WORKING PAPER

A systemic model for the interdependencies between logistics strategy and transportation movements

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ABSTRACT

This papers purpose is to picture interdependencies between logistics strategies and transportation movements through a systemic point of view. The underlying methodology of this research work is system dynamics. The paper starts with a short overview of developments in freight transport and the definition and parameters of a logistics strategy. Afterwards the developed qualitative part, a causal loop diagram is presented and described. Based on the causal diagram the quantitative model is developed and validated to guarantee plausibility. Afterwards first findings of scenarios and experiments will be presented. The results highlight interesting and important interdependencies between parameters of logistics strategy and freight transport. The most usable identified leverage points will be presented. The developed model is a useful tool for the realization of sustainable transportation movements.

Keywords: logistics strategy, efficient transportation, system dynamics

INTRODUCTION

Globalization, European integration and the liberalization of transport markets have created conditions of production and distribution which have led firms to profoundly change their logistics concepts. This has major repercussions on demand behavior in freight transport (Bolis et al., 2003).

The dependence of logistics on efficient and well organized transport infrastructure and technology is well and well documented. The implications of logistics for transport are, however, much less researched (Jespersen et al., 2004). Drewes Nilsen et al. (2003) state that it is still difficult to determine the actual relationship between logistical structures and transport as it is seen on the one hand as an integrated part of the logistical system and on the other hand as an activity embedded in its own systemic logic in transport chains. The relationship between logistic organization and transport is not straightforwardly established. Nevertheless, being able to link strategies of logistical organization with changes in transport would be of importance as it could support industries development of more environmentally sustainable supply chains.

Freight transport is affected by a broad range of corporate decisions. These decisions influence the transport operation in different ways. Logistical decisions affecting freight transport operations are made at four levels (McKinnon et al., 1996): Strategic, commercial, operational and tactical decisions. The growth of freight traffic is the result of a complex interaction between decisions made at different company levels. Generally the influence direction can be described as a top down (from strategic level to the operational level). The purpose of this paper is to define the term logistics strategy, identification of the parameters or determinants of a logistics strategy which do influence transport operations and the development of a causal loop diagram to picture these interrelationships as a basis for deriving the impacts on environment.
Road freight transportation dominates the modal split both in the European Union and in Austria. This development can generally be explained by the so called “structure effects” (Aberle, 2005; Kummer 2007). There is a tendency to smaller consignments, concentration on core competences, lesser depth of added value and the expectation of on scheduled deliveries. Transportation flows are dynamically affected by “modern” logistic concepts within the process of procurement, production and distribution. Additionally existing failures in traffic policy in general as well as national controlled rail operators have favored this development. Due to the current dominant position of road freight transportation a migration to rail or multi-modal traffic is unlikely (Aschauer et. al, 2009).

Freight traffic in the EU 27 grew by 2.8% p.a. from 1995 to 2006 (Mahieu, 2009). More than 60% of transportation flows are transported less than 50 km whereas only 17% of the total amount of road cargo was transported more than 150 km. Goods transportation is dominated by short distance shipment. EUROSTAT found that the Austrian freight transport performance grew from 12.514 million tkm to 14.437 million tkm during the last decade.
It is important to mention that the shipment of semi-finished and finished products are only responsible for one-fifth of the transported volume but accounts for one third of the total ton kilometres in Austria (Pasi, 2008).

For Austria the growth rate of freight transportation between 1999 and 2005 was 2.2%. 54% is domestic freight traffic followed by 23% bilateral freight traffic. 23% of total freight volume is transit traffic. Therefore 77% of freight traffic volume is “homemade” meaning that the origin and/or destination is in Austria.

The findings of the World Economic Forum (2009) are that 24% of goods vehicle kilometres are running empty and when carrying a load, vehicles are typically loaded at 57% of maximum gross weight. Average loading weight in truck transportation was 13.1 tonnes in the EU in 2005. Empty load running fluctuates between 45% (Cyprus) and 17% (Denmark) whereas Austria with 27% can be found in the middle region of the member countries.

The share of empty load running is higher in trucks operated by the industry than in trucks operated by hauliers (Pasi, 2007). For example in Germany empty running in road freight transportation is about 19.7%.
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).
The main influences which favor this development have been determined by several studies and authors (Aberle, 2005; Kummer et al., 2007; European Comission, 2007; McKinnon, 1996):

- “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).

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 (Bleijenberg, 2003).
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. There can be found 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 like economies of scale, locational advantages and reduced costs for warehousing (Bleijenberg, 2003). Another relates to the improvement of the infrastructure (Drewes Nielsen et.al, 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. (2007) 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.

LOGISTCIS & TRANSPORTATION

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 resources (Naim et al., 2006). However, because of growing congestion problems as well as environmental and safety considerations, freight transportation becomes more and more a key issue in logistics in particular in the industrial process in general (Vannieuwenhuyse et al., 2003). The supply chain is only as strong as its weakest component. If one link cracks the chain breaks.

Transportation often represents one of the chain’s weak elements and is there-fore a crucial part of supply chain management (Stank et al., 2000).

Researchers have investigated supply chain uncertainty and developed models, but have paid little attention to transport as a strategic supply-chain activity (Rodrigues et al., 2008).

Morash and Ozment (1996) stated that time-based transportation strategies can be important sources for growing competitive advantage and customer value. Additionally, as firms strategically compete on the basis of cost, service, or time, transportation can play a key integrative role in supply chain structure.

Without transportation’s active participation in structural supply chain design, cost minimization and customer value enhancement will be difficult to realize. Transportation’s contribution to international supply chain structure takes on new and increased importance (Morash et al., 1997).

Giunipero and Eltantaway (2003) acknowledged in their research work, that transportation disruptions are important risk factors threatening supply chains.

Transportation disruptions caused for example by congestion and bottlenecks on road traffic infrastructure are unique since goods in transit have been stopped, alt-hough all other operations of the supply chain are intact. Transportation disrup-tions have per se received less attention than supply chain disruptions (Wilson 2007). These causes of transport uncertainties are uncertainties related to suppliers, customers, carriers and external uncertainty. The external uncertainty can be divided into transport macroeconomics, market road conditions, future government policy and external shocks. Road conditions are in the focus of this research work as they include traffic congestion, route unavailability, delays and unreliable travel times (Rodrigues et al., 2008).

Beside these findings, a study found out that the reasons for need for travel time predictability can be divided into two groups: those related to the nature of the demand for freight transport and those concerned with supply side issues. Demand considerations are for example Just in Time, quick response, port deadlines and Hub and Spoke operations. Supply side issues are for example two way loading, consolidation, driving hours implication, order management and warehousing regimes (Fowkes et al., 2004).

Road congestion is increasingly affecting transport operations (McKinnon et al. 2004). This effect was surveyed by Golob and Regan (2003) by asking more than 700 logistics managers in trucking companies in California. They found out that for example 30% of shippers are often and 56% are sometimes affected by congestion. Another interesting finding was that for 9% of the participating carriers, the issue of congestion is critically serious, for 27% it is very serious, 46% answered that it is somewhat serious and only 19% considered congestion on road infrastructure not as a serious problem.

McKinnon (2004) identified some tactical measures that can make operations particularly sensitive to congestion as well as broader actions that companies could take to reduce the impact of congestion.

Focusing on the supply chain efficiencies causes small reductions in conges-tion, which in turn drives benefits in supply chain efficiency:

- Relative importance of cross-docking to the operation
- Time for internal process

- Dependency on preloading vehicles
- Strict adherence to booking- in times
- Geographical location
- Degree of JIT replenishment
- Level of scheduling deliveries over a 24 hour circle
- Modal shift to rail
- Restructure of the distribution networks
- Schedule vehicle movements to avoid peak times
- Overhaul processes and procedures
- Exploitation of telematics systems

Flexibility is increasingly preferred as a characteristic of transport systems, particularly in light of changes in supply chains and traffic patterns. It is an important but little studied characteristic of transportation systems. Thus this flexibility is the ability of a transport system to accommodate variations or changes in traffic demand while maintaining a satisfactory level of performance (Morlok et al., 2004).

This research work focuses on the suggestion of scheduling vehicle move-ments to avoid peak times. This should make it easier for companies to plan and schedule their transportation movements.

It should contribute to increased flexibility by identifying less time consuming transportation flows and rising planning certainty in transportation as well as the whole supply chain.

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).
Rodrigues et al. (2008) 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.

The SULOGTRA project (2002) analysed the current trends in logistics and supply chain management on the transport system. The key element in a logistics chain is the transportation system which combines the separated activities together (Tseng et.al, 2005).
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 (Naim et.al, 2006). Nevertheless in a study which interviewed responsible managers in companies 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 (Schnell et. al, 1999).

STRATEGY VS. LOGISTICS STRATEGY

"Indeed, there are almost as many different definitions about strategy as there are books written" (Barney, 1996). Also Marchazina et al. (2005) see strategy as a wide used term in science and industry. Two basic strategy "understandings" can be identified; on the one hand strategies can be seen as rational planned action bundles and on the other hand as a basic pattern in the flow of decisions and operations. Gälweiler (2005) characterizes strategy as a specific thinking methodology or a specific procedural method for the development of behavior at the best possible level. Strategy can be derived from the old Greek word "strataego" ("strattos" = something that covers at least everything; "igo"= do or act). Strategies target to obtain competitive advantages to secure the longlasting survival of the company in the market (Schulte, 2008).

To define the term logistics strategy we first have to declare the difference of logistics and Supply Chain Management (SCM) within this paper. Harrison et al. (2008) differentiate the term logistics and Supply Chain Management by the following definitions:

- Supply Chain Management is the planning and controlling of all the business processes – from end customer to raw material suppliers – that link together partners in a supply chain in order to serve the needs of the end customer.
- Logistics is the task of coordinating material flow and information flow across the supply chain.

Logistics has for Harrison et al. (2008) both a strategic (long term planning) and managerial (short- and medium-term planning and control) aspects.

Walters (2007) defines SCM as the series of activities and materials – both tangible and intangible – move through on their journeys from initial suppliers to final customers. Logistics is in his point of view the function responsible for moving materials through their supply chains. He states that there are different opinions about how to distinguish those terms. Christopher (1998) defines the field of activities of logistics in coordinating the flow of materials and information that extend from the market place through the firm and its operations and beyond that to suppliers.

Within this paper, logistics is seen as the task of coordinating the material and information flow in and between companies and is therefore deeply interrelated with transportation.

Hayes et al. (1984) define the term of logistics strategy as: "*The set of guiding principles, driving forces and ingrained attitudes that help to coordinate goals, plans and policies and which are reinforced through conscious and subconscious behavior within and between partners across a network.*"

Logistics strategy planning is a complex process that requires an understanding of how the different elements and activities of logistics interact in terms of trade-offs and the total cost to the organization.
Furthermore, it is always a challenge for logistics strategy planners to develop a series of logistics strategies for different clients, integrating manpower, facilities and workflow in the logistics strategies to complement other clients' logistics strategies (Chow et al., 2005). Considering Fabbe-Costes et al. (2007), the classic approach to formulate a logistics strategy begins with the firm's overall strategy and then defines the logistics strategy that will enable it to reach its objectives; logistics strategy appears as a subset of the overall strategy. Generally the formulation of a logistics strategy can be expressed by three classic concepts of strategy: the profession, the mission and the objectives. The authors state that formulating a logistics strategy somebody has to define:

- The ranges of movement that it produces and how it produces them (technologies, know-how, organization);
- To whom they are directed (internal or external clients) and the needs that they satisfy;
- The kind of performance it aims at and the targeted level of that performance.

There are three different types of strategies to diversify, the corporate strategy, business or business unit/competitive strategy and functional area strategies (Marchazina et al., 2005). Schulte (2008) distinguishes within a company three different levels, the corporate, business unit and functional level. The development of a strategy affects a company on these three levels. At the corporate level the definition of different business levels/units is developed. At the business segment level the definition of the business or competitive strategy (differentiation, cost leadership and segmentation) is evolved whereas at the functional level of a company, the different areas of a company like marketing, logistics, production etc. are strategically oriented towards fulfilling the business/competitive strategy. The business strategy is especially since Porter (1996) also called as generic competitive strategies in the focus of strategy research. Schulte (2008) developed in dependence on Wheelwright and Hayes (1985) a four step model, describing the influence of logistics on strategy within a company.

Companies on step 3 or 4 see logistics activities as an active part of supporting the company's success and competitive advantages. Not every logistical decision can be considered as a strategic decision. Perl et al. (1988) divide logistical decisions into strategical, tactical and operational decisions. Wanke et al. (2003) state in their paper that logistical decisions on a strategic level are for instance make or buy decisions, push vs. pull inventory deployment logic and inventory centralization vs. inventory decentralization. As we are mainly interested in logistical decisions affecting transport,
McKinnon (2003) for example, divided logistical decisions into four different levels, strategic, commercial, operational and tactical decisions. He states that the growth of freight traffic is the result of a complex interaction between decisions made at these levels.

PARAMETERS

There cannot be found a clear definition about parameters of a logistics strategy within literature. Within the authors view, parameters can be defined as important "parts" of a logistics strategy when developing it with influence on transportation operations.
The literature study was based on a ranking of two papers analyzing the importance of journals based on their usefulness and citations. The first paper by Menachof et al. (2009) developed a ranking of Journals with SCM focus. Those papers relevant for transportation issues were conducted as useful for this research study and considered for research. The second paper by Kumar et al. (2004) ranked the most important journals in the logistics and transportation field. Both rankings were taken as basis for literature review. Nevertheless, due to the research, some other journals were found and added to the journal list for completeness

Table 1: Analyzed Journals

Journals	Authors	Period
Journal of business logistics	Menachof et. al (2009); Kumar et. al (2004)	1990 - 2010
International Journal of Distribution & Logisticts Management	Menachof et. al (2009); Kumar et. al (2004)	1990 - 2010
International Journal of Logisticts Management	Menachof et. al (2009); Kumar et. al (2004)	1990 - 2010
Transportation Part Research E	Menachof et. al (2009); Kumar et. al (2004)	1990 - 2010
Transportation Journal	Menachof et. al (2009); Kumar et. al (2004)	1990 - 2010
Supply Chain Management Review	Menachof et. al (2009); Kumar et. al (2004)	1990 - 2010
Supply Chain Management: An International Journal	Menachof et. al (2009); Kumar et. al (2004)	1990 - 2010
International Journal of Logistics: Research & Applications	Menachof et. al (2009); Kumar et. al (2004)	1990 - 2010
Journal of Supply Chain Management	Menachof et. al (2009); Kumar et. al (2004)	1990 - 2010
Transportation Science	Menachof et. al (2009); Kumar et. al (2004)	1990 - 2010
Journal of Tranportation Management	Menachof et. al (2009); Kumar et. al (2004)	1990 - 2010
Production and Inventory Management Journal	Kumar et. al (2004)	1990 - 2010
Transportation Quaterly	Kumar et. al (2004)	1990 - 2010
International Journal of Operations & Production Management	Menachof et. al (2009)	1990 - 2010
International Journal of Production Economics	added by authors	1990 - 2010
Journal of Transport Geography	added by authors	1990 - 2010
Transport Policy	added by authors	1990 - 2010
Transportation Review	added by authors	1990 - 2010
Supply Chain Management Reviw	added by authors	1990 - 2010

Suitable papers were analyzed within references on used books, monograph and dissertations to guarantee completeness and quality. Within these Journals and added literature, about 80 papers were analyzed and as a result nine relevant papers were identified as useful for the research aim. These papers were analyzed on describing logistical indicators affecting transportation which are basis of or influenced by logistics strategies. The named indicators were analyzed by a content analysis to summarize them into “aggregated” terms. The following table gives an overview of the mentioned logistical parameters affecting transportation.

Table 2: Parameters derived from literature

Authors	Mc Kinnon 2001	Mc Kinnon 2007	Nielsen et. al 2003	McKinnon et. al 1996	Jespersen et. al 2004	Schnell et. al 1999	Voordijk 1999	Wanke et. al 2004	Sulogtra 2002
indicator									
product design	x	x		x		x	x		
product range	x						x		
global vs. local sourcing	x		x		x	x	x		x
single vs. multiple sourcing	x		x		x	x	x		
centralised/decentralised manufacturing	x			x	x	x	x		x
centralised/decentralised distribution	x		x		x		x	x	x
Outsourcing/make or buy				x		x		x	x
frequency		x	x		x	x	x		x
flexibility		x	x		x	x	x		x
vehicle routing		x		x					
inventory management	x	x		x		x	x		
packaging	x	x							
consolidation		x		x		x			
make to stock make to order								x	

The following table gives a short definition about the different "aggregated" terms used for developing the causal diagram (Gabler, 2000):

Table 3: Description of identified parameters

product design	-
product range	-
global vs. local sourcing	procurement strategy where needed material for production is either sourced global or local
single vs. multiple sourcing	procurement strategy where material is either sourced by one supplier or multiple suppliers
centralised/decentralised manufacturing	one production plant or multiple production plants
centralised/decentralised distribution	amount of storage levels within distribution
make to stock make to order	producing with or without customer order
frequency	number of deliveries to customer(s) within a specific period
flexibility	ability and speed of a system to adapt to systemic or environmental changes
vehicle routing	transport route planning supported by algorithm or heuristics
inventory management	activities within storage processes
packaging	-
consolidation	bundling of logistical entities for using synergy effects

As mentioned above, McKinnon et al. (2003) divided four different levels of decision making within logistics, strategical, commercial, operational and functional levels. Van Goor et al. (1996) divide logistical decisions into strategically, tactical and operational levels. Within this research work, the parameters are divided into two groups: strategical and operative decisions.

Strategical decisions refer to long-term planning (Harrison et al., 2008) whereas operational level considers short term and day to day decisions. In table 4 the first 7 indicators are defined as strategical decisions, as product design, numbers of distribution centers, global vs. local sourcing etc. usually refer to longer periods than the grey marked parameters do. Nevertheless some indicators can have both, a strategic and operational level and depends on definition and research question. The developed operational indicators are influenced by strategic parameters as e.g. the decision of management for single sourcing could limit the possibilities of consolidation as well as flexibility as the company is dependent on the single supplier. Therefore we concentrate on the operative parameters and their interrelationships with the transport indicators as given a strategic decision, the operational indicators are affected and therefore directly or at least indirectly influence transportation operations.

TRANSPORTATION PARAMETERS

Drewes Nielsen et al. (2003) developed four transport indicators which are showing the impact of changes in logistics on transport. In their research they analyzed the impact of changes in logistical organization on these parameters; nevertheless these developed indicators are also functional describing the impacts on transport when changes in operational parameters of logistics strategy occur:

- Transport mode
- Transport distance
- Transport efficiency
- Transport content

Transport mode describes changes for example from lorry to rail or inland waterway transportation. The other three indicators consider a specific transport mode. Transport distance is the ratio between tone kilometers and payload of a haul. Transport efficiency – the average payload is defined as the ratio between tone kilometers and vehicle kilometers.

Transport content can be divided into the transport content of a given transport which is described by the ratio of average length of a haul and the average payload measured in tone kilometers; on the other hand the transport content of a specific good can be measured as the is the weighted sum of the transport content of all individual transports used in the process of manufacturing. For example an increase of transport content can therefore result due sourcing and marketing in a wider area or more inefficient transport (Drewes Nielsen et al., 2003).

In Comparison to the more “common” indicators of transport like vehicle kilometers and tone kilometers, the developed indicators make it possible to relate transport to a specific product or production (transport content) and give the possibility to distinguish between two aspects of growth in transport, logistical reach (transport distance) and organization of transport (transport efficiency).

As three of the transport indicators are built through “payload” and “vehicle kilometers”, these “building indicators” are implemented into the model. In a later step, the described parameters can be calculated through those two.
By improving these indicators (increasing efficiency and content, reducing distances and switching mode from lorry to rail and inland waterway) more sustainable transportation movements could be realized.

CAUSAL LOOP DIAGRAM

Causal loop diagrams (CLDs) are a kind of systems thinking tool. These diagrams consist of arrows connecting variables (things that change over time) in a way that shows how one variable affects another. Each arrow in a causal loop diagram is labeled with a "+" or an "-." "+" means that when the first variable changes, the second one changes in the same direction, "-" means that the first variables causes a change in the opposite direction in the second variable (Pegasus Communications, 2011). After picturing a causal model, the different identified loops can be on the one hand so called reinforcing loops or balancing loops depending on the number of odd and even “-“ or it is a balancing loop if there are only “+” within the loop.

Figure 1 should illustrate the point of view of the model within a business process. It should illustrate the interdependencies between the operative parameters of a logistics strategy and the transport indicators and serve as a basis for the realization of the quantitative model.

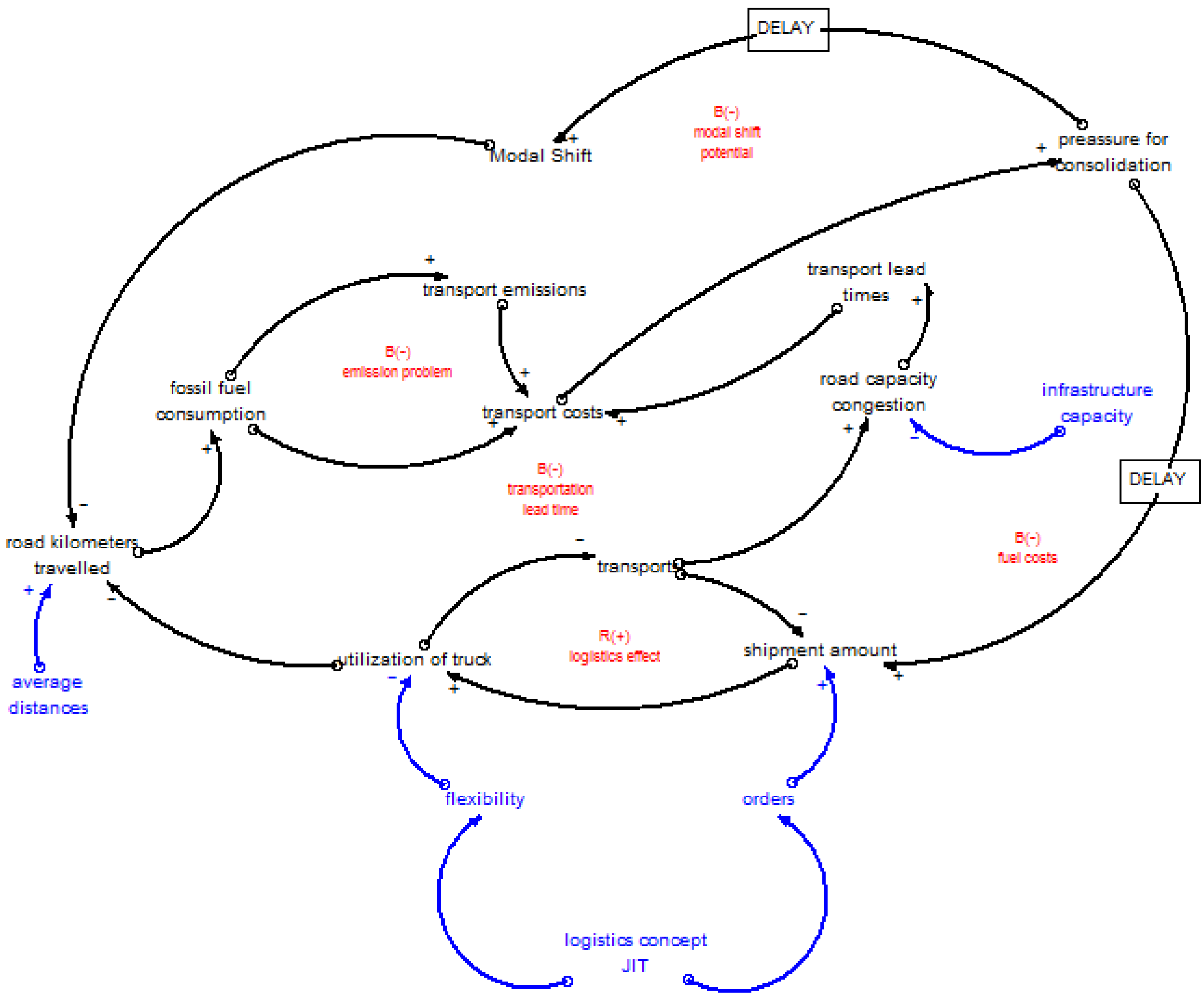

Figure 1: Basic Causal Loop Diagram

The causal diagram shown consists of 5 loops which will be described within the next section:

The first loop, called logistics effect is a reinforcing loop. The three parameters are shipment amount, transports and utilization of trucks. The shipment amount is influenced by the logistics concept (e.g. JIT) which influences the orders cycles and the flexibility of the company or supply chain. The shipment amount is influenced by the orders and depends on the released orders within a certain time period.

High numbers of order releases implicate a smaller shipment amount and vice versa. Small shipment amounts mean a low utilization of trucks whereas high shipment amounts have a positive impact on the utilization of trucks. The parameter utilization is also influenced by the defined transport flexibility of a company.

Defining a high flexibility means that a company does not care that much about the utilization of a truck and e.g. realizes transportations with even 5% of utilization.

The utilization of trucks influences the amount of transports. If the utilization is low, more physical transport movements have to be realized. If there is a high amount of transport movements, the shipment amount decreases whereas having less transports, shipment amount must be raised.

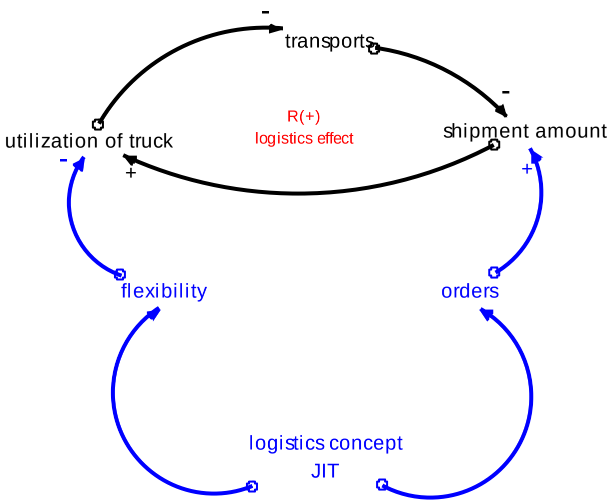

Figure 2: Logistics Effect loop

This described reinforcing loop is the facilitated picture of what we have experienced in road freight transportation within the last 20 years through the introduction of inventory reducing logistics concepts. Nevertheless, transportation and industry face now several new challenges and this reinforcing loop is influenced by the four so called balancing loops.

The first balancing loop is called the “fuel cost loop” and has the following parameters and influences. The percentage of utilization influences the transport distances travelled. This parameter is also influenced by the physical distance between the company and the supplier or costumer. If we have a distance of e.g. 100 km and a utilization of 100% only 100 km are traveled. If utilization is reduced to 50%, 200 km have to be travelled, 10% mean that 1000 km have to be travelled ins sum and so on. The higher the amount of distance travelled, the more the fuel consumption is. This raises the transportation costs (especially if fuel price rises through crises or introduction of new taxes etc.). If transportation costs increase the pressure to consolidate also rises. If this consolidation pressure increases the shipment amount will also be increased through e.g. bundling. This influences the reinforcing loop “logistics effect”.

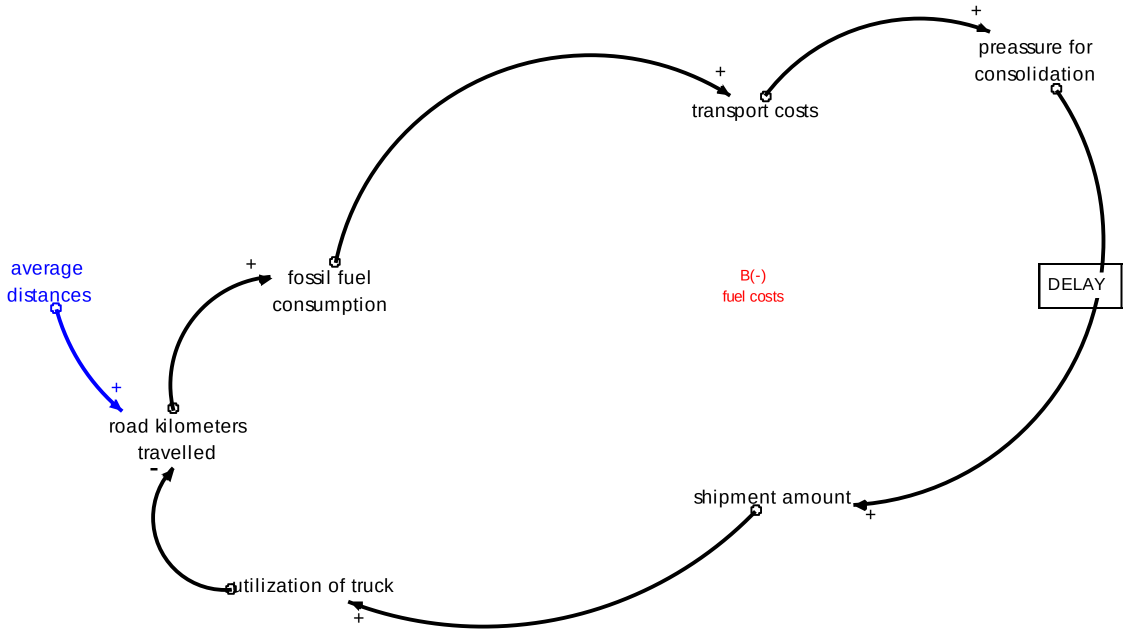

Figure 3: Fuel Costs loop

A very similar effect is the second balancing loop "emissions costs". As described in the second loop the higher the amount of travelled distances, the higher the emissions of the trucks are. Although we do not have realized an emission tax yet, and have not internalized the external costs of transportation, a future tax on that is very probable. Therefore this will also have huge influences on the transportation costs in future. If transportation costs rise, we can find the same effects as described above, the pressure to consolidate will also rise and therefore measurements to increase shipment amount should be implemented.

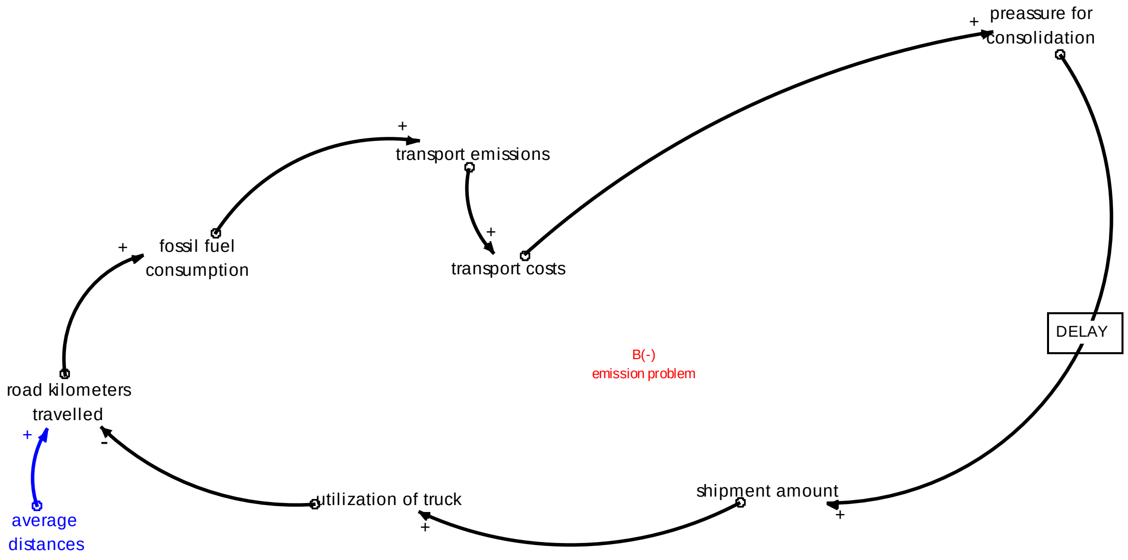

Figure 4: emission Problem loop

The fourth loop of the general model is the balancing loop “transportation lead time”. If the number of transports (truck on the road is high) the risk of being affected by congestion, accidents etc. is crucial. This means a loss of time and planning uncertainty. Nowadays loss of time means loss of money and this has also a huge effect on transportation costs. The bottlenecks and infrastructure constraints on road are an important issue in the future and definitely have to be considered. Having a lot of low utilized trucks running on road infarstructure will also increase the transportation costs and leads to an increase of pressure to consolidate and to increase shipment amounts.

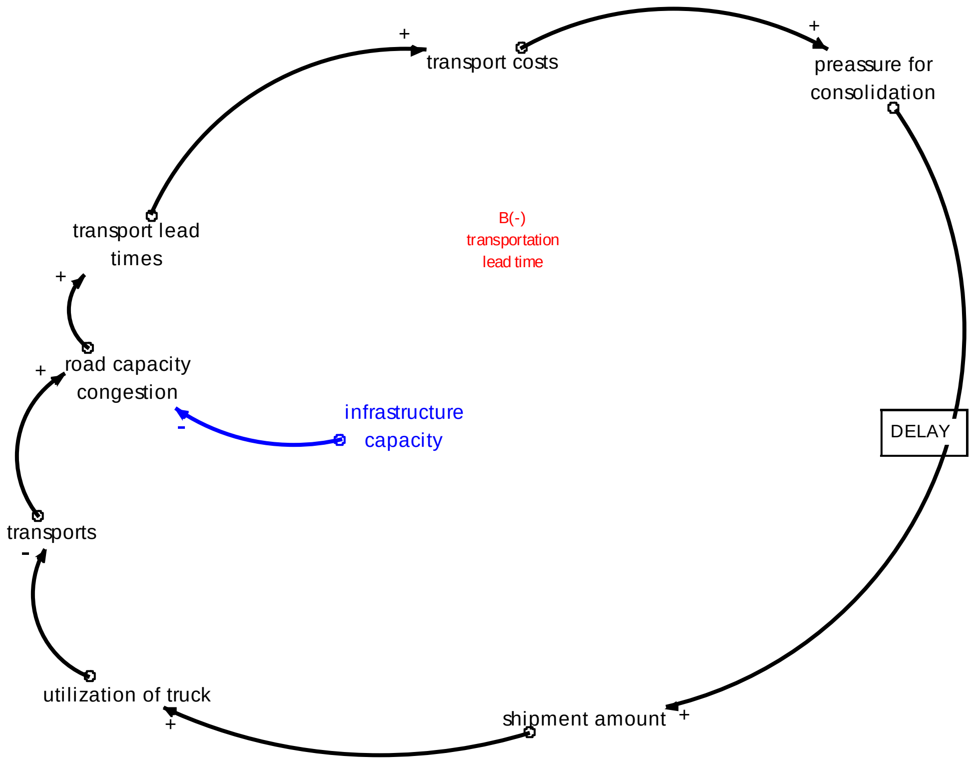

Figure 5: Transport Lead Time loop

Another important aspect is that if the pressure to consolidate increases, the possibilities of a modal shift could be implemented. This balancing loop defined as "modal shift potential" has the following effects. If the pressure rises up to a certain point, modal shifts from truck to rail could be realized. This would reduce the transport kilometers by road. It is clear that also rail consumes energy but rail is a more environmentally friendly transport mode than truck is. This can help to reduce the pressure to consolidate.

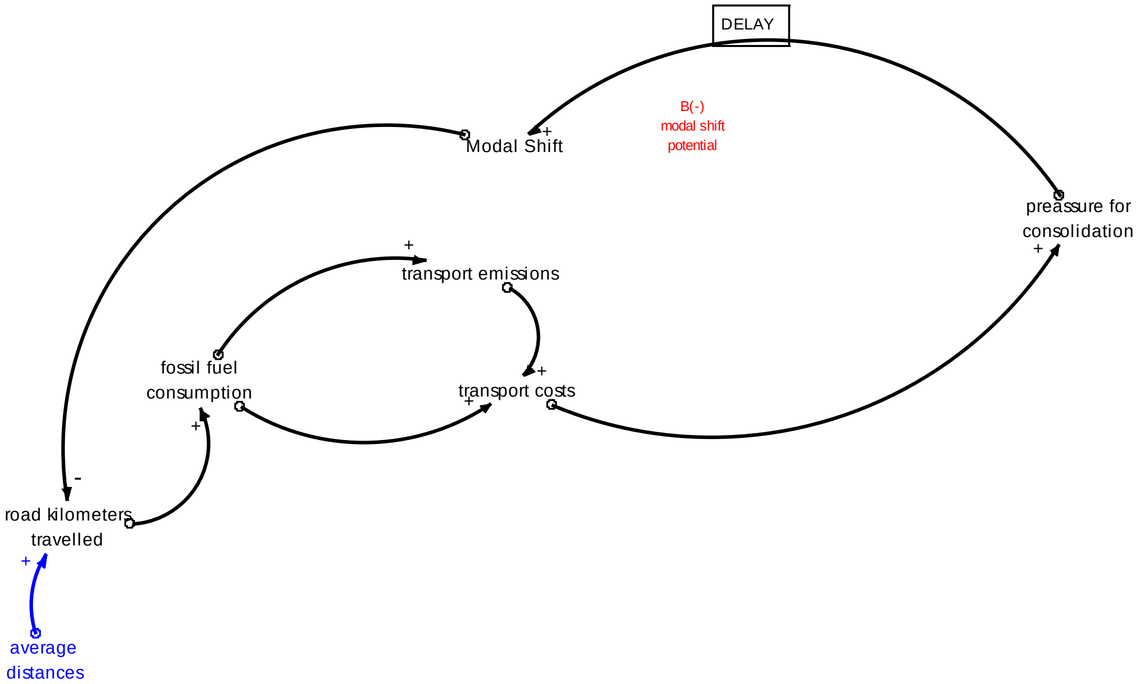

Figure 6: Modal Shift loop

Generally it is clear, that consolidation and modal shifts cannot be realized immediately. Consolidation within truck transportation is easier and faster to realize than modal shifts to train. Such concepts need a longer preparation time. However if realized the positive effects dominate.

STOCK & FLOW MODEL FINDINGS

Based on the causal loop model the quantitative stock and flow model was developed. The model counts about 100 variables. This model was tested and validated to guarantee plausibility via the suggested validation process by Sterman (2000). Used data was collected by two different companies from steel industry. In general six different cases were collected. Out of these six examples, six basic scenarios were developed for comparison with experiments and scenarios. Results of the simulations validated the model and provided a good understanding of the current situation. The model was also tested by well-defined fictive examples, realistic but not coming from a real case. These fictive examples were mostly designed for validation and getting an understanding of the model and its behavior.

The results of the model can be clustered according to two different issues which were analyzed by using different sorts of scenarios. The first part considers experimentation with the eight identified logistic and transport parameters.
Within these experiments, only one parameter was changed whereas the others were held constant. The second part deals with the development of three different scenarios which were compared to the basic scenarios.

Concerning the experiments, the following first findings could be found. The variation of one of the eight parameters showed that especially order releases, truck capacity, cost changes, shifting potential and flexibility have specific influence on model behavior. The other three parameters transport distance, road infrastructure capacity and CO2 tax have a predictable or logical influence on the model. This means that if transport distance and CO2 tax are increased, all key performance indicators show increasing behavior. The same holds for road infrastructure capacity. If this parameter gets lower, the model behaves as it is to be expected. Therefore the emphasis within the scenarios was concentrated on the five parameters mentioned above.

The three developed scenarios differ by the following assumptions. The first scenario analyses, compared to the basic or “as is” scenario, the behavior of the model if all observed identified parameters are increased. This means that, costs grow per year significantly, as well as flexibility is high, transport capacity increases over time, no or only low shifting possibility exits and order releases are very high.

The second scenario can be described as the vice versa compared to scenario one. Here costs increase only by 1% per year. Low order releases, high shifting potential, increasing truck load capacities as well as low importance of flexibility.
The third scenario called moderate scenario, concentrates on moderate increases of costs, moderate existing shifting potential, moderate order releases, flexibility as well as truck load capacities.

The overall first results of the analysis of the three scenarios can be described as follows:

The most important identified parameter is flexibility. If this parameter is changed, a behavior of oscillation can be identified. Nevertheless the parameter of flexibility and its empirical existence suffers still from gaps in research although this parameter is a crucial factor within the creation of sustainable and efficient transport movements.
The parameter shifting potential plays also an important role when trying to sustain freight transport flows. Another interesting finding is that if shifting potential is high

and companies shift a specific amount of their transports to rail, utilization degree of tucks does not suffer. This means that companies in the scenarios still try to get high utilization degrees of trucks transports although they also shift to rail.
Observed results from the cost development shows, that high increases put pressure on companies to be more efficient within their transport operations. The results from moderate increases (15% per year) and low increases (1% per year) are at least the same. Therefore, if public authorities e.g. increase toll costs on highway, the rise must be significant. If it is not above a specific percentage the expected effects cannot be realized.

The change of truck capacities between 24t, 44t and 60t shows that through consolidation measures, at the end of a specific scenario period, the degree of utilization within higher truck load capacities is not completely reached but reaches a close percentage. It could also be found that higher load capacities do not hinder companies to shift if possible to rail. Within this model, the fear that e.g. the introduction of a "gigaliner" would have negative effects on shifting to rail could not be approved. Companies still try efficiency measures, through both consolidation and shifts.

The effects of high and small order releases have especially a close interrelation with truck load capacity. Usually high order releases implicate smaller shipment sizes. Nevertheless the results of the different scenarios do not give clear relations.
A closer look on this parameter has to be taken, as within the scenarios results vary in the observed industry examples. It can be concluded that high or low order releases do not lead automatically to high shipment amounts and utilization as well as higher shift measures to rail. The results vary among the different values of the other identified parameters. A closer look has to be taken on that parameter and its interdependencies with the other parameters.

CONCLUSIONS

This papers aim was to describe the interrelationships between logistics strategies and transportation. After deriving a definition of a logistics strategy, strategic parameters of a logistics strategy were identified via a broad literature review. The identified parameters were divided into strategic and operative parameters. Those with a strategic focus are treated as constant or already "given" for the developed model whereas the operational parameters are treated as those influencing transportation indicators and directly result from the strategic ones. These indicators were linked to each other by the development of a causal loop diagram. The developed causal diagram consists of 5

loops and is the basis for the quantitative model which was validated to guarantee plausibility.
With this model, experiments and scenarios where built based on industry cases. The first findings give an interesting view into the behavior and interrelations of transport parameters and logistics parameters.

This research work should contribute to the field of logistics operations and the environment. The quantitative model should be a starting point for the transformation of measurements for industry within the next research steps as well as a basis for discussion for scientists in this research field.
Practitioners from industry should benefit by the model through having a tool which shows them the different effects on transportation and the environment by decisions within their logistics strategy.

The model should be a further step in trying to picture and model the interrelationships between logistics, transportation and the environment with the overall goal of increasing efficiency as well as the realization of the possibilities to switch from truck to train. This would be a useful contribution for both industry and operations management science.

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