Green logistics concepts for sustainable transport operations

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Abstract
Green logistics deals with logistical flows on an environmental friendly base. This papers purpose is to present existing tools to make transport operations greener. The paper starts with existing obstacles and concludes with tools for green logistics and their potentials. Afterwards, some examples of realization will be presented.

Keywords: Supply Chain Management, Transportation, Sustainability

Introduction
The growth of the three transportation modes truck, rail and inland waterway in the European Union represented 2.8% between 1995 and 2006. At first, this seems not really dramatic. However, observing the modal split it can be found that road transportation developed disproportionately high by 3,5% p.a. (between 2005 and 2006 by nearly 4.9%) rail and inland waterway transportation declined and stagnated. Road freight transportation does not only dominate transport performance (measured in tonne-kilometres, tkm) but earns a significant proportion of the total carbon dioxide emission with 72% comparing the whole transportation sector within the European Union (European Commission, 2007).

In intra-EU trade, road carries some 44.5% of total tones but 61.5% of trade by value. An average road cargo is valued at 1.674 € /tonne compared with 924 €/ tone for rail freight and 87 €/ tone for inland waterway traffic. In total intra-EU traffic road carries 80% of total tonnage but 44% of tone-km since an average haul by road is 110 km against 245 km by rail and 280 km by inland waterway. Only 4% of road freight tonnage is international traffic, compared with 20% of road freight traffic, 45% of rail traffic and 75% of inland waterway traffic. 59% of road tonnage (12% of road tkm) is carried less than 50 km and only 3% of tonnage (but 20% of tkm) is carried 500 km or more which denotes the other extreme (Vickermann et al., 2003).

The main influences which favor this development have been determined by several studies and authors (Aberle, 2005; Kummer, 2007; European Commission, 2001; McKinnon, 1996, 2003):

- “Effect on goods structure”: the quota of high quality goods within the economy increases whereas the quota of mass goods stagnates or decreases (Mass goods would be more compatible for transportation by rail.)
- “Logistics effect”: the change of logistic strategies (outsourcing, just in time, less storage, etc.) has an impact which favours the truck because of its flexibility.

- "Effect of integration": Truck freight transportation is best able to reach new regions and areas. (Reaching new regions by rail is much more difficult because of technical and infrastructure barriers between countries).

Bleijenberg (2003) states that it is often assumed that the growth in freight transport is directly linked to economic growth. Because governments strive for high economic growth, equally strong growth in freight transport is then inevitable. However, freight transportation has decoupled itself from real GDP since 1980. Aberle (2005) found out that a transport intensity of 230.000 tkm was needed in 1980 whereas already 265.000 tkm where needed to gain 1 million of real GDP in 2001 (+15%). Recent scientific research was done by trying to answer the question "what are the reasons or driving forces behind this development?" Generally the changes mentioned and the growing importance of logistics and supply chain management can be deducted as one main source for the development. Nevertheless besides logistics concepts for SCM, other different driving forces have been established through research.

One explanation for the growth in freight transportation relates to the change in the logistically induced demand for transport, especially the increase in flexibility of the production and distribution structures. Another relates to the improvement of the infrastructure (Drewes Nielsen et al., 2003). Bleijenberg (2003) finds two reasons for this development, first the increased purchasing power (income growth) to choose from a large variety of consumption goods (economies of scope) and second the logistics within the production process (economies of scale, locational advantages, and reduced costs for warehousing).

The SULOGTRA project (2002) analysed the current trends in logistics and supply chain management on the transport system. Tseng et al. (2005) state that the key element in a logistics chain is the transportation system which combines the separated activities together. Naim et al. (2006) affirm that transport is a key function in the supply chain as it acts as a physical link between customers and suppliers, enabling the flow of materials and resource. Furthermore with the advent of third party logistics (3PLs) providers and even 4PLs, carriers provide more than just physical transport links. Nevertheless, Schnell et al. (1999) interviewed responsible managers in companies and found out that for most of them, the intentional control of transportation flows is not an urgent issue as well as changes within the economy are answered with isolated and occasionally oriented modifications.

Rodrigues et al. (2007) revealed in their work based on a broad literature research that there is still the need for freight transport to be flexible and responsive for reacting effectively on customer demand while minimizing the impact of transport on costs and on the environment. They stated that there has been a failure to properly integrate transport into supply chains to date because combining cost minimization and flexibility with sustainability in transportation over the whole supply chain is not realized satisfactory. Furthermore they found that little attention to transport as a strategic supply chain activity has been paid so far.

Transportation management is an area that remains critical to overall logistics and supply chain success. A supply chain is only as strong as its weakest component. If transportation is managed independently of other value added supply chain operations it often represents one of the chain's weaker elements (Stank et al., 2000).

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Abukhader and Jönnson (2004) found out by an observation through some primary logistics related journals, that the environment subject within supply chain management and logistics has been treated less than other established subjects in the logistics discipline like management, information technology or business. In 2003 they pointed out the need to evaluate traditional logistics concepts and strategies (Just in Time, postponement and centralization, etc.) to relate them to environmental impacts.

Other research papers also pointed out the need for more intensive research within the field of Supply Chain Management, logistics and its effects on freight transportation volume. The economic potentials for cost reduction within SCM where calculated at around 15 bn € for 1999 (Kasiske, 2005). For example Höfler (2003) criticizes that the logistic aspects and SCM strategies and the growth of freight traffic volume are not considered sufficiently. Drewes Nielsen et al. (2003) assess that integration of transportation in logistic strategies and the results have not been taken into account so far. Aberle (2005) assumes that maybe logistic strategies have to be changed dramatically because of further developments within freight traffic and infrastructure.

Being able to link strategies of logistical organization with changes in transport would be of importance to support the industries development of more environmentally sustainable supply chains (Drewes Nielsen et al., 2003).

Therefore there still exists a lack of investigation in how supply chain management effects transportation growth and the resulting effects on the environment. This is a challenging and important question because in the authors view it is a key question to develop strategies for sustainable transportation in global supply chains in the future.

Two general approaches for reducing the environmental impact can be identified. The first is to put emphasis on more energy efficient technology, which for goods transport and logistics has proven to be insufficient. The second is to rely on companies to restructure their processes (Aronsson et al., 2006). The authors also found out that within the micro perspective view introducing more energy efficient technology is not enough but there is a need to organize logistics by structural changes in sourcing and distribution or in a word spoken over the whole supply chain.

The traditional supply chain is defined as an integrated manufacturing process wherein raw materials are manufactured into final products, then delivered to customers via distribution and or retail. The design, modeling and analysis of the traditional supply chain has primarily focused on optimizing the procurement of raw materials from suppliers and the distribution of products to customers. Extending the traditional supply chain allows the consideration of the total immediate and eventual environmental effects of all products and processes (Beamon, 1999). Many of the environmental benefits accuring from improvements in vehicle technology are therefore being sacrificed as logistical systems become even more transport-intensive. The transport intensity of a supply chain is determined both by the number of links and their average length (McKinnon, 2003).

Drewes Nielsen et al. (2003) illustrate, that the relationship between logistic organization and transport is not straightforwardly established because of the following reasons:

- Logistical organization is not only the dominant variable – it is also connected with other factors of supply chain management.
- Logistical principles are not well defined over the whole processes.
- Surveys about logistics and transport suffer from very few response rates.

- Whether the causes of changes in transportation growth rates are related to logistical organization or to changes in the market cannot be deducted so far.

McKinnon et al. (2006) pointed out that in the UK, the proportion of kilometers run empty by trucks with gross weights over 3.5ton or more has been steadily declining for over 30 years, yielding large economic and environmental benefits. However he states that it cannot be predicted in what way this trend will continue.

The key findings of the study "supply chain decarbonization" of the world economic forum (2009) show that still 24% of goods vehicle kms in the EU are running empty and when carrying a load, vehicles are typically only 57% loaded as a percentage of maximum gross weight. The overall global abatement potential could be 124 mega-tones of CO_2 per year and 30% of this could be reached by improving economic transaction sizes in freight movements.

Drewes Nielsen et al. (2003) developed a first framework for a one way cause and effect relationship, changes in logistical organization explaining the pattern of transport. They stated that it is a simplification of reality but a basis to handle further investigation supporting both qualitative and quantitative approaches.

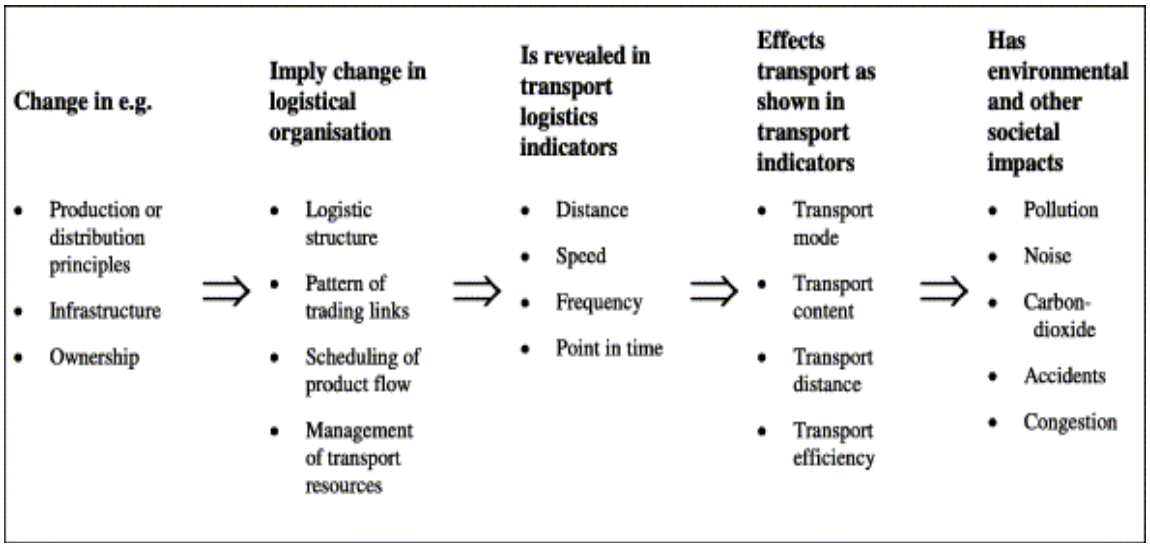

Figure 1 – Analytical approach (Drewes Nielsen et al., 2003)

Based on this framework, studying former research work about their results regarding to logistics systems driving the environment have deducted the following parts within Supply Chain Management as relevant for minimizing the impact on the environment:

Table 1 – Effects on transport of trends in Supply Chain Management

Authors	***effect on transportation***
Aronsson, Brodin (2006)	freight consolidation, modal choice, distribution network design, transport distances, information management
Drewes Nielsen et al. (2003)	distance, speed, frequency, point in time, transport mode, transport content, transport distance, transport efficieny
Wu, Dunn (1995)	raw materials aquistition,freight consolidation, mode selection, materials handling, warehousing, backhaule management, transformation (JIT), collecting, storing, network planning, vehicle scheduling and routing
Naim et al. (2006)	collaborative transport
Sulogtra (2002)	restructoing of logistics systems, realingemnt of supply chains, resceduling of product flows, management of transport rersources, changes in product design
Schnell et al. (1999)	JIT, global vs. regional sourcing, modular sourcing, single sourcing, lean management, concentration on core competences
McKinnon (2001)	numbers- locations- capacities of factors, warehouses, terminals and shops; patterns of trading links, manifestation of trading links as discrete freight movements, management of transport resources

As it can be seen in the above table, there are huge amounts of drivers within Supply Chain Management which influence transportation decisions and their environmental impact. These impacts result in an increase in freight transportation volume causing the well known negative impacts (harmful emissions, noise, congestion, etc.). McKinnon (2003) stated in his work that these factors or decisions are made at different hierarchical levels which mean that some beneficial effects by "green logistics" implemented over a Supply Chain have been offset or negated by higher level decisions. Generally the environmental impact of freight transportation can be measured by three ratios (based on this, environmental-, economic- and social costs and impacts can be measured):

- Total tonne-kilometers: output-transport intensity
- Road tonne-kilometers: total tonne-kilometers – modal split
- Vehicle-kilometers: tonne-kilometers – vehicle utilization

The three ratios are more or less the result of the influencing parts and decisions of Figure 2. These influencing parts are all related and dependent on each other. As Aronsson et al. (2006) state, literature does not provide any clues how these factors are linked to each others. There is a need for companies to take a more holistic view on the effects of their activities on freight transport and related externalities (McKinnon, 2003).

On the one hand there still exists a lack of approaches linking (in best case) all of the interrelationships between these parts of Supply Chain Management. An overall, systematic approach to picture the interdependencies of logistic strategies and freight traffic volume can be one way connecting the different effects. On the other hand the sensitiveness and knowledge within the Supply Chains in different industry fields about the impacts of their decision is also an aspect for further research. An interesting question is if companies do already know about the impacts of their decisions?

Environmental transportation thinking within Supply Chains

The environmental sensibility of companies regarding their overall processes grew steadily within the last decade. Nevertheless it is still a huge challenge for companies to evaluate their logistics decisions and as well as effect on transportation and the environment. It is easier to measure savings within production processes caused by the implementation of new technologies. The contribution of logistics within Supply Chain Management for environmental efficient strategies within transportation can be realized by three steps (Dyckhoff, 2000):

- Reduction of average transportation distances
- Increasing utilization
- Shifting to other transportation modes

Nevertheless these three contributors can only be used efficiently by connecting and finding out about the interrelationships between Supply Chain Management and its logistics behind it. Therefore a survey was carried out to generate basic information about Supply Chain thinking, logistics Know-how and transportation. The survey was realized within the federal region of Upper Austria which is responsible for more than 27% of the Austrian export volume and is besides the urban area of Vienna the most important economic region of the country. Nevertheless there is a lack of disaggregated transportation data because of legal issues as well as security reasons of the leading loaders.

The study was conducted in those companies which were responsible for over 80% of total turnover within the region excluding freight forwarders, hauliers and other service industry. After developing a questionnaire, (including questions about logistics organization, transportation management, delivery destinations and procurement origins, knowledge about the different transportation modes, willingness to co-operation etc.) personal interviews were conducted in 24 companies and 52 companies were surveyed via an internet questionnaire. These 77 (predominantly large and medium sized companies) are part of these 150 (out of 2000) firms which are responsible for over 80% of total turnover in Upper Austria in the production sector. The main findings of this survey were:

- Loading factor of trucks is in only 50% of cases more than 75% which are inefficient transportation movements causing the mentioned negative effects
- 51% of all transportation movements are linked to fixed time slots boosting truck transportation because of its flexibility in planning reliability
- Seasonal fluctuations affect 60% of the companies which also favours truck transportation because of easier planning possibilities and quicker availability
- Intensifying to rail transportation in future is for 57% an option whereas for inland waterway it lies only at 17%
- More inter-company cooperation in inbound transportation to increase utilization of trucks is 71% and for outbound transport it could be found at 58%
- On a scale from 1 (low environmental awareness) to 10 (absolute environmental awareness) still 34% of the companies interviewed do not consider ecological issues within their transportation processes (Figure 2):

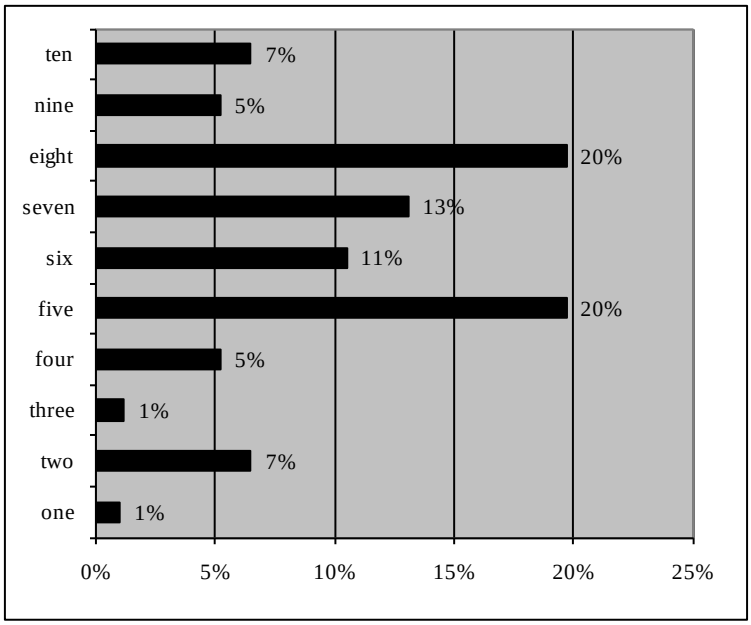

Figure 2 – environmental awareness within transportation

- Considering transportation modes in use, truck transportation is the dominating one compared to rail, inland waterway transportation and intermodal transport:

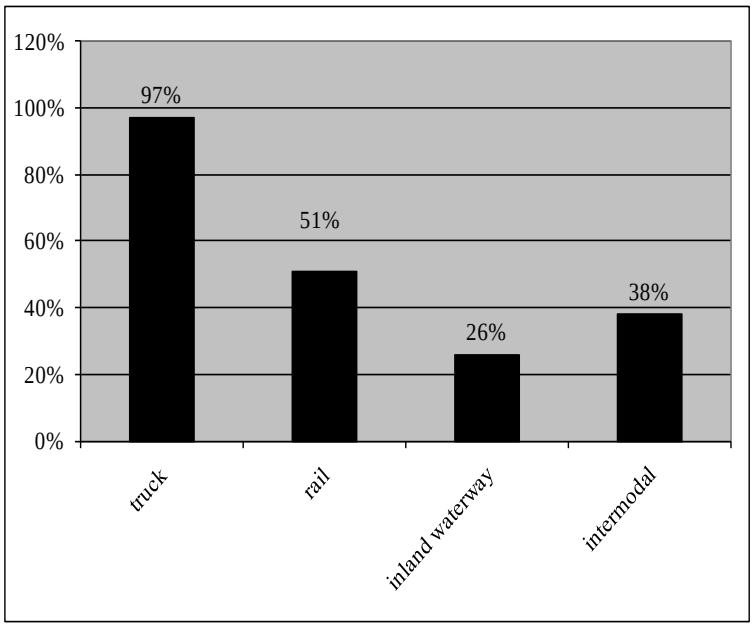

Figure 3 – transportation modes in use

These first findings show a huge lot of potential in diminishing environmental impacts of freight transportation in Upper Austria. Therefore more emphasis has to be put on the interrelationships between logistics concepts and transportation volume, utility, resulting obstacles for shifting to other modes in for further research work. Environmental efficiency needs an orientation on ecological (efficient resource usage, less emissions) and economical aims (increasing competitiveness, cost effectiveness) (Strebel, 2002). Logistic concepts within Supply Chain Management are the main link for this realization.

A prerequisite is the ability to find out about the sustainable "parts" of logistic practices in Supply Chain Management.

Conclusion

This paper presented an overview of existing literature on the issue of Supply Chain Management, logistic concepts freight volume and its effects on the environment. Supply Chain Management and freight transportation have to be considered as a system which does have huge interrelationships as well as connections to exogenous influences. Such exogenous influences, which will have huge effects on the decision and logistics are for example externalization of external costs, new taxes etc. where logistics concepts will have the challenge to react in such ways that economical and ecological goals can be realized in future.

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