# EFFICIENT INTERMODAL PRE AND POST HAULAGE

*Rickard Bergqvist, Logistics and Transport Research Group, Department of Business Administration, School of Business, Economics and Law, Gothenburg University, Sweden, E-mail: rickard.bergqvist@handels.gu.se*

*Sönke Behrends, Chalmers University of Technology, Division for Logistics and Transportation, Gothenburg, Sweden, E-mail: behrends@chalmers.se, Tel: +46 31 7721323*

## ABSTRACT

The demand for inland freight transport in Europe is mainly met by road transport leading to unsustainable impacts such as air pollution, greenhouse gas emissions and congestion. Since rail transport has lower externalities than road transport, a modal shift from road to rail is an accepted policy goal for achieving a more sustainable and competitive transport system. However, intermodal road-rail transport is mainly competitive for long distance transports and as a consequence the potential for modal shift is limited.

The cost-efficiency of road-rail intermodal transport is particularly sensitive to pre and post haulage (PPH) costs since this activity typically has a larger cost mass compared to its share of the total distance of the transport chain. For intermodal transportation over shorter distances, e.g. below 300 km and where there is substantial PPH activities in both ends of the chain, the competitiveness of the intermodal transport system compared to direct road is low. Improving the efficiency of the PPH activities is therefore of outmost importance for the competitiveness of the intermodal transport system.

This paper looks into the issue of improving the cost-efficiency of an intermodal transport chain by implementing an innovative and flexible legal framework regarding the PPH activities in the chain. By extending the legal framework with exceptions for longer vehicles in the pre and post haulage the cost efficiency can be greatly improved. The purpose of such a framework is to allow and enable for PPH of 2*40 foot or even 2 semi-trailers using only one vehicle in the context of Swedish regulatory framework. Within the existing framework there are some degrees of freedom given that the cargo is divisible. This paper suggests extending that framework to the context of intermodal transport. Exceptions to the given regulations require different measures, such as accompanying car, route travelled, etc. This paper aims to investigate the consequences of such a framework and gives some normative suggestions for its setup and design. Furthermore, this paper investigates the potential associated with such a framework in terms of cost-efficiency. In sum, a more innovative and flexible legal framework regarding vehicle length in the PPH links can contribute to greater modal shift, improved cost-efficiency and more environmentally friendly transportation systems.

*Keywords: Intermodal transport, combined transport, pre- and post haulage, drayage, modal shift*

# INTRODUCTION

Transport demand is closely linked to economic development and for several decades there was a close correlation between the growth of freight transport and economic growth. In the economic slowdown 2008/2009 there tends to be a sudden fall in freight transport demand; however, previous recessions have shown that freight transport is bound to recover more quickly than the rest of the economy (European Commission, 2009). Since the increase in freight transport demand is mainly met by road (European Commission, 2006) it imposes significant negative impacts on the society, economy and environment. Despite the introduction of alternative fuels and innovative vehicle technology, the total externalities of the road freight transport sector have increased because the growing road freight transport volumes have over-compensated the improved emission level per kilometre driven.

For a long time European transport policy recognizes that intermodal transport and especially combined road-rail transport has the potential to resolve this problem and therefore is a cornerstone in the construction of an efficient and sustainable transport system. Transport policy was one of the first policies included in the European integration process and the Commission's first White Paper on the future development of the common transport policy, published in December 1992, emphasized the opening and integration of the EU transport market (European Commission, 1992). As a response to the expected increase in traffic volumes due to the formation of the internal market, the importance of the development of intermodal transport as an alternative to road transport has been highlighted. In 1997 it was acknowledged that the "business as usual" approach to transport policy cannot solve the transport related problems. Instead, a systems approach is needed and the promotion of intermodality is seen as a policy tool to enable such an approach. According to (Lowe) (2005) this was a vital step forward in the development of intermodalism in Europe. Another vital step was achieved in 2001 when the EU Commission published its Transport White Paper (European Commission, 2001). While in the 1990s the guiding principle of European transport policy was the opening-up of the transport market, the 2001 White Paper recognised that the response to continuously increasing transport volumes cannot be limited to build new infrastructure and liberalising markets. Sustainable development was emphasized focusing among other things on modal shift from road to rail and inland waterways.

However, despite a series of initiatives aiming at revitalizing rail freight (e.g. the Marco Polo Programme), rail's modal share of inland freight transport in EU-25 continues to decline. Traditionally, intermodal transport has a medium to high market share for large flows over long distances, for seaport hinterland flows, for flows between production plants and to depots and for bulk commodities and dangerous goods (Bontekoning and Priemus, 2004). Intermodal transport provides good transport quality and economy in these markets and can compete with road transport, but the short and medium distance transports remain a domain of the road transport sector (Bärthel and Woxenius, 2004).

The competitiveness of intermodal rail very much depends on the costs of the pre- and end haulage (PPH)(e.g. (Niérat, 1997, Kreutzberger, 2001). This paper addresses the possibility of improving the competitiveness of intermodal transport services by improving the cost-efficiency of the PPH activities. It does so by investigating the setup of longer vehicles that allows for a maximum load of four 20 foot units by constructing a Differential Calculation Model that can give insight into the cost dynamic of such a setup. The paper also address the circumstances under which such regulations could function, however, this is not the primary focus of this paper. The principal idea, now discussed, e.g. by the Swedish road authority is to allow for such regulations for specific goods flows between the location of major shippers and nearest intermodal terminal where PPH circumstances makes intermodal transport solutions unprofitable. The exemption as defined in this paper does not allow for any more pay load in terms of weight for the entire vehicle than what regulations currently allow.

In the next section, previous research on PPH in the intermodal transport chain is reviewed and the legal framework for its operation is discussed. Then, the Differentiated Calculation Model is constructed and discussed from a Scandinavian perspective. The article concludes with a strategic discussion.

# FRAME OF REFERENCES

## PPH in intermodal transport

Intermodal transport is the combination of two or more transport modes in one transport chain. The United Nations Economic Commission for Europe (UNECE) defines intermodal transport as (UNECE, 2001):

> "The movement of goods in one and the same loading unit or road vehicle, which uses successively two or more modes of transport, without moving the goods itself in changing modes."

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.

In the intermodal transport chain, PPH operations involve the provision of an empty intermodal loading unit (ILU) to the shipper and the subsequent transportation of a full ILU to the intermodal terminal (Macharis and Bontekoning, 2004). (Kreutzberger, et al., 2006) evaluates the cost performance of PPH and illustrates that the factors that crucial for the cost performance. These are the location of shippers around a terminal (hence distance); the freight volumes per shipper or area; the resource productivity, e.g. labour or fuel costs; and the network productivity, e.g. number of roundtrips per load unit and loading(unloading times. In Europe most PPH operations around inland terminals have a distance of 0-25 km (one direction) and the number of terminal visits of a truck is 1.4 -2.1.

PPH operations are very fragmented with various PPH companies serving each terminal and distribution and pick-up trips to and from shippers are not coordinated, resulting in many additional empty trips (Morlok, et al., 1995). Besides its low capacity utilization due to empty driving, which is inherent in pick-up and delivery traffic, the centralized intermodal production system lead to concentrated PPH flows and waiting times at the large-scale intermodal terminals (Walker, 1992). In addition, since terminals as well as consignor and consignees are usually located in or in the vicinity of urban areas, PPH is affected by urban congestion. Given the reliable and fast dedicated train service, PPH is the primary source of both long transit times and transit time unreliability leading to serious problems in the intermodal chain's service quality (Morlock, et al., 1995). Furthermore, PPH accounts for a large fraction (between 25% and 40%) of total expenses, despite its relatively short distance compared to the rail line haul (Macharis and Bontekoning, 2004).

PPH operations therefore seriously affect the quality and profitability of intermodal transport and by that significantly limit the markets in which it can compete with road transport. The development of efficient PPH operations can improve the attractiveness of intermodal transport. However, despite its influence on the performance of intermodal transport, little research has been conducted in this category (Caris, et al., 2008), (Bontekoning, et al., 2004). Morlok et al. (1995) show that a decrease of 30% in PPH costs reduces the break-even distance by 42% and concludes that PPH improvements are clearly the key for enlarging the intermodal market, since improvements in other parts of the transport chain will not lead to such substantial effects

Given the large costs associated with PPH, there is a substantial profitability potential for operational improvements. However, as previous research have illustrated it is hard to achieve improvement to the haulage organization (Niérat, 1997). As a result, changes to the regulatory framework might be necessary and even desirable. The legal framework for the transport market determines to a large extent the cost level of PPH since it is a complex business burdened by a large number of restrictive governmental directives and regulations, including maximum vehicle dimensions and weights, operator licensing, limits on driver working times, etc (Lowe, 2005). Moreover, environmental regulations affect PPH operations since accessing consignors and consignees to and from terminals often take place in urban areas, where they are likely to increase the local external effects (Woxenius, 2001).

## Legal framework for pre- and post haulage

There are three main types of intermodal loading units: ISO containers, swap bodies and semi-trailers. ISO containers are 20, 40 or 45 foot long (5.98, 12, 13.50 metres). For swap body two classes can be distinguished. For the carriage on road trains Class C swap bodies with lengths of 7.15, 7.45 and 7.82 metres are used. For articulated vehicles Class A swap bodies with lengths of 12.50 and 13.60 metres are the most important. The typical length of semi-trailers is 13.60 metres which is also their maximum length (Vrenken, et al., 2005).

The maximum size of vehicles in intra-national and inter-national traffic as well as the weight limits in international road freight traffic is regulated by the European Union. Council Directive 1996/53/EC restricts vehicle lengths to 16.50 m for truck-trailer combinations and to 18.75 m for articulated vehicles. The maximum permissible weight can only be exceeded to 44 tons when carrying 40-foot containers from and to combined transport terminals.

These load units and vehicle dimensions permit the following carrying capacity of intermodal vehicles. Articulated vehicles can carry one class A swap body, one class C swap body, two 20-foot containers or one 40-foot container. Road train combinations can carry two class C swap bodies or two 20-foot swap bodies (Lowe, 2005).

Exceptions from the rules for road-freight vehicles which exceed the size limits of current heavy goods vehicles (HGVs) of 16.50 m / 18.75 m are subject to special permissions by national governments. The Council Directive 1996/53/EC allows member states to legalise longer and heavier vehicles, so long as they conformed to the standard modular dimensions. These exemptions, however, are only valid for transports within their national borders and do not apply for border crossing traffic. Some countries generally allow a vehicle length of 25.25 m and a weight of 60 t (Doll, et al., 2009). Sweden and Finland generally allows the use of longer and heavier vehicle combinations (LHV's) consisting of the longest semi-trailer, with a maximum length of 13.6 m, and the longest load-carrier according to C-class, with a maximum length of 7.82 m, allowed in EU. This results in vehicle combinations of 25.25 m, which is significantly longer than the maximum length within the rest of Europe of 18.75 m. These vehicle combinations are known as the European Modular System (EMS).

Concerning weight limits, different exceptions from the current maximum weights of 40 t are tested or are in use. Sweden and Finland generally allow a maximum vehicle weight of 60 tons. In some states in Germany trails have been taken place that allow a vehicle length of 25.25 metres, but do not allow exceeding the current weight limit of 40 tons (Doll, et al., 2009). The Netherlands have been carrying out series of LHVs trials for several years. Since November 2007, longer vehicles with a weight of 50 tonnes have been allowed and since May 2008, 60 tons LHVs are allowed on Dutch roads. Denmark is another European country that sets the LHVs with a maximum length of 25 meter and maximum weight of 60 tons free[1].

The European Commission is considering a revision of the rules in force on weights and dimensions of heavy commercial vehicles which would allow using LHV also in international transport, since due to an increased payload per vehicle fewer trucks would be required to transport the same volume of trade. The general benefits are a reduction in vehicle operating costs and a reduction in lorry traffic which helps to alleviate environmental impacts and congestion. However, the reduced operating costs can also have negative environmental effects, since they can induce a modal shift from rail to road and induce additional demand for transport. Furthermore, they affect safety and have implications for road transport infrastructure.

Various studies have been undertaken which arrive at different conclusions on the relative economic and environmental costs and benefits. In Scandinavia, experiences of using EMS vehicle combinations are mostly positive. A study by Åkerman and Jonsson (2007) indicates that the use of LHV's according to EMS in Sweden and Finland have positive effect on economy and environment, while not affecting traffic safety negatively. Furthermore, the Dutch trials indicate that it is possible to operate with LHV's on a limited road net. On the

[1] http://www.nomegatrucks.eu/

other hand, Doll, et al. (2009) concludes that a general extension of the provisions of directive 1996/53/EC towards extra long and possibly extra heavy lorry combinations would result in a considerable shift in the mode of transport to the roads with negative consequences for the environment, climate and safety. Furthermore, the Transport Committee of the European Parliament and some Member States expressed their opposition mainly due to safety and infrastructure availability reasons.

Hence, the case for increasing the maximum length and weight of trucks is one of the most controversial issues to arise in freight transport field for many years. McKinnon (2008) highlights the difficulties in assessing the net-benefits and extrapolating of the experiences made in national trials to the EU as a whole.

# A SCANDINAVIAN PERSPECTIVE

In line with the ambitions set out by the European Commission, Scandinavia in general and Sweden in particular have been able to achieve a substantial modal shift. From a Scandinavian perspective, the development of road-rail intermodal transport has been remarkable over the last decade. The development has to a large extent been based on the expanding system of rail shuttles and dryports in Scandinavia. At heart of the system is Port of Gothenburg (PoG) with currently 26 different rail shuttles to destinations and dryports in Scandinavia. Some eleven different rail operators exist in the system (Port of Gothenburg, 2009), an impressing number given that the rail sector in Sweden started its deregulation in 1988.

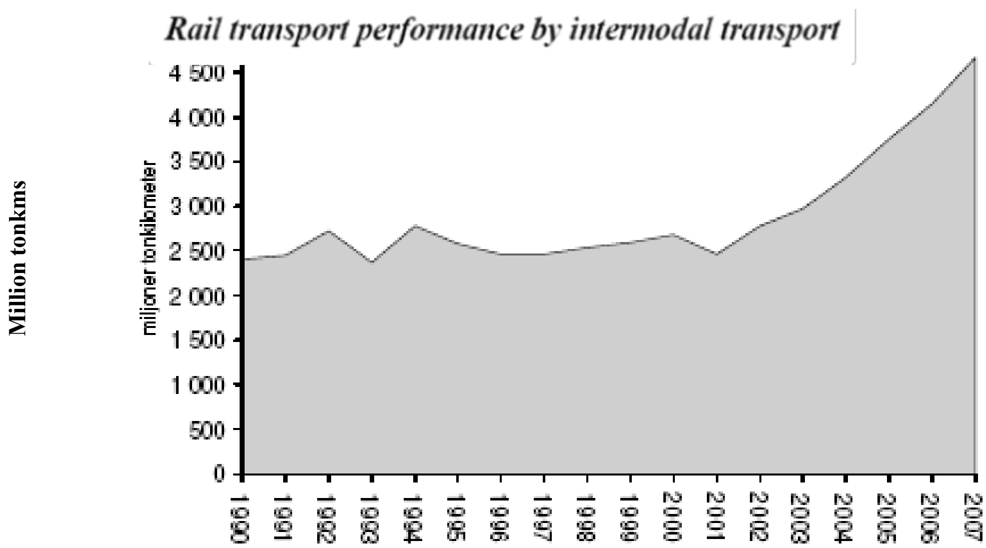


*Figure 1 – Rail transport performance by intermodal transport (Source: SIKA 2009)*

Statistics of the development of rail based intermodal transport clearly illustrate the change of trend and growth starting about 2001 (Figure 1). In 2008, the system of shuttles and dryports handled about 350,000 twenty-foot equivalent units (TEUs) with a turnover of about €60 million (Bergqvist 2009). In 2008, Port of Gothenburg (PoG) handled 860,000 TEUs, which means that the container rail shuttle system handled about 40 percent of all containers to and from the PoG.

Contrary to what many expected when the system of rail shuttles was implemented, large shippers have not utilised the rail shuttle system to the expected extend. One of the main reasons for this is that the goods flows of large shippers often are the platform for many carriers distribution networks which means that shippers often enjoys very low transport costs, and occasionally, even at a rate below operating costs. This paper addresses this issue with the aim of improving the cost-efficiency of the intermodal transport service for this type of situations. The main problem related to the competitiveness of the intermodal service is the pre- and post- haulage to and from the terminal and the location of the shipper. In Sweden, current traffic regulations allows for the maximum possible transport of three TEUs in one single truck haulage. What many projects and actors, such as the Swedish road authority, currently are discussing is to allow for special regulations for specific large goods flows between location of shipper and nearest intermodal terminal of a maximum length of truck that allows for four TEU truck haulage setup. The issue of course is under which circumstances this regulation could be applied, e.g. specific routes, time of day, warning signs, etc. No consensus has been achieved for this regulation yet but there are substantial potentials associated with this type of regulation worth mentioning. More importantly, the issue of when it would be suitable for such exemptions is difficult to address without an in-depth knowledge of the cost structure of such a setup. Therefore, this paper aims to address this issue by constructing a Differential Calculation Model that can give insight into this issue.

# STRATEGIC CALCULATION MODEL

## A systems comparison

The problem that we analyse here involves a comparison between two designs of an intermodal transport chain. The difference between the designs lies in haulage setup. In one design, “regular” haulage, the PPH activities in the chain are carried out given current regulations for vehicles and their combinations. In the “double” haulage system, the haulage activity can be carried out given the exemptions from current regulations. The two versions of the intermodal transport chain are presented in Figure 2.

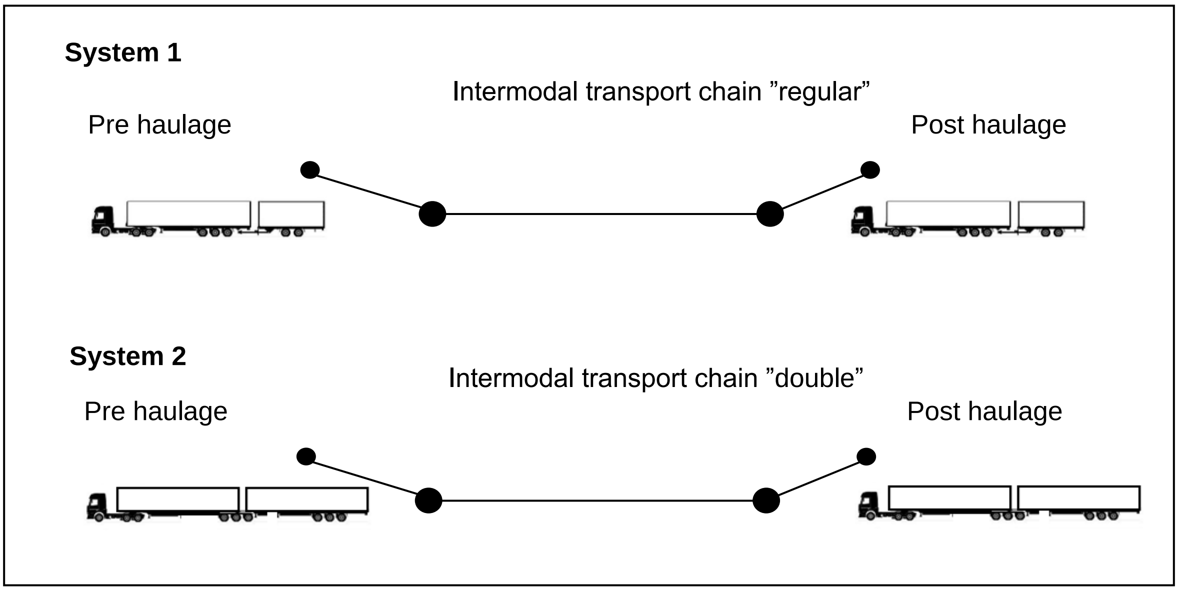


*Figure 2 – Two system designs of an intermodal transport chain regarding pre and post haulage regulations*

When designing the comparison as a differential calculation between the two systems, all cost components that do not change will cancel out, a fact that simplifies comparison and model building.

## Strategic calculation models and their use

Strategic economic calculation models are useful tools in analysis, the purpose of which is to identify threats or opportunities in a future development or to find promising areas for more precise analysis. These models are useful for sensitivity analysis and scenarios. Sensitivity analysis and scenarios represent possible states or courses of events that are well defined in a few key dimensions computed with reasonable mathematical precision, but more vaguely expressed in other dimensions. The primary reason for using precise mathematical models in strategic analysis is not the quantitative precision they deliver per se, but that they admit transparent expression of assumptions and methods and allow systematic manipulation. However, it is important to integrate the most important factors and to make the model flexible in terms of allowing sensitivity analysis.

Strategic calculations can be used for estimating threats and opportunities in a future development and are especially useful in a setting where little empirical data may be gathered. The sensitivity analysis does not necessarily have to be completely defined or exact in all aspects. The important thing is that they can give a picture that is sufficiently clear and relevant for drawing strategic conclusions.

The total cost differentiation of the intermodal transport chain given the two systems defined in Figure 2 depends on many factors. This differentiation model and sensitivity analysis is especially interested in the underlying prerequisites of the shippers' situation of such as setup, namely, goods volumes, volume distribution over time, distances, average shipments sizes, etc. In order to construct a valid differential calculation model transport related costs, such as, distribution of fixed and variable costs, haulage costs as share of total transport costs, etc. needs to be defined.

The output of the differential calculation model is given by the total cost change of the transport chain $TCC_{chain}$ when changing from regular haulage to double haulage, including all relevant costs related to haulage operations and associated terminal handling. $TCC_{chain}$ depends on the haulage cost as share of total cost of the chain $CS_{road}$ and the total cost change of the haulage part $TCC_{haulage}$. The $TCC_{haulage}$ depends on a combination of variable $VCS_{haulage}$ and fixed cost share $FCS_{haulage}$ and their respective cost change (when shifting from regular to double haulage), $VCC_{haulage}$ and $FCC_{haulage}$.

$FCC_{haulage}$ is a result of the number of shipments required with the regular haulage setup $NS_{reg}$, double haulage setup $NS_{double}$ and the average shipment size for regular haulage setup $Av_{reg}$ and the total TEU volume on the given transport link $Vol_{TEU}$.

$VCC_{haulage}$ is a result of variable cost difference between double and regular haulage setup $VCD_{double}$, the number of shipments required with the double haulage setup $NS_{double}$ multiplied with the distance between terminal and origin *D,* regular haulage setup $NS_{reg}$ multiplied with the distance between terminal and origin *D*. This expression is then multiplied with the fraction *of* the average shipment size for regular haulage setup $Av_{reg}$ multiplied with the distance between terminal and origin *D* and the total TEU volume on the given transport link $Vol_{TEU}$.

$NS_{double}$ is equal to the total volume of TEU on the given transport link multiplied with the share of shipments with more than 3 TEU $SS_{>3TEU}$ divided by four which is the maximum capacity with the double haulage setup.

$NS_{reg}$, number of shipments with regular haulage setup is equal to the number of shipments related to the number of 40f units that is not shipped with double haulage setup ($Vol_{TEU}$*-($NS_{double}$*4)*$SV_{40f}$) and the number of shipments related to the number of 20f units that is not shipped with double haulage setup divided with the average shipment size in TEU of regular haulage setup ((($Vol_{TEU}$-$NS_{double}$*4)*(1-$SV_{40f}$))/$AV_{reg}$).

Given this background the following differential calculation model is constructed:

$$TCC_{chain} = TCC_{haulage} * \frac{1}{(1+CS_{road})}$$

$$TCC_{haulage} = FCC_{haulage} * FCS_{haulage} + (1-FCS_{haulage}) * VCS_{haulage}$$

$$FCC_{haulage} = \left(NS_{double} + NS_{reg}\right) * \frac{Av_{reg}}{Vol_{TEU}}$$

$$VCC_{haulage} = \left(VCD_{double} * NS_{double} * D + NS_{reg} * D\right) * \frac{AV_{reg} * D}{Vol_{TEU}}$$

$$NS_{doubel} = Vol_{Teu} * \frac{SS_{>3TEU}}{4}$$

$$NS_{reg} = \frac{Vol_{TEU} * -\left(NS_{double} * 4\right) * SV_{40f}}{2} + \frac{\left(Vol_{TEU} - NS_{double} * 4\right) * \left(1 - SV_{40f}\right)}{AV_{reg}}$$

$TCC_{chain}$ = Total cost change for transport chain (%)

$CS_{road}$ = Haulage costs as share of total cost of the chain (%)

$TCC_{haulage}$ = Total cost change for the haulage part of the chain (%)

$FCC_{haulage}$ = Fixed cost change for haulage part of the chain (%)

$FCS_{haulage}$ = Fixed cost share for haulage part of the chain (%)

$VCS_{haulage}$ = Variable cost share for haulage part of the chain (%)

$NS_{double}$ = No. of shipments required with double haulage (No.)

$NS_{reg}$ = No. of shipments required with regular haulage setup (No.)

$VCC_{haulage}$ = Variable cost change for haulage part of the chain (%)

$VCD_{haulage}$ = Variable cost share for double compared to regular haulage setup (%) (given)

$D$ = Distance from origin to terminal (kms) (given)

$Vol_{TEU}$ = Total volume on transport link (TEU) (given)

$SS_{>3TEU}$ = Share of shipments with more than 3 TEU (%) (given)

$NS_{reg}$ = Estimation on the number of shipments required with regular haulage setup (No.)

$SV_{40f}$ = Share of volume with shipments of 40foot (%) (given)

$AV_{reg}$ = Average shipment size for regular haulage setup (TEU) (given)

*Formula 1 –Differential calculation model*

$NS_{reg}$ is to be regarded as estimation since the number of shipments is dependent not only on the average shipment size in TEU but also the statistical distribution of it. Here, shipment sizes are assumed to be very stable in connection to the average shipment size (e.g. no trend or seasonal patterns). Furthermore, this variable is closely linked with the variables $SV_{40f}$ and $SS_{>3TEU}$.

## Sensitivity analyses

For the sensitivity analyses we use default numbers bases on an estimation of the situation of a typical large shipper (cf. (Bergqvist, 2007)). Given the previous strategic differential calculation model it is interesting to investigate the impact certain variables has on the total cost change of the intermodal transport chain. Examples of cost related variables are: haulage costs as share of total cost of the chain $CS_{road,}$ fixed and variable cost share for haulage part of the chain $FCS_{haulage}$ and $VCS_{haulage}$. Other more physically depend variables interesting to analyse are: distance between origin and terminal *D,* total volume on transport link $Vol_{TEU}$, share of shipments with more than 3 TEU $SS_{>3TEU}$, share of volumes with shipments of 40f units $SV_{40f}$ and average shipment size for regular haulage setup $AV_{reg}$.

The following default numbers for each variable were used:

Table 1, Default number for sensitivity analysis

$$CS_{road} = 20\% \text{ (Sensitivity anlysis)}$$
$$FCS_{haulage} = 10\%$$
$$VCD_{haulage} = 30\% \text{ (Sensitivity anlysis)}$$
$$D = 20kms \text{ (Sensitivity anlysis)}$$
$$Vol_{Teu} = 1000TEU$$
$$SS_{>3TEU} = 20\% \text{(Sensitivity anlysis)}$$
$$SV_{40f} = 30\%$$
$$AV_{reg} = 3\,\text{TEU}$$

The other variables are given on the basis of the above defined default numbers. The variables marked (sensitivity analysis) are the variables tested in the sensitivity analyses. The sensitivity analyses focuses on single variable analyses, hence, no combinations of variables are systematically treated in the sensitivity analyses at this stage. Such combinations are dealt with ad hoc. For example, there are great correlation between the variables of $SS_{>3TEU}$, $SV_{40f}$ and $AV_{reg}$, so the result of the sensitivity analyses for one of them are likely to illustrate similar results as for the often two interrelated variables.

*Table 2 – Results from sensitivity analyses*

| Sensitivity analysis 1 | | | Sensitivity analysis 2 | | | Sensitivity analysis 3 | |
|---|---|---|---|---|---|---|---|
| $CS_{Road}$ | $TCC_{chain}$ | | $VCD_{haulage}$ | $TCC_{chain}$ | | $SS_{>3TEU}$ | $TCC_{chain}$ |
| 5,0% | 105,8% | | 100,0% | 89,2% | | 10,0% | 94,2% |
| 10,0% | 101,0% | | 105,0% | 89,7% | | 15,0% | 93,4% |
| 15,0% | 96,6% | | 110,0% | 90,3% | | 20,0% | 92,5% |
| 20,0% | 92,5% | | 115,0% | 90,9% | | 25,0% | 91,7% |
| 25,0% | 88,8% | | 120,0% | 91,4% | | 30,0% | 90,9% |
| 30,0% | 85,4% | | 125,0% | 92,0% | | 35,0% | 90,1% |
| 35,0% | 82,3% | | 130,0% | 92,5% | | 40,0% | 89,3% |
| 40,0% | 79,3% | | 135,0% | 93,1% | | 45,0% | 88,4% |
| 45,0% | 76,6% | | 140,0% | 93,7% | | 50,0% | 87,6% |
| 50,0% | 74,0% | | 145,0% | 94,2% | | 55,0% | 86,8% |
| 55,0% | 71,6% | | 150,0% | 94,8% | | 60,0% | 86,0% |
| 60,0% | 69,4% | | 155,0% | 95,4% | | 65,0% | 85,1% |

From the sensitivity analyses results (

Table 1), some interesting observations can be made. The haulage costs as share of total cost of the chain ($CS_{road}$) have a rather substantial influence on total cost change ($TCC_{chain}$) which was expected. The share of shipment sizes over 3 TEU ($SS_{>3TEU}$) has a greater impact on total costs suggesting that also the average shipment size for regular haulge ($AV_{reg}$) and the share of volume with shipments of 40foot ($SV_{40f}$) have a large impact on the total cost change. The most interesting observation however is the relative robustness of the relative haulage costs ($VCD_{haulage}$) which implies that there is quite a buffer to deal with factors that increases the cost of "double" haulage compared to regular haulage. This would give the exemption setup some room for additional costs, such as special regulations on speed, route, etc., without losing too much of its cost-advantage compared to the regular haulage setup. However, it may interact with other variables outside the scope of this sensitivity analysis.

# STRATEGIC INTERPRETATIONS AND CONCLUSIONS

From a Scandinavian perspective the haulage costs of intermodal transport services indicates great potentials associated with exemptions for more efficient PPH setups. The differential calculations model combined with the default numbers of a typical shipper's situation indicated a total cost mass of about 90% compared to a regular haulage setup. This implies that new regulations related to vehicle setups for haulage have the potential to decrease total cost for intermodal transport services for a typical large scale shipper with about 5-10%. This change might not seem that impressing but given the pricing situation of carriers and large shippers this change can be enough to achieve substantial modal shift. Combined, such regulations have the possibility to improve the cost-efficiency and environmental performance of the overall transportation system.

Overall, this paper indicates substantial potentials associated with flexibility in the regulatory framework of intermodal transport. More generous rules on vehicle length, etc. may contribute to a better cost-efficiency for intermodal transport by addressing the problem of the "last mile" efficiency. As long as there are potentials for improved cost-efficiency and environmental performance, regulatory exemptions related to intermodal haulage activities, deserves to be taken seriously and viewed with open minds by policymakers. We would like to point out that we do not suggest increasing weight and length dimensions for regular all-road traffic.

The issue of feasibility is left to be addressed. Given the potential of such new regulations it is important to address possible negative effects thoroughly before any regulations are adapted and widespread. The main focus of this paper has been to construct a feasible differential calculation model and give some indications on the potential associated with changed regulations for PPH and not primarily on the possible negative effects of such regulations. However, we would like to stress some important factors and aspects that should be addressed in the bigger picture of implementation. Given that intermodal terminals as well as the customers of intermodal transport are often located in cities, these negative effects are most palpable in urban areas which constitute the living environment of the vast majority of the population, and the demands on a high quality of life increase. From this perspective, local authorities and citizens perceive freight traffic in urban areas as a disturbing factor for the local sustainability.

Given that the discussed new regulations primarily may affect the safety on the road (however, one might argue that meeting one “front” instead of two is better), there are some possible aspects that should be used as means for dealing with the safety issue:

- The speed the vehicle may travel
- The route it may travel
- The time of day it may travel
- Accompanying car for warning traffic
- The time of year/month/week it may travel
- The number of shipments it may carry out per year for the exemption

As local authorities are partly-responsible for traffic regulations such as access restrictions, decisions at the local level highly influence the operation conditions of PPH; however, planning staff often neither has the capacity nor the knowledge to successfully integrate freight transport aspects into the municipality’s planning processes (Lindholm, 2008). Local authorities usually focus on passenger transport and the lack of key skills and expertise for freight transport represents a practical barrier. A greater balance between passenger and freight therefore entails possibilities to increase the efficiency of PPH and, hence, the total intermodal transport chain.

Combined, this research have illustrated that there are substantial potentials associated with changed regulations for PPH. However, it is of outmost importance that the circumstances and context of such regulations are investigated further to better understand the feasibility of such new regulations and policies. It is essential to take the urban context of PPH into account.

# REFERENCES

Bergqvist, R. (2007). Studies in Regional Logistics - The Context of Public-Private Collaboration and Road-Rail Intermodality. Logistics and Transport Economics, Department of Business Administration. Göteborg, Göteborg University. **Ph.D.:** 250.

Bergqvist, R. (2009). Hamnpendlarnas betydelse för det Skandinaviska logistiksystemet. BAS Handelshögskolan vid Göteborgs universitet, Göteborg.

Bontekoning, Y. M., Macharis, C. and Trip, J. J. (2004). Is a new applied transportation research field emerging? A review of intermodal rail-truck freight transport literature. Transportation Research Part A: Policy and Practice, 38, 1-34.

Bontekoning, Y. M. and Priemus, H. (2004). Breakthrough innovations in intermodal freight transport. Transportation Planning and Technology, 27, 335-345.

Bärthel, F. and Woxenius, J. (2004). Developing intermodal transport for small flows over short distances. Transportation Planning and Technology, 27, 403-424.

Caris, A., Macharis, C. and Janssens, G. K. (2008). Planning Problems in Intermodal Freight Transport: Accomplishments and Prospects. Transportation Planning and Technology, 31, 277 - 302.

Doll, C., Fiorello, D., Reynaud, C., et al. (2009). Long-Term Climate Impacts of the Introduction of Mega-Trucks - Study to the Community of European Railways and Infrastructure Companies (CER). Fraunhofer ISI (study co-ordinator, Karlsruhe) TRT (Milan), NESTEAR (Gentilly), Fraunhofer-ATL (Nuremberg), Fraunhofer-IML (Dortmund), Karlsruhe.

European Commission (1992). The Future Development of the Common Transport Policy: A Global Approach to the Construction of a Community Framework for Sustainable Mobility. Brussels.

European Commission (2001). White Paper - European transport policy for 2010: Time to decide. Brussels.

European Commission (2006). Keep Europe moving - Sustainable mobility for our continent. Brussels.

European Commission (2009). The future of transport - Focus groups' report. Brussels.

Jensen, A. (1990). Combined transport : systems, economics and strategies. Swedish Transport Research Board: School of Economics at Gothenburg University, Göteborg.

Kreutzberger, E. (2001), "Strategies to achieve a quality leap in intermodal rail or barge transportation", paper presented at IEEE Intelligent Transportation Systems Conference, August 25-29, 2001, Oakland (CA) USA.

Kreutzberger, E., Koningd, R. and Aronson, L. (2006). Evaluation of pre- and post-haulage in intermodal freight networks. B. Jourguin, P. Rietveld and K. Westin (ed.), *Towards better performing transport networks*, Routledge, London, pp. 256-284.

Lindholm, M. (2008). A sustainability perspective on urban freight transport - Factors and incentives affecting local authorities in the planning procedure. Department of Technology Management and Economics, Chalmers University of Technology, Gothenburg.

Lowe, D. (2005). Intermodal freight transport. Elsevier Butterworth-Heinemann, Amsterdam, Boston.

Macharis, C. and Bontekoning, Y. M. (2004). Opportunities for OR in intermodal freight transport research: A review. European Journal of Operational Research, 153, 400-416.

McKinnon, A. (2008), "Should the maximum length and weight of trucks be increased? A review of European research", paper presented at 13th International Symposium on Logistics (ISL 2008), 6-8 July 2008, Bangkok, Thailand.

Morlock, E. K., Sammon, J. P., Spasovic, L. N., et al. (1995). Improving Productivity in Intermodal Rail-Truck Transportation. P. T. Harker (ed.), *The service productivity and quality challenge*, Kluwer Academic Publishers, Dordrecht, pp. 407-434.

Morlok, E. K., Sammon, J. P., Spasovic, L. N., et al. (1995). Improving Productivity in Intermodal Rail-Truck Transportation. P. T. Harker (ed.), *The service productivity and quality challenge*, Kluwer Academic Publishers, Dordrecht, pp. 407-434.

Niérat, P. (1997). Market area of rail-truck terminals: Pertinence of the spatial theory. Transportation Research Part A: Policy and Practice, 31, 109-127.

UNECE (2001). Terminology on combined transport. The United Nations Economic Commission for Europe, New York, Genua.

Walker, W., T (1992). Network Economies of Scale in Short haul truckload Operations. Journal of Transport Economics and Policy, 26, 3-17.

Woxenius, J. (2001), "Intermodal freight transport - Urban impact of new network operation principles and transhipments", paper presented at Cities of tomorrow: Human living in urban areas - Transportation of people and goods, 23-24 August 2001, Gothenburg.

Vrenken, H., Macharis, C. and Wolters, P. (2005). Intermodal Transport in Europe. European Intermodal Association, Brussels.

Åkerman, I. and Jonsson, R. (2007). European Modular System for road freight transport - experiences and possibilities. TFK Transportforsk AB, Stockholm.