The modal shift potential of intermodal line-trains from a haulier's perspective

Drivers and barriers in the mode choice process

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Abstract

Intermodal line-trains operating in corridor network designs are regularly promoted a means for intermodal transport to compete on transport costs and time with all-road transport for distances shorter than 500km. The purpose of this paper is to identify existing drivers and barriers to the usage of time and cost competitive intermodal in the decision making process of road hauliers who in many cases make the modal choice, i.e. deciding whether to outsource long-distance haulage to rail as an alternative to producing road haulage itself.

This paper addresses the complexity of the mode choice that is often stressed in mode choice literature but more seldom explained. It looks into the potential of using an intermodal line-train for the long-distance transport of consolidated cargo between a forwarder's terminals. In a multiple case study, the operations of four hauliers contracted by two forwarders in Sweden for the long-distance transport on two domestic routes (Göteborg – Malmö and Örebro – Stockholm) are assessed. In semi-structured interviews with four hauliers and two forwarders the drivers and barriers in the mode choice process for a modal shift are analysed.

The results indicate that consolidated cargo is generally suitable for intermodal transport, but for outsourcing the long-distance haulage to rail the road hauliers face significant obstacles. The main barriers are a vehicle fleet that is not adapted for rail transport as well as small transport volumes and time-intensive terminal access that do not allow efficient PPH. Hence, in the current industry structure the modal shift potential for consolidated cargo is limited. New business models may be needed to reach transport volumes that allow efficient PPH operations, which in turn may lead to reduced business for road hauliers.

What is original/value of paper?

Keywords: decision making, haulier, intermodal transport, linertrain, modal shift, Sweden, sustainable transport

1 Introduction

The general problem of intermodal transport is its competitiveness in relation to all-road transport. One significant factor that limits the competitiveness of intermodal transport is inefficient pre- and post haulage (PPH) operations between the intermodal terminal and the shipper or receiver (Walker 1992; Morlok, Sammon et al. 1995; Niérat 1997). In Europe, most PPH operations around inland terminals have a distance of usually not more than 25 km, only a few trips exceed a distance of 100km (Kreutzberger, Konings et al. 2006). Despite this relative short distance in relation to the rail haul, PPH can be responsible for up to 40% of the total transportation cost (Bontekoning, Macharis et al. 2004; Woxenius and Bärthel 2008). Consequently, intermodal transport is usually only competitive in distances longer than 500 km. Intermodal transport can be competitive in distances between 250 and 500 km if the conditions are right (Flodén 2007), but the profitability decreases if PPH distances are too big or in case of detours in relation to the door-to-door road transport to reach an intermodal terminal (Bergqvist, Falkenmark et al. 2010). A higher geographical coverage of intelligently linked intermodal terminals is therefore a pre-requisite for intermodal transport to compete on relatively short distances (Bergqvist, Falkenmark et al. 2010). Intermodal line-trains operating in corridor network designs with intermediate stops between the start and end terminal are regularly promoted by intermodal transport researchers as a means to compete on transport costs and time with all-road transport for transport distances shorter than 500 km (Rutten 1995; Rudel 2002; Bärthel and Woxenius 2004).

Flodén, Bärthel et al. (2010) reviewed the literature on modal choice and conclude that most research is done on mode choice of the shipper. After ensuring that the quality requirements are met most of the decision are made based on price. However, The mode choice is not all determined by customer requirements. In many cases it is the road haulage company which makes the modal choice, i.e. deciding whether to outsource long-distance haulage to rail as an alternative to producing road haulage itself. The major issue for the hauliers is how to achieve high resource utilization in providing the transport quality demanded by the shippers and an alternative to producing road haulage itself is to outsource the long-distance haulage to rail, and hence only producing PPH. Sommar (2006) studies the transport mode choice of road hauliers and concludes that the mode choice is also affected by factors not directly related to transport costs and time. It is often determined in the decision on what resources to acquire and all-road transport is often the chosen alternative due to the lack of time flexibility of conventional intermodal transport, which is characterised by a highly concentrated rail network with a relatively small number of nodes focusing on a limited number of high-volume corridors.

Intermodal line-trains offering a higher time flexibility and geographical coverage in a future scenario would change the preconditions of the road haulier's mode choice. Accordingly, the purpose of this paper is to identify existing drivers and barriers to the usage of time and cost competitive intermodal in the decision making process of road hauliers.

This paper is based on a case study of four hauliers in Sweden. The paper is structured as follows. The next section introduces the concept of intermodal transport in general and the intermodal line-train in particular. Section 3 develops a framework for the road haulier's mode choice process. This framework guides the case study analysis, which is presented in Section 4. Section 5 discusses existing barriers to modal shift from a haulier's perspective. The final section presents the conclusions.

2 Intermodal transport

2.1 Conventional intermodal transport

Intermodal transport is the combination of two or more transport modes in one transport chain. The fundamental idea behind intermodal transport is that the service and cost advantages of each transport mode are joined together in order to improve the overall efficiency of the transport system (Jensen 1990). The by far biggest distance is performed by large-scale transport modes like rail, inland waterways, short sea shipping or ocean shipping where the units are consolidated with other shipments and economies of scale are being achieved. Road transport is assigned to the short-haul, or collection and distribution of freight. Intermodal transport thus increases the reach of the larger modes of sea and rail and enhances the efficiency of the transport system.

Different options for intermodal rail network design are discussed by several intermodal transport researchers (Bontekoning 2000; Ballis and Golias 2004; Woxenius 2007). Although the research has not arrived at common definitions yet, all researchers distinguish several basic network designs. Woxenius (2007) defines six significantly different theoretical designs from the perspective of a transport system operator: direct link, corridor, hub-and-spoke, connected hubs, static routes, and dynamic routes (Figure 1).

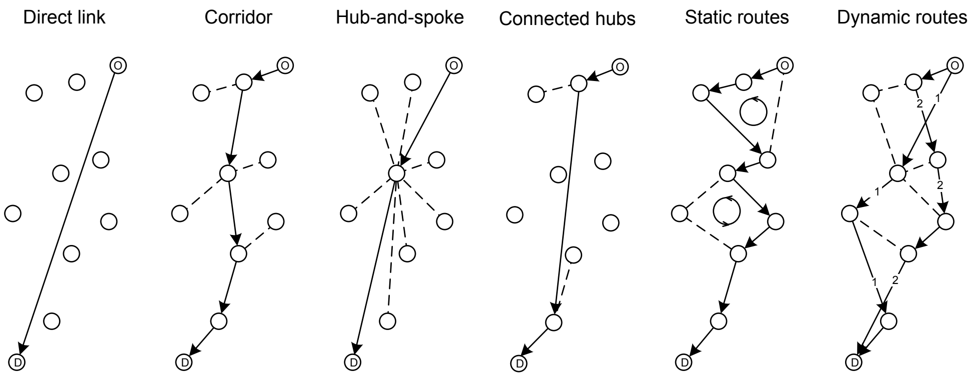

Figure 1 – Six options for transport network design. Source: Woxenius (2007)

Direct links are the best rail product wherever full trainloads with the required frequency can be organised. In this setting intermodal road-rail transport is easy to operate and provides good transport quality and economy for transport flows over long distances. Hence, night-leaps directly between large-scale transhipment terminals using gantry cranes and reach stackers is the dominating production paradigm in Europe (Bärthel and Woxenius 2004). The need for rationalising of the railway sector, competition from road transport and the high purchase and exploitation costs of terminal equipment have encouraged a strategy aiming at increasing the economies of scale and abandoning intermediate transhipment or shunting (Trip and Bontekoning 2002). According to Woxenius and Bärthel (2008), the trend of abandoning networks and instead focusing on direct links between major conurbations and ports continues, and Gouvernal and Daydou (2005) find that the use of dedicated trains has increased dramatically in the U.K. Also Woodburn (2009) states that most intermodal freight flows in the U.K. are operated as direct trainloads from terminal to terminal.

Since most freight flows on road are transported over shorter distances and/or are too small to facilitate full trains, the market potential of intermodal transport is limited. According to an analysis made by Lammgård (2007) shippers in Sweden see only limited possibilities to implement modal shift measures due lack of quality of today's intermodal road-rail transport services. This is supported by Rich, Kveiborg et al. (2011) who show in an analysis for the Scandinavian region that a majority of all transports less than 500 km have truck as the only alternative. This imposes a strong inelasticity for modal shift for shorter trips for which truck is the dominant option. In order to compete in the road sector's home ground, i.e., in the transport market for semi-finished and manufactured goods at the relatively short distances of 200-500 kilometres, alternative network and terminal designs are needed.

2.2 Intermodal line-trains

2.2.1 Intermodal line-trains in practice – The Swedish Light-Combi project

Line-trains are often proposed as a measure for competing in the market segment characterised by small volumes or short distances. A *short distance* is here regarded as shorter than the 500 kilometres, often mentioned as the break-even distance for European IFT and a *small volume* refers to a volume less than economically viable for direct trains (Woxenius 2007). A typical line-train that covers the intermediate markets would stop for transhipment for 15 to 30 minutes approximately every 100 kilometres, hence facilitating shorter PPH.

The intermodal line-train is, however, not a new invention. Except for passenger intercity services it was used for intermodal transport in Japan (Woxenius 1998), Switzerland (Rudel 2002), and some hinterland shuttles stop on route to or from the Port of Gothenburg. Furthermore, in the Swedish Light-Combi project intermodal line-trains were operated between 1998 and 2001. To recapture markets abandoned by wagonload and conventional intermodal transport the Swedish rail operator Green Cargo started the development of an intermodal service for small and dispersed flows in 1995. The Light-Combi service was introduced as a commercial pilot distributing groceries for a wholesaler. The pilot was based upon two line-trains serving intermodal terminals connected by lorries to 37 grocery stores.

The evaluation of the pilot showed that the Light-Combi concept fulfilled in practice most of the commercial and technological requirements and demands. The concept worked technically (transhipment under catenaries using simple and conventional technology) and logistically (timetable with several intermediate stops at unmanned terminals for overnight deliveries) well in the applied scale. The retailer valued the service quality higher than the previous road alternative. Economic deficiencies were that mean rail distances were short, the load factor in the loops was low as 30-35% and road distribution distances were long. For some relations 70% of the total costs were terminal handling and distribution costs (Bärthel and Woxenius 2004).

The pilot was not expected to prove economic profitability but there were concerns that the concept would be profitable even in larger scale. When the agreement was to be renegotiated after three years the retailer and the project team highlighted the high transport quality and environmental performance, but the decision makers negotiated on the basis of traditional transport services without taking the added values into account. Prices were pressured downwards by potential competition from a haulier with backhaul capacity offered at marginal costs. Green Cargo could not match the competing road-based forwarders and the last train ran in April 2001.

2.2.2 Line-train implementation barriers

Line-train services are rarely offered in Europe since the operation of line-trains is challenging. The intermediate terminals must be inexpensive yet efficient not to incur too much time loss and cost, which would deter shippers as elaborated by Bontekoning and Kreutzberger (2001). They found that this requires substantial improvement of the cost-quality ratio. Incremental improvement of conventional terminals and related shunting operations do not suffice. Instead they consider side-track terminals where unit loads can be transhipped under the overhead contact wire more promising. In recent years/decades inventors have designed numerous sophisticated terminal concepts for rapid and efficient handling, which waked the hope to significantly reduce the impedances of consolidation and to justify the operation of innovative networks (Kreutzberger 2010). However, despite the potential and positive outcomes of technological and economic feasibility studies they share the feature of not being used commercially in a large scale (Bontekoning and Priemus 2004). Most technologies are still in the development phase of a blue-print or prototype, and many are now abandoned by their inventors.

The implementation problems are often attributed to technological as well as organizational complexity of intermodal transport characterised by a wide variety of activities, actors and resources. Implementing rail innovations serving entire networks requires a shift of this intermodal organisational paradigm (Rudel 2002; Bärthel and Woxenius 2004), which currently typically reflects mass production principles applied to transportation on the basis of economies of scale (Bontekoning and Priemus 2004). This paradigm shift remains problematic, since various players are required to cooperate and the interrelated system components have to be replaced at the same time (Bontekoning, Macharis et al. 2004). Rail operators still focus on cost reductions and efficiency improvements on single routes instead of entire networks (Kreutzberger 2010). Wiegmans, Stekelenburg et al. (2007) argue that the business opportunities of innovative rail services based on entire networks end up at the rail operator while the investments have to be made by the terminal operators. Hence, implementing rail innovations is not only a matter of simply replacing the transhipment technology but also imposes significant inter-organisational challenges.

3 The road haulier's mode choice decision making

Generally, decision making in freight transport can be classified into the three planning levels: strategic, tactical and operational. The strategic level broadly shapes the logistics structure and sets the general guidelines for decisions taken at the tactical level, which determines goals, rules and limits for the operational level (Crainic and Laporte 1997). According to Jonsson (2008) these decisions differ in scope and time perspectives. Strategic decisions are targeted at the conditions for future high performance systems. They concern the organization of systems and contain policy related standpoints. Furthermore, they affect resource investments and influence the relations to external players. The decisions are therefore long-term and may reach several years into the future. Tactical decisions are aimed at increasing the performance of the organization through reorganizing and developing internal resources. Tactical decisions have a medium-term perspective. Short-term decisions are operative decisions that are targeted at creating high performance within the existing resources of an organization. In this section the road hauliers' decisions relevant for the modal choice on the different levels are analysed.

3.1 Strategic level

Decisions on the **strategic level** have a long-term focus and include the investments in transport resources, i.e. decisions on *capacity and capability of the vehicle fleet*. The decisions on which transport resource to acquire are guided by the market requirements, e.g. in form of timing of delivery, operations resource capability, e.g. freeze capacity, removable side or adaptation to intermodal transport, and costs (Sommar 2006).

<u>Capacity and capability of the vehicle fleet</u>

The market requirements guide the decision-making on what type and how many transport resources to acquire. The shippers' transport volumes and the required quality of service determine the amount of transport resources that a haulier needs to produce the service. Once a transport resource is acquired it is expected to roll seven or eight years on long-distance relations. Since the length of transport contracts is shorter than this write-off period, general expected rather than specific product characteristics guides the investments (Sommar 2006).

In domestic long-haul traffic a lorry with a truck body with an attached trailer (a 24 metres vehicle combination) is most common (Lumsden 2006). This vehicle combination cannot be used in an intermodal transport chain, since the division of tasks between short haul on road and long haul on rail requires standardised load units facilitating the transhipment between road and rail. These intermodal load units need to comply with strength parameters, resulting in additional investments and slightly higher tares and thereby lower payloads (Vrenken, Macharis et al. 2005).

In domestic intermodal traffic mainly lorry and trailer with swap bodies as well as tractor with semi-trailer are used (Vrenken, Macharis et al. 2005). Hauliers in Sweden consider both vehicle combinations for their intermodal transport (Sommar 2006). Two swap body classes are distinguished: For the carriage on road trains swap bodies with lengths of 7.15, 7.45 and 7.82 metres are used. For articulated vehicles swap bodies with lengths of 12.50 and 13.60 metres are the most important (Vrenken, Macharis et al. 2005). For semi-trailers the typical length is 13.60 metres.

3.2 Tactical level

Tactical decisions have a medium-term time horizon and aim at adequate allocation and utilisation of existing resources resulting in a transportation plan that achieves the best trade-of between operating cost and service performance (Crainic and Laporte 1997). Tactical planning of hauliers aims at establish an efficient flow of transport resources on their specific transport relation, i.e. creating a transport plan that deals with the issues of *service network design* and *crew and motive power scheduling* (Sommar 2006).

Service network design

The planning of the service network design concerns the selection of the routes (origin and destination, physical routes and intermediate stops) and the determination of the characteristics of each service, particularly frequency (Crainic and Laporte 1997). In a transport network different options for transporting a shipment from origin to destination exist. The easiest and usually fastest option is a direct service between origin and destination. However, if transport demand is low the service can only be operated with low resource efficiency and/or low frequency. It may therefore be more efficient to consolidate the shipment with freight to other destinations and operate the service with intermediate stops. This would result in a higher frequency and/or a higher resource utilisation but at the cost of additional loading operations and longer transport time.

Furthermore, there is often an imbalance between freight demand and supply and hence vehicles have to be moved empty in order to bring them where they will be needed to satisfy known demand. These empty vehicle movements are essential to continuing operations but they do not directly contribute to the profit of the firm (Crainic and Laporte 1997). To avoid empty return trips triangle round trips combining three origin/destination pairs can be designed.

Crew and motive power scheduling

Transport resources and drivers need to be allocated to the services defined in the transport plan. Sommar (2006) analyses the crew and motive power scheduling of two hauliers in Sweden and he shows that trucks are scheduled to drive on a preset route with some typical stops and arrival or departure times that structures the route on the long-distance relation. The goal is to enable stable driver schedules that allow a round-trip within the working time of the driver in order to save the allowance for expenses when the drivers are away from the home city. The setup can either be point-change, i.e. when the drivers with a vehicle from each city meet somewhere along the way to switch vehicles and the drivers drive back to the origin city, or complete trip, i.e. the same driver drives the vehicle the whole distance. The point change option requires timely departure of vehicles from both cities, but the advantage is that the driver is in his home city at the end of his work shift. The complete trip option does not require any planning with other vehicles but may require allowances in case the round trip cannot be conducted within one work-shift.

3.3 Operational level

Short-term **operational decision-making** aims to ensure that customer demands are met and the resources are efficiently used. Strategic and tactic plans can be drawn to guide operations but the operational capabilities of the firm will ultimately determine its performance (Crainic and Laporte 1997). For the hauliers, decision making at the operational level implies carrying out and adjusting the transportation plan according to prevailing circumstances. This mainly concerns handling fluctuations in demand (Sommar 2006).

3.4 Intermodal transport from a haulier's perspective

The basis for the mode choice of hauliers is largely determined on the strategic level in the decision of what resource to acquire (Sommar 2006). The focus is mostly on operational flexibility to be able to meet all customer demands rather than on costs. Explicit customer demands for intermodal transport is low. Road transport is then considered the best mode and consequently the resources are not adapted to intermodal transport. Intermodal transport is only used for daily varying volume demands. According to Liljestrand (2010) this approach is commonly known as the "rubber band" strategy, facilitating a stable demand for both trucks and staff resulting in a high utilization rate for the expensive resources. If intermodal transport is used it is booked on short term with the intermodal rail operator.

However, there are also hauliers aiming to utilise the cost advantages of intermodal transport (Liljestrand 2010). These hauliers have outsourced the long-distance haul to rail. They produce themselves only the PPH and the daily varying volume demands and consequently they require less transport resources and drivers for producing the services. Hauliers in this category have pre-booked capacity with the intermodal rail operator.

A pre-requisite for enabling a modal shift are transport volumes that are big enough to fill the intermodal load units, since co-loading of other consignments along the long distance haul by rail is not possible. Furthermore, the scheduled points of time for departure and arrival need to be in line with the night-jump production model of intermodal transport. Transports that require more departures per day are usually not suitable for intermodal transport, which usually offers one departure in the evening and arriving in the early morning.

An additional challenge for hauliers when switching to intermodal transport is achieving a good resource utilisation. PPH trips are shorter and fragmented (early morning and late evening) than the all-road operations. The numbers of PPH operations and matching inbound and outbound freight (i.e. rate of empty hauls in PPH) are crucial factors to achieve steady working hours for their drivers and expensive resources (Niérat 1997; Kreutzberger, Konings et al. 2006). Table 1 summarizes the mode choice decision factors and their impact on the modal shift potential.

Table 1 – Mode choice decision factors and requirements for modal shift

Decision factor	Requirements for modal shift
Strategic level	
Transport volumes	Several load units, stable volumes, balanced flows
Transport resources	Applicable for intermodal transport
Tactical level	
Network design	Direct transport of full loads
Timing and frequency	Night jump
Transport time	Slack time for PPH and transhipment
Driver and motive power scheduling	High resource utilisation in PPH operations

4 Intermodal transport for consolidated cargo – A case study

This case study analyses the potential of intermodal transport for consolidated cargo within a freight forwarder's transport network for which transport time and punctuality are very crucial. Since the inherent transhipment and PPH of intermodal transport implies a certain handicap in cost and time against all road transport, intermodal transport is usually only used on distances that all-road cannot cover in one night jump. For distances that can be covered by road transport in one night-leap (usually up to 700km), intermodal transport is not competitive. Over distances shorter than 400 km there is enough slack between pick-up in the late afternoon and the delivery in the early morning to compensate for PPH and transhipments (Sommar and Woxenius 2007). This case study looks into potential of using the services of an intermodal linertrain of two relations in this distance class in the network of two freight forwarders.

Woxenius, Andersson et al. (2004) propose a small-scale fine-meshed intermodal transport system in Sweden based upon line-trains, which matches the technical and operational characteristics of the network operation principles and freight flows of a large forwarder in Sweden. The forwarders currently base their operations mainly on all-road transport and the study indicates that rail can take a significant share of the long-distance haulage between the forwarder's terminals, fulfilling demands regarding transport time. The goal of this case study is to identify potential drivers and barriers in the mode choice process of the road hauliers, which are not related to cost and time.

4.1.1 The freight-forwarders' consolidated cargo network

The Swedish market for consolidated cargo is dominated by the forwarders Schenker and DHL. With approximately 80% of the market they form an oligopoly and they also maintain strong positions in the segments of part loads and full loads. According to Sommar and Woxenius (2007) consignments too small for economically justifying direct transport are either transported as part loads (over 1000kg) or consolidated cargo (less than 1000kg). Part loads are picked up and delivered in sequence with other part loads and the consignments stay on the same lorry while transport of consolidated cargo is based on sorting at consolidation terminals. The consolidated cargo service is then produced by a number of sequential activities; pick-up during the afternoon, sorting and consolidation of consignments at a departure terminal in the early evening, long-distance transport during the night, sorting of consignments at arriving terminal in the early morning, and, finally, delivery during the morning.

Between terminals hauliers are contracted for the long-distance transport and one haulier can be responsible for several of these long-distance relations. The contracted haulier decides whether to use own lorries or, in turn, subcontract the long-distance transport to intermodal operators (Figure 2).

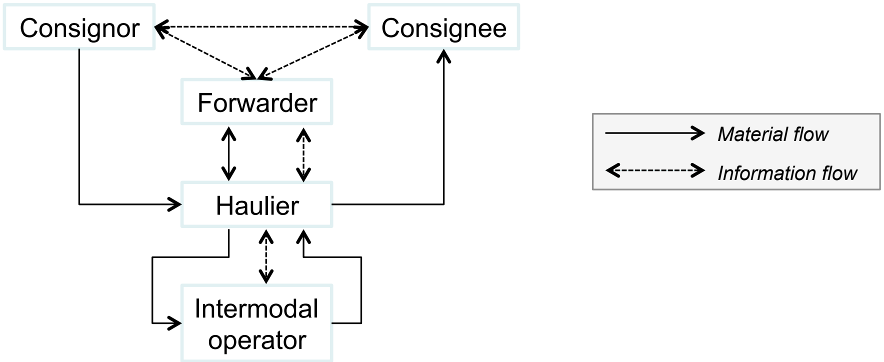

Figure 2 – The haulier as the mode deciding firm

4.2 Case description and data collection

This case study analyses the long-distance operations of two lines in the freight forwarders networks, i.e. Göteborg – Malmö and Stockholm – Örebro, for which conventional intermodal transport is usually not available or not a competitive alternative. Each forwarder has contracted one haulier for each relation, so in total four hauliers operate these long-distance transports. The distance between Göteborg and Malmö is approx. 280 km and the hauliers operating on this relation are denoted *Haulier GM1* and *Haulier GM2*, the hauliers operating between Stockholm and Örebro (approx. 200 km, depending on the location of the forwarders terminal in the Stockholm region) are denoted *Haulier SÖ1* and *Haulier SÖ2*. Figure 3 shows a possible network of intermodal line-trains connecting these destinations as suggested by Woxenius, Andersson et al. (2004). It is assumed that the line-trains provide the same transport quality and economy as the all-road alternative. In semi-structured interviews, based on the mode choice factors developed in the previous section, with one forwarder and the four contracted hauliers on the lines Göteborg – Malmö and Örebro - Stockholm, the drivers and barriers in the mode choice process for a modal shift are analysed.

Figure 3 - The two analysed corridors

4.3 The current road transport operations

4.3.1 Strategic level – Transport volumes and resources used

Haulier GM1 transports approximately 6 TEU consolidated cargo between Gothenburg and Malmö in both directions. Two truck and trailer combinations (a lorry with a truck body with an attached trailer 24m long) are used. Out of these load units one trailer is capable of being used for intermodal transport. *Haulier GM2* transports approximately 3 TEU in both directions, including both consolidated cargo and part loads. Two truck and trailer combinations are used.

Haulier SÖ1 transports approximately 3 TEU of consolidated cargo between Örebro and Stockholm and uses one truck and trailer combination for this. From Stockholm to Örebro there are less volumes of consolidated cargo, only filling the trailer. The truck then is filled with other goods, not belonging to the freight forwarder.

The forwarder for which *Haulier SÖ2* transports consolidated cargo has two consolidation terminals in Stockholm (Terminal A, north of Stockholm and Terminal B, south-east of Stockholm). Each terminal is served by one truck and trailer combination from Örebro, hence in total 6 TEU of consolidated cargo are transported between Örebro and Stockholm. Approx. half of that is transported between Stockholm and Örebro, i.e. filling one truck and trailer combination.

For all hauliers the amount of goods is rather stable; there are no significant variations, which would require adjusting the number of trucks and load units.

4.3.2 Tactical level – Network design and scheduling of staff and transport resources

The long-distance transport between the forwarders' consolidation terminals is operated as direct transports, i.e. consolidation with other goods on the way between the consolidation terminals does usually not take place. *Haulier GM1, Haulier SÖ1* and *Haulier SÖ2* operate the transports as shuttles between the one origin and destination. *Haulier GM2* operates a triangle network, combining the Gothenburg-Malmö transport with transports to and from Borås.

The timing and frequency follows the production schedule of the freight forwarders consolidated cargo service, which requires over-night transport once a day. The sorting and consolidation of consignments at the departure terminal in the evening, and the sorting of consignments at the arrival time in the morning limit the time window for the long-distance transport. The earliest departure and latest arrival times are more or less similar for all consolidation terminals. Usually, earliest departure time is between 7pm and 8pm and latest arrival time is between 4am and 5am. Hence, the time window for the long-distance transport is 8 to 10 hours, which perfectly fits the driver's work shift.

The driving time between Gothenburg and Malmö is approx. 4 hours. *Haulier GM1* operates this relation by complete trip. The fist truck leaves Gothenburg at 7pm and arrives Malmö at 11pm. After 1 hour break the truck drives back to Gothenburg arriving at 4am. This schedule implies a 9 hours shift for the driver. The schedule of the second truck has the same structure starting one hour later, i.e. leaving Gothenburg at 8pm arriving in Malmö 12pm, a two-hours break, leaving Malmö 2am and arriving Gothenburg 6pm. *Haulier GM2* operates this relation by point change, i.e. both from Gothenburg and Malmö one driver with a vehicle leaves at 7:30 pm, the drivers meet somewhere along the way to switch vehicles and drive back to their origin city arriving at 11:30pm. (What are the drivers doing in the rest of their working time? Borås?).

Due to the shorter distance of the second line Örebro – Stockholm the driving time is only 3 hours. *Haulier SÖ1* operates this relation by complete trip. The truck leaves Örebro at 7pm and arrives Stockholm at 10pm. After 1 hour break the truck leaves Stockholm and arrives Örebro at 2am. This schedule implies a 7 to 8 hours shift for the driver.

Haulier SÖ2 transports in total two truck and trailer combinations between Örebro and the two terminals (Terminal A and Terminal B) in Stockholm. The first truck leaves Örebro around 6:30pm and arrives the Terminal A around 9:30pm. The second truck leaves the Örebro terminal around 7pm with consolidated cargo for the Terminal B in Stockholm. On the other direction (Stockholm – Örebro) transport volumes are smaller only filling one truck and trailer combination, the truck filled with goods from the Terminal A and the trailer filled with goods from the Terminal B. After the truck has been filled with consolidated cargo from the Terminal A at 9pm, the truck drives to the Terminal B picking up a trailer filled with consolidated cargo from that terminal and the continues to Örebro.

4.4 Analysis - Drivers and barriers in the mode choice process

Overall the long-distance transport of the freight forwarders' consolidated cargo is suitable for intermodal transport. The transport volumes are big enough to fill intermodal loading units, hence making further consolidation with other transport tasks unnecessary allowing direct transport between origin and destination. Furthermore, the time and frequency requirements (overnight transport once a day) of consolidated cargo are in line with the characteristics of intermodal transport, which is usually operated as night jumps. Moreover, a time window of 10 hours for covering a transport distance of 200 to 300 km gives enough slack for PPH, transhipment and rail haul.

However, there are also barriers to the modal shift. The hauliers use transport resources, which are not adapted to intermodal transport. Hence, the hauliers need to invest in new resources to make the intermodal alternative a possible option. Another barrier is the scheduling of drivers and trucks. In the distance class of 200 to 300km a round-trip perfectly matches the duration of one working shift, resulting in very efficient operations. Furthermore, empty driving is avoided since both directions can be served within the work shift. Moreover, the all-road round trip take place during night, which is the preferred working time of most drivers.

A modal shift to rail would imply more fragmented operations during daytime, changing the scheduling of the drivers and trucks completely. Instead of one 8-hour-trip driving during night, two short PPH trips would be necessary at both ends: one pick-up trip of a full load from the intermodal terminal in the morning, and one delivery trip of a full load unit to the intermodal terminal in the evening. Due to the time requirements of consolidated cargo, these two trips cannot be combined, hence resulting in two empty trips. Furthermore, the big time interval between inbound and outbound freight exceeds one working shift, hence requiring two drivers, one for the morning pick-up and one for the evening delivery. Moreover, since the PPH trips are very short other transport tasks are necessary to cover the remaining time of the drivers work shift. Table 2 summarizes the drivers and barriers in the road haulier's mode choice process.

Table 2 - Drivers and barriers in the mode choice process

Decision factor	Current operation	Modal shift potential
Strategic level		
Transport volumes	Several load units, stable volumes, balanced flows	+
Transport resources	Not applicable for intermodal transport	-
Tactical level		
Network design	Direct transport of full loads	+
Timing and frequency	Night jump	+
Transport time	10 hours for 200-300 km	+
Driver and motive power scheduling	Round trip serving both directions in one work shift	-

5 Discussion

In order to use intermodal transport for consolidated cargo, the hauliers need to implement changes at the strategic and tactical level. Hence, implementing these changes has medium to long-term consequences for hauliers. However, these changes are seen as possible and potentially rewarding. Although explicit customer demand for intermodal transport is still low and transport customers don't accept a reduced delivery service, environmental factors grow in importance in transport purchasing. Intermodal transport is seen as a means to meet these growing demands in the future.

Furthermore, if the long-distance transport is outsourced to rail transport, the haulier's need fewer own transport resources to produce the same service, hence offering cost saving opportunities. Moreover, the interviewed hauliers highlighted that less drivers would be needed which can be an important factor in the future. Although currently there are enough drivers, it is expected that in the coming years there will be a lack of drivers which already existed before the economic turndown in 2008/2009. Intermodal transport therefore could be a means to deal with the potential lack of drivers. On the other hand, switching to intermodal transport implies a change of the drives' working time. While long haulage by road implies driving during night, PPH traffic is characterised by morning and evening driving in eventually congested urban areas. Since the drivers prefer night driving when traffic volumes are low it could be difficult to get enough drivers for the relatively unattractive PPH in case of a general lack of drivers.

Moreover, if the long distance transport is outsourced to rail, the haulier looses part of the control of the goods and becomes dependent on the intermodal operator. Still, the haulier is responsible for the goods and will have to compensate their customers in case of problems with the rail haul, e.g. delays and damages. Hence, a high reliability of the intermodal services is a prerequisite for a modal shift in this market segment. Yet, both the interviewed hauliers and the freight forwarder have experienced a decline in transport quality and reliability of the intermodal services. Although they do not attribute these problems to the intermodal operators but to the general lack of capacity of the rail infrastructure, the current reliability of the intermodal services increases the risk of loosing customers. Hence, the bad transport quality of rail is seen as a major barrier to a modal shift and there are doubts that the quality can be improved in the near future.

The second barrier for the haulier is the efficiency of PPH operations, since the fragmented operations involve a high share of empty driving. As shown by Kreutzberger, Konings et al. (2006) several PPH trips are required during the work shift of 10 hours to distribute the vehicle and driver costs on several transports for achieving efficiency in operations. However, the volumes of consolidated cargo for each haulier are too small to achieve several PPH trips per day. One possibility for hauliers to overcome this barrier is to match the PPH trips with other assignments of their business, e.g. with other intermodal transport tasks of different customers, and by this to increase the number of PPH trips to utilise their resources.

The time needed per PPH trip is critical in this respect, since the time window between pick-up time at the customer and terminal closing time is usually limited. It has been highlighted in the interviews that the terminal handling (e.g. check for damages) takes up to one hour per handling, hence two hours in a complete intermodal chain, which corresponds to approx. two thirds of the total driving time between Örebro and Stockholm and half of the driving time between Göteborg and Malmö.

An additional problem related to terminal access is the location of the terminals and the traffic condition on the access roads. In Stockholm the intermodal terminal is located on the ring road around the wider city centre, which is one of the most congested roads in Sweden. Hence, PPH trips take a lot of time reducing the possibility for efficient operations. Consequently the congestion on the access road to the terminal in Stockholm is seen as a major barrier to modal shift for transports to and from Stockholm.

One solution to increase the PPH efficiency is to extend the legal framework with exceptions for longer vehicles in PPH as elaborated by Bergqvist and Behrends (2010), i.e. to allow PPH of 2*40 foot or even 2 semi-trailers using only one vehicle. They found that extending the legal framework with exceptions for longer vehicles in PPH could greatly improve the cost efficiency. An additional positive effect of such a framework would be that fewer trips would be needed to transport the same amount of load units to the intermodal terminal in the limited time window.

To summarize, relatively large volumes are required to utilize the benefits of an intermodal transport system consisting of a relatively large number of small-scale terminals offering an attractive alternative to all-road transport. The forwarders' amount of consolidated cargo suitable for intermodal transport may be large enough for a modal shift, however, different hauliers are contracted on specific long-distance lines, and often one haulier being responsible for only one line (Sommar 2006). Hence, the possibilities of each haulier to shift modes might be limited. In this case the haulier's potential competition with the intermodal operator should be addressed. Instead of contracting several hauliers to handle the long distance transports, the freight forwarder may buy the long-distance service directly at the intermodal operator and contract only one haulier per terminal area handling all PPH trips to and from this terminal (Figure 4). This would imply that several hauliers would loose part of their business to the intermodal operators.

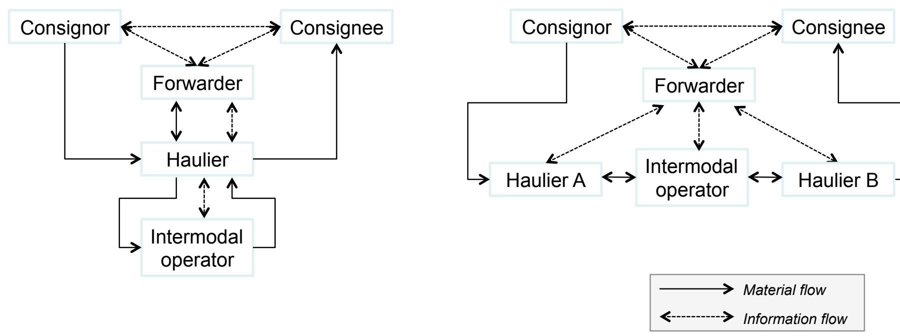

Figure 4 - Two business models (Left: The haulier as mode deciding firm. Right: The forwarder as mode deciding firm)

6 Conclusion

This paper analysed the modal shift potential of intermodal line-trains for the long-distance transport of consolidated cargo in the network of freight forwards. The results indicate that transport time requirements and the freight forwarders network design are in line with the operational principles of intermodal line-trains; hence consolidated cargo is generally suitable for intermodal transport. Furthermore, the hauliers see a modal shift as potentially rewarding due to the general environmental and cost benefits of intermodal transport but they face significant obstacles for outsourcing the long-distance haulage to rail as an alternative to producing road haulage itself.

First, investing in new transport resources that are capable for intermodal transport has medium to long-term consequences for the haulier's operations. However, the confidence in intermodal transport services is low due to the experienced decline in transport quality and reliability of the intermodal services in recent years.

Second, time is a very critical factor for consolidated cargo and the cost share of PPH in medium distance transports is high. Hence, efficient PPH operations are of outmost importance for a modal shift in this market segment. An additional barrier to a modal shift is therefore the time intensive terminal access and terminal handling which limits the haulier's ability to organize efficient PPH operations.

Finally, in the current industry structure where different hauliers are contracted by the forwarders on specific long-distance relations the transport volumes of each haulier is limited. New business models may be needed to reach transport volumes that allow efficient PPH operations, which in turn may lead to reduced business for road hauliers.

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