selection of transport efficiency measures relevant for road hauliers operating in an urban context relied on a series of 12 semi-structured interviews with experts representing transport providers, forwarders, shippers and authorities. The transport providers included medium-sized road hauliers offering services on a regional market and rail operators. In the forwarder segment, the interviewed experts represent global players with a truly extensive market offer regarding spatial coverage, consignment sizes and transport time. The shippers were large Swedish firms purchasing a substantial amount and a wide selection of transport services who were thus both very familiar with and powerful in the logistics market. They were selected from different industries including food, pulp, agriculture, construction, vehicle production, clothing and personal care products. The public sector was represented at the municipality level by the Traffic and Public Transport Authority of Gothenburg and at the national level by the Swedish Road Administration, now merged with its rail counterpart to become the Transport Administration. The final selection included a portion of logical deduction based on personal experience from transport research and advice to the industry and the public sector.

Sweden is a large and sparsely populated country, which has led to an oligopoly in the general cargo market where the two dominant players typically have controlled 80% of the flow. The forwarders are now part of German groups DB Schenker and DHL respectively, and maintain a strong grip on the consolidation market, with some challenge by the logistics arm of PostNord, which is the merger of the Swedish and Danish post offices. The empirical basis for the case study in part three was structured personal interviews with CEOs of the pick-up and delivery hauliers who act as subcontractors to DB Schenker and DHL in Gothenburg. They were selected as case study companies based upon their sizes and dominant positions in the local pick-up and distribution market. They are considered as representative for the segment and choosing two similar road hauliers facilitates comparison since the same questions were asked to both CEOs. The CEOs both used the opportunity to comment on the interview transcripts in order to avoid misinterpretation and to increase reliability. The road hauliers were interviewed in their Swedish context, although the aspects covered should be rather universally relevant to city distribution.

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. In relation to transport efficiency and the numerous measures that can be used to promote more environmentally sustainable distribution, those which yield both economic and environmental benefits command the greatest support and are the easiest to implement (McKinnon, 2003).

On an EU level, congestion is the external transport effect that costs the most for society. Road congestion costs approximately 1 percent 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). Costs and the environmental impact often point in the same direction, i.e., a solution for lower cost for transport also reduces pollution. This paper explores some of the reasons why this might not always be the case, (e.g., optimising transport efficiency might be at the expense of overall logistics costs).

The impact of transport efficiency on the environment can be analysed in a bottom-up vehicle approach (Behrends and Flodén, 2012) where the focus is the vehicle and its driver (e.g., reducing mileage, decreasing the energy and CO_2 intensity per transport unit and changing driver behaviour). A variety of mainly vehicle-related performance measures, or key performance indicators (KPIs), try 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 and can thus be used as a measure of the number of links in a supply chain. 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-kilometres. The modal split specifies the amount of tonnes carried or tonne-kilometres 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 kilometres 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, 2011). 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 kilometres and tonne-kilometres (e.g. De Jong *et al.*, 2010).

Using measures of traffic work measured in vehicle kilometres in relation to transport work measured in tonne-kilometres requires care due to the strong effect of vehicle sizes. KPIs such as load factor and directness can easily be manipulated by using smaller vehicles or dispatch vehicles first when full but not necessarily fulfilling the shippers' demand in an efficient way as investigated by Woxenius (2012) and Kalantari (2012).

A review of the literature concerning freight vehicle activities in urban areas, with a focus on 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 is addressed from a policy level by Danielis *et al.* (2011), Anderson *et al.* (2005), Muñuzuri *et al.* (1998), and Allen *et al.* (2003). Other studies focus on particular parts or measures such as light goods vehicles (Browne *et al.*, 2011; 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.

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 (e.g. Santén and Blinge , 1996). A division along the lines of operational, tactical and strategic levels is yet another way of approaching the concept. Aronsson and Huge Brodin (2006) consider how 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 shipper. They conclude that nearly all measures lead to both reduced logistics costs and environmental impact.

The forwarders depend on how their customers value environmental aspects, which varies among shippers. This was shown by a large survey in 2003, including answers from 567 transport buying firms 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 shippers, and some of the largest logistics service providers (LSPs) now offer services with better environmental 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.*, 2009).

3 Review of measures for increasing transport efficiency

The focus of this paper is on the road hauliers together with the actors affecting the hauliers' process of increasing energy efficiency in transport. Therefore it is necessary to consider not only operational measures—day-to-day activities—but also those macro or strategic measures that affect the road haulier directly or indirectly in an urban setting.

The road haulier, more generically called a transport operator, is the actor physically moving the goods. There is often a middleman between the road haulier and the shipper, typically called a freight forwarder or LSP, often providing additional logistics services such as consolidation in terminals, information processing and warehousing. In the remainder of the paper this organisation will be referred to as a forwarder.

As indicated above, most transport efficiency decisions depend on or are affected by other stakeholders 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 three main groups. These are internal transport efficiency measures (to the haulier), joint transport efficiency measures with the customers (the forwarder or the shippers) and joint transport efficiency measures with the public sector. These measures are neither mutually exclusive nor 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 three 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 or in cooperation with suppliers of vehicles and energy carriers. The reason for not using joint efforts with suppliers as its own category is that each of the 600 000 road hauliers in EU-27 (van Duin *et al.*, 2012, p. 25) has an insignificant influence on the supply of vehicles and fuels, although some are involved as commercial test beds for vehicle and fuel manufacturers. In practice, road hauliers select vehicles and fuels offered in the open marketplace rather than developed in close collaboration with manufacturers.

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 percent (Blinge and Svensson, 2006), even though the long-term savings are closer to 3-6 percent (Swedish Road Administration, 2004). Nevertheless, eco-driving seems to be more effective if combined with additional driver incentives, 2-12 percent (Hedenus, 2008). Today, many lorry drivers go through some kind of driver efficiency training. Maintaining the vehicle’s technical standard, using the right tyre pressure, travelling at a suitable speed and minimising vehicle idling contributes to fuel economy. In urban freight distribution, idling situations occur regularly and are not always driver related. According to McKinnon (2010) 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 overall effect (Hvolby and Trienekens, 2002, p. 209). Implementing these measures leads to a cost reduction for the road haulier and consequently lower transport costs for all actors under perfect market competition conditions.

3.1.2 Vehicle efficiency

A rule of thumb is that the vehicle, the driver and the fuel each account for a third of a Western European long-distance road haulier’s costs. This is in line with Freight Best Practice (2009), which claims that fuel accounts for approximately 30 percent of a road haulier’s operational expenses and fuel consumption obviously attracts attention as a major cost that can be affected. In a series of case studies presented by Freight Best Practice, the road hauliers used monitoring systems to observe fuel consumption with positive results and vehicle manufacturers have long prioritised improving fuel economy. Between 1980 and 2006, fuel consumption has been reduced by almost 40 percent (Mårtensson, 2006) for the same type and size of vehicle. According to Hedenus (2008), Volvo Truck estimates that lorries will be 15 percent more efficient in 2020, although Hedenus also argues that the greatest improvements have already been achieved with more or less stagnated improvements since the early 1990s. A contributing factor is vehicle emission standards, where a decrease in NOx increases fuel consumption (Hvolby and Steger-Jensen, 2010). Hybrids and electrical vehicles would make a significant contribution to energy efficiency (Åkerman and Höjer, 2006) and are best suited for short urban freight services. Aerodynamic improvements and alternative fuels are also important factors for improved efficiency.

In the UK, light goods vehicles with less than 3,5 tonnes of gross weight have grown in both vehicle numbers and activity levels, and much of this growth is obviously in urban areas (Browne *et al*, 2010a). This trend is also identified in Sweden by SIKA (2009) and Trafa (2012). The last rows in the tables show the calculated change between the years. Note the increased use of alternatives to petrol such as ethanol, diesel and gas. A decrease in the use of electric vehicles up to 2008 is significant, even though the numbers are relatively small.

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

At the end of	Petrol	Diesel	Electricity	Ethanol-hybrid/E85	Other hybrids	Natural gas/ Bio gas	Other	Total
1999	2 441	1 844	1,7	0	3,7	0	0,2	4 290
2008	1 154	6 368	0,8	7,3	0,9	37	0,1	7 569
Change	-53%	+245%	-53%	+	-76%	+	+25%	+76%

Table 2: Number of light lorries (<3.5 tonnes) in use by type of fuel and permissible maximum weight, by year 2002 and 2011 (Technologies *et al.*, 2009)

At the end of	Petrol	Diesel	Other (Gas, Ethanol, Hybrid, Electricity)	Total
2002	166 249	165 735	793	332 777
2011	81 687	378 520	7 326	467 533
Change	-49%	+228%	+924%	+41%

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. It should be noted, though, that compared with long-distance road haulage, the fuel's share of total costs is far less for urban distribution with comparatively short annual driving distances. Instead, labour costs constitute the bulk of costs since the vehicle costs are also comparatively low with small, standardised and mass-produced vehicles. The load factor and the back-haul problem could also be seen as a time- or sales-related problem, and, 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.

3.2.1 Intelligent transport systems and route efficiency

An effective way to reduce environmental impact is route planning; the use of information and communication technology (ICT) is an often-mentioned measure for facilitating better planning and control of transport activities. ICT adapted to the transport sector are often referred to as intelligent transport systems (ITS). Today ITS offer real-time information and they are readily available at affordable prices and its efficient use could result in significant cost reductions for road hauliers.

From the road haulier's perspective, a significant pressure from vehicle suppliers, the government, forwarders and shippers 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 incur a cost for the road haulier. The European Commission and project partners have spent significant resources in development and standardisation of ICT and ITS for freight transport (e.g., in the projects EASYWAY, SMARTFREIGHT, FREIGHTWISE, e-Freight, EURIDICE, and iCargo). The ITS Action Plan adopted by the European Commission in 2009 (European Commission, 2009) also aims at reducing this risk. The ITS and route efficiency measure brings benefits to all actors, but the outcome is somewhat more uncertain for the road haulier because of the risk of investing in ITS without being able to implement and use them efficiently.

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 phenomenon is known as the back-haul effect, empty running or unbalanced flows. 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 in the morning into cities than away from cities. 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 (2010) 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. Vierth and Mellin (2008) exemplify this with the Swedish supermarket chain ICA, which has decreased the number of empty backloads by vertically integrating transport with an increase in consolidation in ICA's warehouses and collecting inbound supplies with returning delivery vehicles. On the other hand, when ICA takes control of its flow of soft drinks, the efficiency for Coca Cola might go down. Nevertheless, some measures to eliminate the back-haul effect which would potentially benefit all actors might lower the frequency and increase the lead time for shippers.

3.2.3 Utilisation efficiency—load factor

The load factor is a measurement of vehicle utilisation that obviously has attracted the attention of researchers and the industry for many years. The European Environment Agency (2006) concludes that the average load factor has declined for heavy goods vehicles between the years 1990 and 2004. The results of studies of the load factors in Sweden vary between 30 and 70 percent (Blinge and Svensson, 2006). In theory, this implies that the environmental impact of road transport could roughly be cut to half if more loads were consolidated. In reality, however, this is a very difficult task. For instance the load factor is typically measured in weight but many vehicles are full in terms of their volume capacity before they reach their maximum weight. Another example is route imbalances where a distribution vehicle is successively emptied during the delivery route.

Furthermore, from a societal perspective, an increase in load factor is almost always something to strive for, and examples of projects aiming at increasing the load factor are plentiful. In one such project, the Swedish Exhibition & Congress Centre situated in the Gothenburg city centre has saved more than one-third of the deliveries by the use of a c/o address to a forwarder's terminal on the city rim from where the flow to exhibitions is coordinated (Feo-Valero *et al.*, 2011).

The load factor in city distribution is very dependent on delivery time restrictions, the number of stops along the route and the time available for loading the vehicle carefully. A high load factor would be positive for society since more service can be produced with less traffic. For the road hauliers, however, an increase in load factor could mean a decrease of delivery trips and thus a potential loss in sales.

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). The 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-kilometres would go down. 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-kilometre 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 design of ordering systems obviously affects transport efficiency. The diffusion of the use of just-in-time (JIT) strategies might increase emissions from transport (Halldórsson *et al.*, 2009; McKinnon, 2010; McKinnon and Piecyk, 2009; Rodrigue, 2001). This is also true when combined with geographical changes in supply chains (Hesse and Rodrigue, 2004).

The arguments behind JIT strategies often relate to benefits associated with lower inventory levels, but the price to pay is smaller order quantities and an increase of traffic work. The studies that support this theory are mainly qualitative (Yang *et al.*, 2005; Schonberger, 2007). More quantitative studies such as Nathan's (2011) are needed on the effects of sub-optimisation, pushing the activities up the supply chain and adding extra nodes and links to the chain. Her study also uses a more holistic approach, taking into account both production and transport aspects of JIT. Another way to lessen the impact of the order is by using the "nominated day delivery" system (Hvolby and Trienekens, 2010). Road hauliers could achieve higher levels of efficiency by encouraging shippers 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).

One solution to these inefficiencies includes wider time windows for road hauliers (Lyk-Jensen, 2011) and an increased acceptance of waiting for consolidation or return loads. By offering lower environmental impact as a value-added service, forwarders could counteract these environmental inefficiencies. One example of this is the Danish forwarder DSV, which has re-branded the classic economy cargo with longer lead time as a sustainability service to its Swedish customers, which are used to expecting overnight deliveries except for transport to and from the far north. Shippers willingness to use the service is thus uncertain, and transport researchers have not contributed with an abundance of freight value of time studies, as investigated by Feo-Valero *et al.* (2012) and Zamparini and Reggiani (2007).

For urban freight distribution, there are signs that time windows are getting stricter rather than more relaxed. The reason is that more cities implement stricter time regulations for city distribution, mainly in order to reduce traffic congestion during peak traffic hours (Forsgren *et al.*, 2009). These time-window trends call for careful analysis, since the driving forces and effects are different. An extensive review is available in Quak (1996), who concludes that although time-window restrictions contribute to social sustainability by improving liveability, safety, access to the city centre for customers, and noise reduction, this comes at a cost of financial and environmental sustainability. More research on the correlation between transport efficiency measures, other logistics costs and transport price is needed; for example, hauliers have identified problems of recovering costs for waiting from shippers.

Measures that increase order efficiency benefit society and shippers, but they will reduce benefits to road hauliers and forwarders, since this will ultimately lead to a decrease of frequency and speed in the system, therefore increasing utilisation and perhaps decreasing the number of transport movements and therefore transport revenues.

3.2.6 Mode efficiency

Mode efficiency relates to means by which traffic modes freight is transported. European transport statistics reveal that transport by rail and inland waterways has decreased in favour of more "reliable" and time-efficient transport such as road and air. In terms of transport and energy efficiency, a modal change towards an increased use of rail and sea is often preferable, but the sustainability of fast, short sea shipping services can be challenged as done by Hjelle (2010).

According to logistics literature, goods transported over longer distances are more likely to undergo a modal shift than short-haul urban freight distribution. Worth noting is that some cities in Europe—Amsterdam, Dresden, Zurich, and Vienna—have implemented city distribution by using the existing tram system; however, this has been with mixed success (see Arvidsson, 2010). The use of bicycles in the last leg of distribution from an urban consolidation centre was also investigated by Browne *et al.* (2012). From the road haulier's perspective, a move from lorry to tram or bicycle is considered a cost or a loss in sales, unless it is part of a multimodal service.

3.3 Joint transport efficiency measures with the public sector

While this paper addresses efficiency measures from a road haulier'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. This was tested in the EU-project START (2009), in which 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. However, the effects of these measures are not always evident as investigated by Quak (1996).

3.3.1 Regulatory and incentive-based measures

Policies in urban freight transport are frequently implemented by local authorities. Studies show the complex effects on supply chains (Yu, 1998; Danielis *et al.*, 2010) since the effects on stakeholders and environmental outcomes vary. 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. Traffic regulations concerning access to loading places and fiscal policies might increase transport costs and decrease load factors. Urban consolidation centres might increase consignment costs but increase consolidation and pave 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 towards 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 (Browne *et al.* 2005).

Regulation can also be designed with incentives. Copenhagen introduced a licensing system where road hauliers fulfilling the required 60 percent load factor were given access to preferred loading and unloading points. The road hauliers 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 percent or deliveries to more than 50 consignees gave access to special loading zones and dedicated bus lanes. The test gave mixed results and it was terminated in 2007 (Olsson and Woxenius, 2012). In 2008, strictly enforced time windows were implemented in a smaller area in Gothenburg's city centre. Close collaboration between the Traffic and Public Transport Authority, the Police and road hauliers were used to implement and enforce the regulations, resulting in a 55 percent decrease of heavy-duty vehicles in less than a year. However, a negative impact was that the drivers had to circulate more to conform to the time-window restrictions. Furthermore, access restrictions in time or space could limit some market activities, while promoting others by giving way to pedestrians. Researchers warn against potential suboptimal situations by enforcing too strict time restrictions (Browne *et al.*, 2005; Quak, 2008; Danielis *et al.* 2010; Forsgren *et al*, 2009). Another incentive-based measure 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, as was developed and tested in the EU-project SMARTFREIGHT.

Collaboration with local stakeholders and local authorities in a city is another initiative 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 of 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). A similar initiative in the UK is the Freight Quality Partnership (Taniguchi *et al.*, 2012).

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, and thus the society, might gain from regulatory and incentive efficiency measures, but the outcomes are more uncertain for the other three groups of actors (road hauliers, forwarders and shippers).

3.3.2 Coordinated distribution

In theory, efficiency can gain considerably from consolidating different types of consignments and increasing cooperation between competitors, referred to as "collaborative transportation" by Gonzales and Salanova (2012), but this practice is controversial since it risks violating competition laws. It is often advocated and used in very scarcely populated areas and for deliveries in historic city centres where coordinated transport might offset the risks of eliminating free market forces. Still, road hauliers and forwarders often show signs of resistance to cooperating with competitors. According to Blinge and Svensson (2006), smaller road hauliers do not easily collaborate in the ways required and coordinated distribution projects are often discontinued. Furthermore, some shippers do not allow forwarders to consolidate with goods for their direct competitors. Own-account transport is much less efficient compared to third party or road hauliers, 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 trips for the road haulier—society benefits, but the competitive laws may need to be revised.

4 The view of two Swedish road hauliers

Gothenburg is the second largest city in Sweden with some 900 000 inhabitants, of which 500 000 live in the inner city area. As subcontractors to the forwarders dominating Sweden's oligopolistic transport market for consolidated goods, the road hauliers GB Framåt and TGM dominate the distribution of general cargo and parcels in Gothenburg. According to the CEO of TGM, "[TGM] and GB Framåt are by far the largest hauliers" in the Gothenburg area. TGM is DB Schenker's dedicated subcontractor for pick-up and delivery in the Gothenburg area using a fleet of 190 vehicles. GB Framåt performs most of the distribution for DHL in Gothenburg and has a fleet of more than 110 vehicles. As the forwarders are responsible for the consolidation terminals, most of the transport planning, as well as marketing and sales, the road hauliers strictly focus on pick-up and distribution activities. Consequently, the number of employees approximately equals the number of vehicles in both companies. The CEOs of TGM and GB Framåt are referred to as CEOTGM and CEOGBF, respectively, in the following section.

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 better economy, but also included speedy deliveries and an optimisation of loading the cargo in the vehicles. Below, the interview results are categorised and presented along the lines of the main headings of the previous sections.

4.1 Driver efficiency

Both CEOTGM and CEOGBF find eco-driving effective, especially on longer hauls. The time lost by driving more carefully is small compared to the fuel saved, which results in less emissions and better economy for the road haulier. 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 engine 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 than the maximum allowed in order to make deliveries on time and to gain accessibility in the streets and loading docks. CEOGBF points out that normally economy and the environmental impacts go hand-in-hand, but not always. He exemplifies this with the investment cost for a gas and petrol-fuelled lorry being 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 of gas vehicles, accounting for nearly ten percent of the GBF fleet, now have to collect petrol vouchers from the main office. CEOGBF points out the environmental benefits if the lorries are bought and replaced more frequently than today, but the hauliers' tight profit margins do not allow this.

4.3 *Intelligent transport systems and route efficiency*

CEOTGM argued that it is very difficult to recover the costs of a specific route planning system because of the initial investment and implementation costs 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 kilometres per year. Also the availability of GPS in smart phones makes complex route planning systems somewhat redundant. Furthermore, route planning system facilitates increased competition from drivers from low-wage countries, since local geographic knowledge is no longer required to drive a lorry, CEOTGM concludes. However, a low line-haul price is the competitive advantage, but it is not as severe in city distribution as in long haul because proficiency in Swedish is important and may be an absolute requirement. 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 useful 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 deliveries, having to exceed 25 kilometres in order for the cost and time used with a GPS to be offset by reduced diesel consumption. Both CEOs identified delivery time restrictions from customers as an important limitation for route efficiency.

4.4 *Utilisation efficiency—the back-haul effect*

The distribution in greater Gothenburg has rather balanced flows in terms of volume, according to both CEOs, much due to Gothenburg's character as a manufacturing city. This is in contrast to most cities with more goods to deliver than to pick up, not the least of which is Sweden's capital, Stockholm, which is dominated by the administration and service industry. However, the same unbalance applies to Gothenburg's 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 road haulier 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 from A to B, rather than in an A-B-A situation as the operator might lack 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 promotes in its market communication. “If we knew what we will deliver tomorrow, we would be even more efficient,” said CEOTGM. Planned deliveries imply less transport and less emission. For short-haul transport, the lorries are usually filled in the morning for delivery throughout the day. Ability to increase 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, a view shared with CEOGBF: “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 consignees 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 shippers, 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. Poorly packaged consignments increase 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 towards more JIT, CEOTGM agreed and has witnessed how it has resulted in smaller shipments. CEOGBF was unsure, but thought that the development would probably move towards 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 consolidation terminal 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 lorry operated on its own account where the loops are more static and homogenous in size. 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 stops 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 consignor pays the delivery, not the consignee, which makes coordination of deliveries to a specific consignee 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 often perform pre- and post-haulage in intermodal transport chains arranged by the forwarders.

4.9 *Regulatory and incentive-based measures*

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 forwarders, for which TGM and GBF work—DB Schenker and DHL—have historically cooperated in line-haul since their Swedish terminal networks are more or less mirrored. In pick-up and distribution, the cooperation has been focused on scarcely populated areas, primarily in the far north. A closer example of cooperation is deliveries to an island north of the city called Marstrand, but it 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 (e.g., who pays for damaged goods or the last delivery on a route). The forwarders' cooperation in distribution might also violate European competition laws, particularly considering their joint dominance of the Swedish market, and the shippers often turn suspicious when strong players cooperate.

The freight transport market they are part of has tight margins according to the CEOs. If the distribution is further coordinated, then CEOGBF fears a problem with pricing the services. He also thinks it could be "messy" since the goods might have to go through too many consolidation terminals. Both CEOs think that shippers enjoy too low transport prices considering current operating costs.

5 Discussion

Driver efficiency was regarded satisfactorily, especially on longer hauls but somewhat less so 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 the 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 adapts the lorries to an urban environment. *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). The *back-haul effect* was of limited importance as the distribution in greater Gothenburg has rather balanced flows in terms of volume according to the interviewees. 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 road hauliers viewed work with *packaging efficiency* as a means to be competitive towards transport customers. The CEOs interviewed believed in the trend towards smaller and more frequent shipments, which is the opposite of *delivery efficiency* as it is defined here. *Mode efficiency* was not relevant for the interviewed CEOs. 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 3 summarises the rendering on the efficiency measures. It departs from a set of measures generally viewed as positive from different stakeholder perspectives. The measures were identified and selected based upon the literature review, 12 expert interviews and personal experience from transport research. A measure triggers a minus in a specific stakeholder column if the result of implementation logically results in a cost or a loss of sales for the stakeholder. If the cost or benefit outcome is uncertain, a plus and a minus were inserted and, lastly, a plus was rewarded to the measures that would benefit the stakeholder. Information was derived from the literature review, the interviews with experts and the more specific ones with the road haulier CEOs and processed with a portion of logical deduction.

Table 3: Transport efficiency measures in distribution and the effect on actors in the system.

Efficiency measure\Actors	Decision maker	Road hauliers	Forwarders	Shippers	Society/city
Driver efficiency	RH	+	+	+	+
Vehicle efficiency	RH/VM	+	+	+	+
ITS and route efficiency	RH/F	+/-	+	+	+
Utilisation efficiency - back-haul effect	RH/F/So	+	+	+	+
Utilisation efficiency - load factor	RH/F/Sh/So	+/-	+/-	+	+
Packaging efficiency	RH/F/Sh	+/-	+/-	+	+
Delivery efficiency	RH/F/Sh/So	-	-	+/-	+
Mode efficiency	RH/F/Sh/S	-	+/-	+/-	+
Regulatory and incentive-based measures	RH/F/Sh/So	+/-	+/-	+/-	+
Coordinated distribution	F/Sh/So	+/-	+/-	+	+

(-) cost, (+) benefit. F: Forwarder; RH: Road haulier; Sh: Shipper, So: Society/City, VM: Vehicle manufacturer.

Several urban freight researchers have pointed out the conflicting objectives and interests among stakeholders (Holgu'n-Veras *et al.*, 2012; Yu, 1998; Danielis *et al.* 2010; Russo and Comi, 2012; Gonzalez-Feliu and Routhier, 2012 and Anand *et al.*, 2012). It is important to recognize the concerns of different stakeholders (Ruesch *et al.*, 2012); the preferred solution for an operator does not always correspond to the best solution for the system (Browne *et al*, 2012). If the interaction and the various stakeholder perspectives are not taken into account the introduction of new policies might be unsuccessful. Not surprisingly, low-cost policies generate the most support (Lindholm, 2012).

According to Table 3, the stakeholders that would find the measures the least beneficial are the operators followed by the forwarders and shippers. A similar result can be found in Stathopoulos *et al.* (2012, p. 37), where the stakeholders scored a series of policy measures. Exceptions to this order are also found in their study; operators score higher than the other actors on "real time information on state of traffic" and "variations of time windows." The study found no measures that completely shared the support of all actors. A qualitative and perhaps overly simplified argument could be the importance of the transport service for the different actors. Transport obviously accounts for most of a transport operator's turnover, while a forwarder usually also relies on complementary services such as warehousing and information processing. For a typical shipper, freight transport is approximately 5 percent of total costs, and the city regards transport as not only a means to an end, but also a nuisance creating congestion, noise, accidents and pollution.

6 Conclusion

Many of the environmentally beneficial transport efficiency measures categorised as beneficial for the society in Table 3, result in less kilometres to drive for the road haulier. Therefore, implementing these measures would not intuitively foster more business for the road haulier, at least not in the short term. This could partly explain the inertia to change within the freight industry. Nevertheless, the reluctance might alternatively be explained by the fact that the road hauliers are hardened after many years of improvements without being able to keep, from their perspective, a fair share of the efficiency gains. Most cost reductions have been fully passed onto the forwarder and much of that further to the shipper. The results are thus in line with McKinnon's (2003) statement: "Those measures which yield economic as well as environmental benefits generally command the greatest support and are the easiest to implement."

The empirical part of the article also revealed that fuel saving was not of top priority for the interviewed CEOs. This is not interpreted as a negligence of society challenges, but a consequence of the fact that a distribution lorry travels about 10 000 kilometres per year, which is actually far less than the average private car does in Sweden. This leads intuitively to the conclusion that technical improvements of distribution vehicles might better focus on emissions with a local effect and let long-distance road transport lead the challenge of decreasing CO_2 emissions with a global impact. Against this conclusion stands the large and strongly increasing amount of distribution lorries.

Time is a much more important driving force, including working time for drivers, delivery time windows, lead times for customers and time available for planning and efficient loading. In addition, time restrictions in city traffic and street accessibility have significant effect on transport efficiency.

Nevertheless, road hauliers could become the principal actors in making transport efficiency and sustainability a trademark and positioning environmentally better transport as a strategic issue. Road hauliers and forwarders increasingly identify this as a business opportunity, and several are already moving in this direction, which is likely to offer them a competitive advantage in the future. From a policy point of view, identifying the stakeholders that risk being affected negatively by a certain measure could improve incentive actions and avoid the high discontinuation frequency of future collaborative urban freight projects.

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.

Anand, N., Quak, H., van Duin, R. and Tavasszy, L. (2012) City Logistics Modeling Efforts: Trends and Gaps - A Review. *Procedia - Social and Behavioral Sciences* 39, pp. 101-115.

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.
Behrends, S. and Flodén, J. (2012) The effect of transhipment costs on the performance of intermodal line-trains. *Logistics Research* forthcoming(available online 12 January 2012), pp.
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.
Behrends, S. ö. (2012) The Urban Context of Intermodal Road-Rail Transport – Threat or Opportunity for Modal Shift? *Procedia - Social and Behavioral Sciences* 39, pp. 463-475.
Bergqvist, R. and Behrends, S. (2011) Assessing the Effects of Longer Vehicles: The Case of Pre- and Post-haulage in Intermodal Transport Chains. *Transport Reviews* 31(5), pp. 591-602.
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.
Browne, M., Allen, J., Nemoto, T., Patier, D. and Visser, J. (2012) Reducing Social and Environmental Impacts of Urban Freight Transport: A Review of Some Major Cities. *Procedia - Social and Behavioral Sciences* 39, pp. 19-33.
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, Anderson, S (2005) Low emission zones: the likely effects on the freight transport sector. *International Journal of Logistics* 8(4), pp. 269-281.
Cheng, Y. (1996) Optimal train traffic rescheduling simulation by a knowledge-based system combined with critical path method. *Simulation Practice and Theory* 1996(4), pp. 399-413.
Clearwater, S. (1996) *Market-Based Control: A Paradigm for Distributed Resource Allocation*. Singapore, World Scientific Publishing Company.
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 (2009) *The Future of Transport Focus Groups*. Directorate General Transport and Energy, Brussels.
European Environment Agency (2006) *Transport and environment: facing a dilemma*. Office of Official Publications of the European Communities, Brussels.
Feo-Valero, M., García-Menéndez, L. and Garrido-Hidalgo, R. (2011) Valuing Freight Transport Time using Transport Demand Modelling: A Bibliographical Review. *Transport Reviews* 31(5), pp. 625-651.
Forget, P., D'Amours, S., Frayret, J.-M. and Gaudreault, J. (2009) Study of the performance of multi-behaviour agents for supply chain planning. *Computers in Industry* 60(9), pp. 698-708.
Forsgren, M., Aronsson, M., Kreuger, P. and Franzén, T. (2009) *A Novel Approach to Railway Planning*. Paper presented at The 16th ITS World Congress; 21-25 September, Stockholm.
Freight Best Practice. Your route to operational efficiency. http://www.freightbestpractice.org.uk/, accessed 2011-02-14.
Gonzalez-Feliu, J. and Routhier, J.-L. (2012) Modeling Urban Goods Movement: How to be Oriented with so Many Approaches? *Procedia - Social and Behavioral Sciences* 39, pp. 89-100.
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.

Hjelle, H. M. (2010) Short Sea Shipping's Green Label at Risk. *Transport Reviews* 30(5), pp. 617-640.
Holgu'n-Veras, J., Marquis, R. and Brom, M. (2012) Economic Impacts of Staffed and Unassisted off-Hour Deliveries in New York City. *Procedia - Social and Behavioral Sciences* 39, pp. 34-46.
Holmgren, J., Davidsson, P., Ramstedt, L. and Persson, J. A. (2012) TAPAS: A Multi-Agent-Based Model for Simulation of Transport Chains. *Simulation Modelling Practice and Theory* 23(pp. 1-18.
Hvolby, H.-H. and Steger-Jensen, K. (2010) Technical and industrial issues of Advanced Planning and Scheduling (APS) systems. *Computers in Industry* 61(9), pp. 845-851.
Hvolby, H.-H. and Trienekens, J. (2002) Supply chain planning opportunities for small and medium sized companies. *Computers in Industry* 49(1), pp. 3-8.
Hvolby, H.-H. and Trienekens, J. H. (2010) Challenges in business systems integration. *Computers in Industry* 61(9), pp. 808-812.
Ilie-Zudor, E., Kemény, Z., van Blommestein, F., Monostori, L. and van der Meulen, A. (2011) A survey of applications and requirements of unique identification systems and RFID techniques. *Computers in Industry* 62(3), pp. 227-252.
Jevinger, Å., Davidsson, P. and Persson, J. A. (2010) *Agent-Based Intelligent Goods*. Paper presented at 6th International Workshop on Agents in Traffic and Transportation; Toronto.
Lammgård, C. (2007) *Environmental perspectives on marketing of freight transports - The intermodal road-rail case*. PhD thesis, University of Gothenburg, Gothenburg.
Leonardi, J., Browne, M. and Allen, J. (2012) Before-After Assessment of a Logistics Trial with Clean Urban Freight Vehicles: A Case Study in London. *Procedia - Social and Behavioral Sciences* 39, pp. 146-157.
Lindholm, M. (2008) *A sustainability perspective on urban freight transport*. Licentiate of Engineering thesis thesis, Chalmers University of Technology, Gothenburg.
Lindholm, M. (2012) How Local Authority Decision Makers Address Freight Transport in the Urban Area. *Procedia - Social and Behavioral Sciences* 39, pp. 134-145.
Lyk-Jensen, S. V. (2011) Forecasting Freight Flows. *Transport Reviews* 31(5), pp. 603-624.
Maes, J. and Vanelslander, T. (2012) The Use of Bicycle Messengers in the Logistics Chain, Concepts Further Revised. *Procedia - Social and Behavioral Sciences* 39, pp. 409-423.
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: D. A. Henscher and K. J. Button (eds.) Handbook of Transport and the Environment. Oxford, Elsevier Ltd, pp. 665-686.
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.
Mönch, L., Lendermann, P., McGinnis, L. F. and Schirrmann, A. (2011) A survey of challenges in modelling and decision-making for discrete event logistics systems. *Computers in Industry* 62(6), pp. 557-567.
OECD (2003) *Delivering the goods - 21st century challenges to urban goods transport*. OECD, Paris.
Olsson, J. and Woxenius, J. (2012) Location of Freight Consolidation Centres Serving the City and Its Surroundings. *Procedia - Social and Behavioral Sciences* 39, pp. 293-306.
Purvin & Gertz (2009) *Impacts on the EU Refining Industry & Markets of IMO Specification Changes & Other Measures to Reduce the Sulphur Content of Certain Fuels*. report for the European Commission, DG Environment, London.
Rodrigue, J.-P., Slack, B. and Comtois, C. (2001) *The Paradoxes of Green Logistics*. Paper presented at the 9th World Conference on Transport Research; 23-27 July, Seoul.
Ruesch, M., Hegi, P., Haefeli, U., Matti, D., Schultz, B. and Rütsche, P. (2012) Sustainable Goods Supply and Transport in Conurbations: Freight Strategies and Guidelines. *Procedia - Social and Behavioral Sciences* 39, pp. 116-133.
Russo, F. and Comi, A. (2012) City Characteristics and Urban Goods Movements: A Way to Environmental Transportation System in a Sustainable City. *Procedia - Social and Behavioral Sciences* 39, pp. 61-73.
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.

Schonberger, R. J. (2007) Japanese production management: An evolution - With mixed success. *Journal of Operations Management* 25(2), pp. 403-419.
Siror, J. K., Huanye, S. and Dong, W. (2011) RFID based model for an intelligent port. *Computers in Industry* 62(8–9), pp. 795-810.
Stefansson, G. and Woxenius, J. (2007) *The concept of smart freight transport systems – the road haulier's perspective*. Paper presented at The 19th NOFOMA conference; 7-8 June, Reykjavik.
Swedish Road Administration (2004) *Klimatstrategi för vägtransportsektorn (Climate strategy for the Road Transport Sector)*. Publication 2004:102. Borlänge.
Taniguchi, E., Thompson, R. G. and Yamada, T. (2012) Emerging Techniques for Enhancing the Practical Application of City Logistics Models. *Procedia - Social and Behavioral Sciences* 39, pp. 3-18.
Technologies, A., Aspen, A., IVL and TNO (2009) *Cost Benefit Analysis to Support the Impact Assessment accompanying the revision of Directive 1999/32/EC on the Sulphur Content of certain Liquid Fuels*. Report for the European Commission, DG Environment, Didcot, UK.
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.
van Duin, J. H. R., van Kolck, A., Anand, N., Tavasszy, L. ó. A. and Taniguchi, E. (2012) Towards an Agent-Based Modelling Approach for the Evaluation of Dynamic Usage of Urban Distribution Centres. *Procedia - Social and Behavioral Sciences* 39, pp. 333-348.
Whiteing, T., Browne, M. and Allen, J. (2007) *City logistics: the continuing search for sustainable solutions*. In: D. Waters (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.
Ülkü, M. A. (In press) Dare to care: Shipment consolidation reduces not only costs, but also environmental damage. *International Journal of Production Economics* Available online 14 September 2011.
Yu, C. (1998) Hybrid simulation for resolving resource conflicts in train traffic rescheduling. *Computers in Industry* 35(3), pp. 233-246.
Zamparini, L. and Reggiani, A. (2007) Freight Transport and the Value of Travel Time Savings: A Meta-analysis of Empirical Studies. *Transport Reviews: A Transnational Transdisciplinary Journal* 27(5), pp. 621 - 636.
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.