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Study on the Effects of the Introduction of LHVs on Combined Road-Rail Transport and Single Wagonload Rail Freight Traffic

In co-operation with

Fraunhofer ISI

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Table of contents

List of figures

List of tables

1. Background

Background

(1) The terms of reference (TOR) issued by CER on May 20th 2010 explained that the main objectives of the study were to collect and assess evidence on the potential impact of longer and possibly heavier vehicles (LHVs) on non-block train rail freight being combined road-rail and on single wagonload transport.

In addition to the many studies conducted on EU and Member State level, we strongly believe that at the current point of discussion, sound investigations of logistics processes are required to identify the conditions, under which larger and heavier trucks will not have an adverse effect on railways market shares. This is on the one hand important to move from a general risk perception to a differentiated picture of hot spots to be affected. On the other hand, such a differentiated scenario can help the railways and policy to launch measures against the negative impacts of LHVs in the event that they are introduced.

We are thus in favour of adding sound knowledge of logistics markets to the findings of the more general economic analyses that have been conducted in the past on a European level, including the previous studies by Fraunhofer et al. (2008) on behalf of CER, K+P (2007) for the German BMVBS, TIM Consult (2007) for UIRR, TML et al. (2009) for the European Commission or by TRL for UK DfT, This collection and assessment of logistics evidence should, in our view, be supported by experts from the client's side. We thus appreciated the announcement in the TOR to include CER members and the UIRR in the study.

Mission

(2) Our mission was elaborated along the following list of objectives

- The impacts of longer and heavier road freight vehicles have been researched by numerous studies in recent years. Most of the approaches have concentrated on technical, infrastructure or entrepreneurial issues, or have assessed the social impacts in a rather general manner. This study aims at advancing the discussion on the trans-national level by analysing in detail selected European freight corridors. Particular emphasis is put on rail markets, goods structures, technology options and external impacts of road and rail shipments.

- The first objective of the study is to quantify the potential range and impact of modal shifts of rail freight to road due to the introduction of longer and / or heavier trucks. The two rail freight production systems "single wagonload" and "combined road-rail transport" are considered separately. For both production systems the potential shifts by goods category and LHV setting are analysed in the short run and include shifts entailed by the economic 'downward spiral'.

- For each of the selected European corridors and rail freight production systems the study analyses the development of traffic volumes shifted to road by different LHV settings. Cost structures and the economic viability of road and rail carriers are approached by taking a broad look at network utilisation and infrastructure investments required. As concerns social impacts the study includes latest knowledge on current and future levels of the classic externalities, including greenhouse gas emissions, air pollutants, accidents and noise. By reviewing current policy documents the future of Combined Transport (CT) and single wagonload is analysed in the light of the potential permission of LHVs on European roads.

Structure of the report

(3) This report is structured according to the overall objectives of the study. In a first technical chapter (chapter 2) we describe the preparatory work for the study, i.e.

- The definition of the geographical scope of the study, namely the five corridors where we have estimated the intermodal back-shift from rail to road due to the introduction of LHVs
- The identification of relevant markets for the LHVs since a couple of studies elaborated by the authors brought to evidence that some commodities must be excluded for a transport by LHVs with regards to technical (volume/weight ratio) and economical (costs) limits
- With regard to the naturally limited time budget of the study, it was not possible to calculate modal back-shift for all possible LHV combinations. Thus in this part will be described which LHV types were chosen and why
- Finally, we describe in this chapter the literature analysis concerning (cross-) price elasticity, i.e. the intensity of modal reaction on decreasing costs on the road, which is a crucial part of the whole study.

In ***chapter 3*** the methodology for the model estimation of the modal back-shift is described, for example the mid- medium and long-term forecast (2015-2020-2030) of the total demand per corridor, the case studies reflecting the “reality” of the transport costs and the elaboration of the O/D matrices per corridor.

Chapter 4 gives then detailed results for each corridor, which will enter hereafter in the sustainability assessment, described in ***chapter 5*** and the transport sector internal cost analysis in ***chapter 6***.

Like in every model calculation, assumptions and hypotheses had to be made which impact more or less the results of the study. Hence, it seems inevitable to discuss the impact of these assumptions in terms of order of magnitude, impact on volumes shifted and impact on the sustainability assessment. These “sensibility analyses” are described in ***chapter 7***.

Finally, ***chapter 8*** gives a synthesis of all the results in a nutshell.

2. Preparatory work

2.1 Geographical scope of study

Corridors

(1) The geographical scope of the study extends to five major transport corridors in Europe:

- ***Corridor 1:*** **German North – Sea Ports – Czech Republic**
- ***Corridor 2:*** **Belgian and Dutch sea ports (Antwerp, Rotterdam) – Ile de France – Spain (Barcelona)**
- ***Corridor 3a:*** **Scandinavia (Malmö) – Denmark – Germany (Ruhr area)**
- ***Corridor 3b:*** **Germany (Ruhr area) – Switzerland/Austria – Northern Italy**
- ***Corridor 4:*** **South East Germany (Munich) – Austria – Hungary (Budapest)**

From the very beginning it must be pointed out that these corridors cover the major European rail transport axis for the two examined rail freight production systems CT and single wagonload.

Corridor 1

(2) **German North – Sea Ports – Czech Republic**

Figure 2.1: Corridor 1 (scheme)

(Source: K+P based on Google Earth)

Even though this corridor is not part of the actual TEN-T corridors, it is of utmost importance especially for Combined Transport between Hamburg and Prague. It can be specified by the following:

- Max. Length: 698km
- Total transport 2008 (wagonload): 11 billion tonne-kilometres
- Total transport 2008 (CT): 3.2 billion tonne-kilometres

Table 2.1: NUTS2 Regions on the corridor 1

Corridor 1 German seaports - Czech Republic	
NUTS 2 regions in Germany:	**NUTS code**
Hamburg	DE6
Bremen	DE5
Braunschweig	DE91
Hannover	DE92
Lüneburg	DE93
Weser Ems (Wilhelmshaven)	DE94
Dessau	DEE1
Halle	DEE2
Magdeburg	DEE3
Brandenburg Südwest	DE42
Berlin	DE3
Dresden	DED2
NUTS 2 regions in Czech Republic:	**NUTS code**
Praha	CZ01
Severozápad	CZ04
Stredni Cechy	CZ02

(Source: K+P)

Corridor 2

(3). **Belgian and Dutch sea ports (Antwerp, Rotterdam) – Ile de France – Spain (Barcelona)**

Figure 2.2: Corridor 2 (scheme)

(Source: K+P based on Google Earth)

Corridor No. 2 was chosen because it is the only corridor covering France and Spain. Unfortunately, for this corridor no data was made available to us on single wagonload.

- Max. Length: 1374km
- Total transport 2008 (wagonload): no data available
- Total transport 2008 (CT): 3.1 billion tonne-kilometres

Table 2.2: NUTS2 Regions on the corridor 2

Corridor 2: Belgium and Dutch seaports (Antwerp, Rotterdam) – Ile de France – Spain (Barcelona)	
NUTS 2 regions in The Netherlands	**NUTS code**
Zeeland	NL34
Noord Brabant	NL41
NUTS 2 regions in Belgium	**NUTS code**
Prov. Antwerpen	BE21
Prov. West Vlaanderen	BE25
Prov. Oost Vlaanderen	BE23
Brussels	BE10
Prov. Vlaams Brabant	BE24
Prov. Brabant Wallon	BE31
Prov. Namur	BE35
Prov. Luxembourg	BE34
NUTS 2 regions in France	**NUTS code**
Ile de France	FR10
Nord Pas de Calais	FR30
Champagne Ardenne	FR21
Picardie	FR22
Bourgogne	FR26
Rhône Alpes	FR71
PACA	FR82
Languedoc Roussillon	FR81
NUTS 2 regions in Spain	**NUTS code**
Cataluna	ES51

(Source: K+P)

Corridor 3a (4). **Scandinavia (Malmö) – Denmark – Germany (Ruhr area)**

Figure 2.3: Corridor 3a (scheme)

(Source: K+P based on Google Earth)

The Scandinavian – Ruhr corridor was chosen for the study because it is a typical corridor for semi-trailer transports. In addition, this corridor is together with the following corridor 3b is one of the most important European corridors.

- Max. Length: 894km
- Total transport 2008 (wagonload): 4.8 billion tonne-kilometres
- Total transport 2008 (CT): 2.4 billion tonne-kilometres

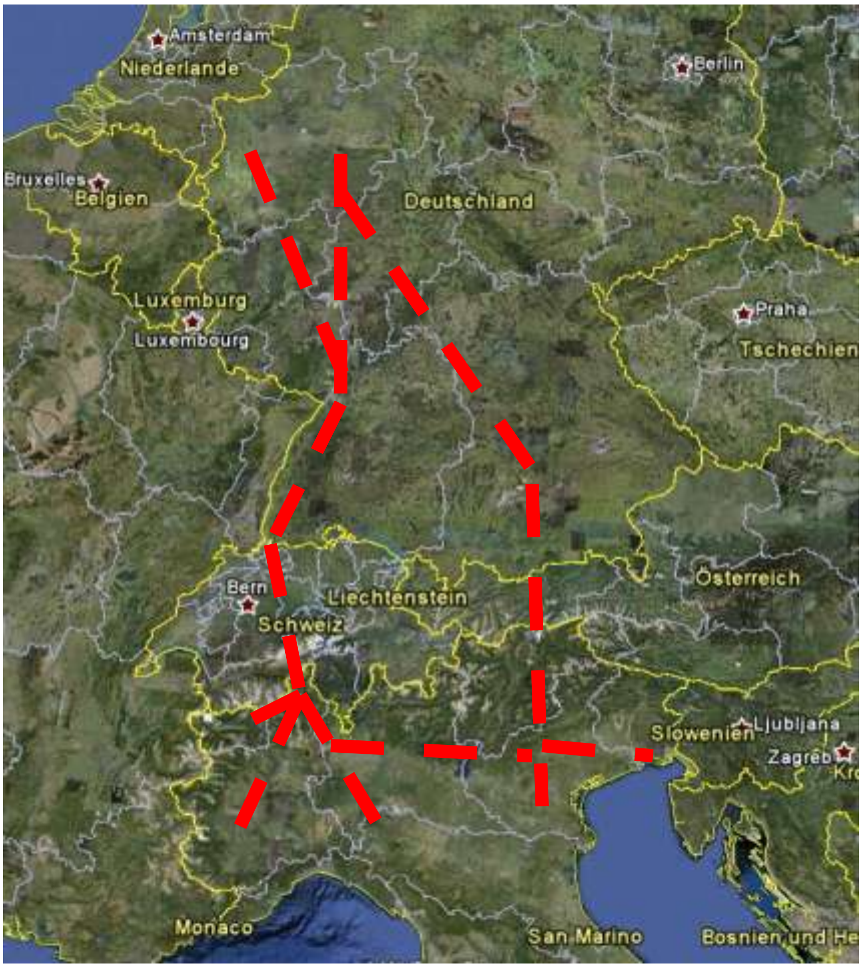
Table 2.3: NUTS2 Regions on the corridor 3a

Corridor 3a: Scandinavia (Malmö) – Denmark – Germany (Ruhr area)	
NUTS 2 regions in Sweden	**NUTS code**
Stockholm	SE01
Östra Mellansverige	SE02
Sydsverige	SE04
Norra Mellansverige	SE06
Mellersta Norrland	SE07
Övre Norrland	SE08
Smaland med öarna	SE09
Västsverige	SE0A
NUTS 2 regions in Danmark	**NUTS code**
Danmark	DK00
NUTS2 regions in Germany	**NUTS code**
Schleswig-Holstein	DF0
Hamburg	DE6
Hannover	DE92
Lüneburg	DE93
Düsseldorf	DEA1
Köln	DEA2
Münster	DEA3
Detmold (Bielefeld)	DEA4
Arnsberg (Dortmund)	DEA5

(Source: K+P)

Corridor 3b (5) **Germany (Ruhr area) – Switzerland/Austria – Northern Italy**

Figure 2.4: Corridor 3b (scheme)



(Source: K+P based on Google Earth)

- Max. Length: 855km
- Total transport 2008 (wagonload): 17.2 billion tonne-kilometres
- Total transport 2008 (CT): 5.7 billion tonne-kilometres

Table 2.4: NUTS2 Regions on the corridor 3b

Corridor 3B: Germany (Ruhr area) – Switzerland / Austria – Italy	
NUTS 2 regions in Italy:	**NUTS code**
Piemonte	ITC1
Valle d'Aosta	ITC2
Liguria	ITC3
Lombardia	ITC4
Bolzano	ITD1
Trento	ITD2
Veneto	ITD3
Friuili-Venezia Giulia	ITD4
Emilia-Romagne	ITD5
NUTS2 regions in Austria	**NUTS code**
Tirol	AT33
Regions in Switzerland	**NUTS code**
(Bern)	CH2
(Zürich)	CH4
(Basel)	CH3
NUTS2 regions in Germany	**NUTS code**
Düsseldorf	DEA1
Köln	DEA2
Münster	DEA3
Detmold (Bielefeld)	DEA4
Arnsberg (Dortmund)	DEA5
Koblenz	DEB1
Rheinhessen-Pfalz (Ludwigshafen, Mainz	DEB3
Karlsruhe (Mannheim)	DE12
Freiburg	DE13
Kassel	DE73
Oberbayern (München)	DE21
Mittelfranken (Nürnberg)	DE25
Unterfranken (Würzburg)	DE26

(Source: K+P)

Corridor 4 (6) **South East Germany (Munich) – Austria – Hungary (Budapest)**

Figure 2.5: Corridor 4 (scheme)

(Source: K+P based on Google Earth)

Corridor 4 was included in the study because of its importance regarding east-west flows via Austria and to include Hungary as an important country for Combined Transports.

- Max. Length: 860km
- Total transport 2008 (wagonload): 2.6 billion tonne-kilometres
- Total transport 2008 (CT): 0.8 billion tonne-kilometres

Table 2.5: NUTS2 Regions on the corridor 4

Corridor 4: Germany (Munich) – Austria – Hungary (Budapest)	
NUTS2 regions in Germany	**NUTS code**
Oberbayern	DE21
Niederbayern	DE22
Mittelfranken	DE25
NUTS2 regions in Austria	**NUTS code**
Burgenland	AT11
Niederösterreich	AT12
Wien	AT13
Steiermark	AT22
Oberösterreich	AT31
Salzburg	AT32
NUTS2 regions in Hungary	**NUTS code**
Közép-Magyarország	HU10

(Source: K+P)

2.2 Identification of relevant markets

Relevant markets

(1) Three base-assumptions have been made to identify relevant markets in single wagonload for the different LHV configurations:

- Only O/D-relations with more than 200 kilometres are considered (for single wagonload and CT).
- For single wagonload some commodity groups that are not suitable for specific LHV configurations are excluded.
- According to the current regulation hazardous goods are excluded for 44t/25.25m and 60t/25.25m LHV.
- Block trains are not considered since - given their cost advantage - they normally are not subject to back-shifts to road transport.

Exclusion of O/D-relations <200km

(2) O/D relations less than 200 kilometres are excluded in this study under the assumption that all LHV configurations can play out their advantages only on longer distances and especially on trunk roads between major hubs or hinterland traffic. In addition to that, we assumed that single wagonload on distances < 200 km will be in most cases specific transports, thus captured markets.

It goes without saying that this general exclusion might in some specific cases lead to an underestimation of the impact of LHVs. But given that rail transport over short distances concerns in most cases intra-industrial rail services between production plants or logistic sites (e.g. Ruhr area in Germany and seaports) with heavy loads generally not suitable for road transport, this exclusion seems justified.

Exclusion of commodity groups

(3) Contrary to CT, for single wagonload some commodities are excluded from the modelling process: the commodities with highest weight utilisation are excluded because they are not suitable for shifting on 14.92m semi-trailers and 44t/25.25m LHVs with maximum payload of 25–26 tonnes. The higher volumes of these vehicles cannot be used for heavy commodities due to their limited payload.

Commodities with highest volume utilisation (NST-9, machinery, transport equipment, manufactured articles and miscellaneous articles) have also been excluded from the shift potential to 60t/25.25m LHV´s. The higher weights offered by these vehicles cannot be used efficiently for voluminous goods.

This reflection is based on the analyses of the use of capacity in terms of weight and volume of more than 1 million data sets on observed truck movements per commodity (KBA Fahrleistungsstatistik). This huge data set gives representative values of the weight payload ratio, on which these conclusions are based.

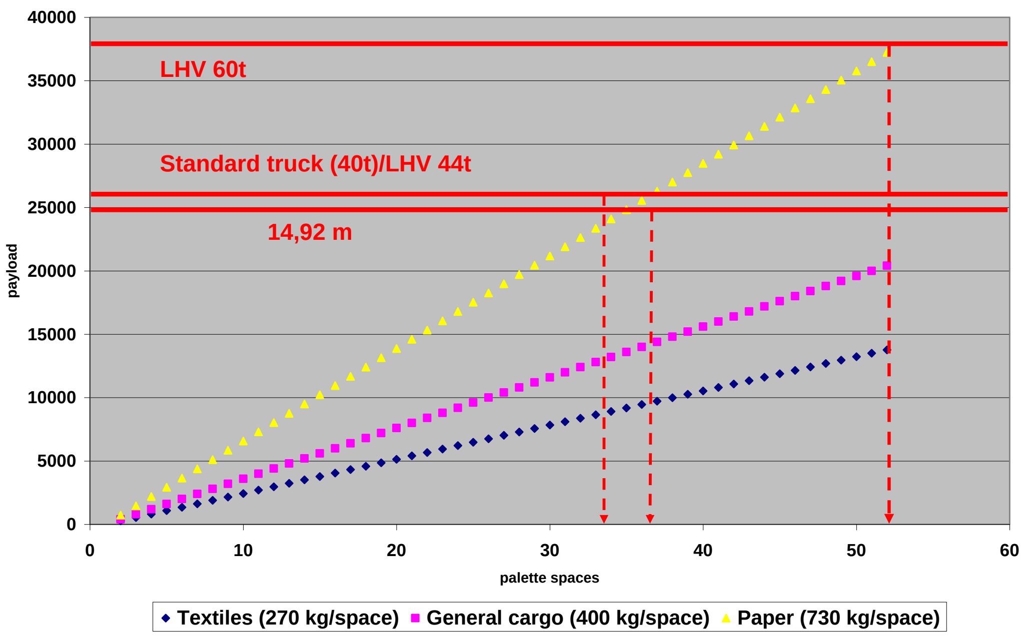
The following concrete example might illustrate this reflection: The analysis of 5.6 million tonnes transported in NST/R 6 (crude and manufactured minerals, building materials) showed that the average weight per pallet space is 0.649 tonnes, which in turn means that a 44t/25.25m LHV offering a payload of 26t reaches its maximum payload with 40 pallet spaces i.e. 78% use of capacity (measured in pallet spaces).

It must be clarified that "pallet space" is a synthetic dimension unit with the aim to cover weight and volume in one.

Figure 2.6 shows as another example the mentioned coherence between payloads and available pallet-spaces for three different commodity groups. It shows clearly that low weight commodity groups (example "textiles" in ***figure 2.6***) are not optimal for 60 tonne LHV´s since the higher payload offered by these vehicles could not be used.

Otherwise, heavy commodities like "paper" (yellow line in ***figure 2.6)*** are not suitable for the other LHV configurations (25.25m/44t and 14.92m/40t) because their maximum payload is reached with far less than 51 pallet spaces.

Figure 2.6: Coherence between payloads and maximum pallet spaces for different commodity groups



(Source: K+P)

In addition to these commodities, we excluded according to the current regulation (e.g. "Feldversuch" in Germany) all transports of hazardous materials, i.e. petroleum products and chemicals.

Again should be noted that NST/R 8 chemicals are not necessarily classified as hazardous goods, however the data base at our disposal did not allow the separation of hazardous and non-hazardous goods in NST/R 8. The technical committee for the study (see Annex 3) and the authors decided to "stay on the safe side" and to completely exclude NST/R 8 transports.

Table 2.6 below shows which commodity groups were finally excluded for further calculations after analysing all corridors.

Table 2.6: Excluded commodity groups (single wagonload)

Excluded commodity groups (NST-R 10)		
14.92m semi-trailer	**44t/25.25m LHV**	**60t/25.25m LHV**
3 - Petroleum products	0 - Agricultural products and live animals	3 - Petroleum products
6 - Crude and manufactured minerals, building materials	3 - Petroleum products	9 - Machinery, transport equipment, manufactured and miscellaneous articles
8 - Chemicals	5 - Metal products	
	6 - Crude and manufactured minerals, building materials	
	8 - Chemicals	

(Source: K+P)

It has to be clearly pointed out that the exclusion of commodities concerns only the single wagonload, not CT since CT data is not differentiated by commodities but per market (maritime/continental and light/heavy).

Exclusion of block trains

(4) It is well known that cost advantages of block train shipments are paramount, which justifies their general exclusion from the modelling of the back-shift rail to road. Nevertheless it seems worth mentioning again that in some specific cases even block trains might be subject to a back-shift to road.

This might be the case when special train services were established mostly on short distances (e.g. household waste to recycling facilities). But in general these cases could not be modelled.

2.3 Identification of the LHV types considered

Base reflections

(1) The impact of each LHV type had to be estimated compared to the base scenario (without LHV). Since each LHV type is more or less appropriate for different transport markets due to its technical characteristics, it was crucial from the very beginning to define the LHV types examined in this study.

The 60t/25.25m LHV is considered even though the authors and the technical committee both think that its chances of being generally allowed on the European network are not very likely. Nevertheless in Finland, Sweden, Denmark, Norway and the Netherlands these trucks are already used on a wide scale, which justifies the inclusion of this LHV configuration.

In the modelling process, each LHV type was considered in a scenario, which allowed to analyse the effects for each LHV separately and to identify the LHV configuration which affects rail transports the most.

LHV configuration

(2) Finally, after intensive discussion with the technical committee the following 3 LHV configurations were considered in the modelling process (c.f. ***figure 2.7****)*

- 14.92m semi-trailer (example: Kögel's Big Maxx) offering a maximum gross weight of 40/44[1] tonnes and 37 pallet spaces
- 25.25m LHV with a maximum gross weight of 44 tonnes offering 51 pallet spaces and a payload of 26 tonnes
- 25.25m LHV with a maximum gross weight of 60 tonnes offering 51 pallet spaces and a payload of 38 tonnes

At least two different configurations exist for the 25.25m LHV:

- Truck with semi-trailer on a dolly (cf. scheme for 60t/25.25m in ***figure 2.7***) and
- Standard tractor-semi trailer configuration with tandem axle trailer with low hinge point (cf. scheme for 44t/25.25m)

According to the results of the studies we carried out for the automotive industry both configurations can be seen as nearly equal regarding payload and costs. (In a market analysis with road transporters the first combination was clearly preferred, due to its flexibility to assemble LHV with existing vehicles).

1 44 tonnes in combined transport

Figure 2.7: Vehicle types considered in the study

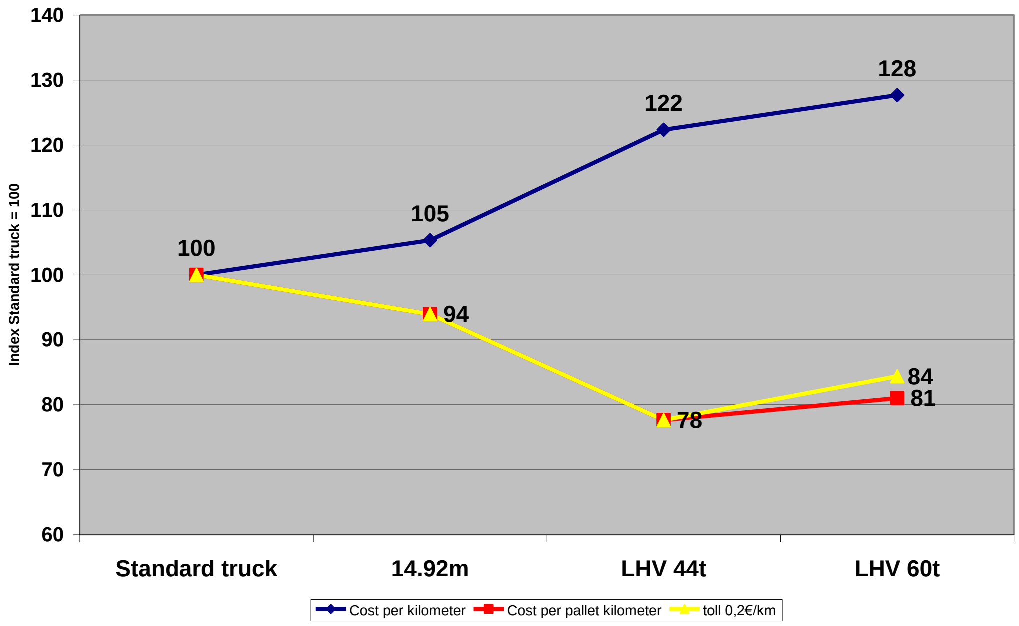
Vehicle type	Maximum payload	Maximum volume/ pallet spaces
Standard semi-trailer 40 t vehicle gross weight 16,5 m length	26 t	100 m³ 33 pallet spaces
„BigMaxx“ 40 t vehicle gross weight 17,8 m length	14,9 m 27,5 t	110 m³ 37 pallet spaces
44 t vehicle gross weight 25,25 m length	18 t (maximum payload) 8 t	150 m³ 51 pallet spaces
60 t vehicle gross weight 25,25 m length	11 t 27 t	150 m³ 51 pallet spaces

(Source: K+P)

In the modelling process these LHV configurations were compared to the reference vehicle i.e. standard 40/44t/18m semi-trailer combination offering 33 pallet spaces and a payload of 26 tonnes.

In other studies elaborated for the automotive industry and the German Federal Ministry of Transport, Building and Urban Development, cost evaluations for various LHV configurations have been carried out, which are valid for this study too (cf. ***chapter 3.2***). The following ***figure 2.8*** presents the total cost index as well as the cost index per pallet space for the LHV configurations chosen for this study.

Figure 2.8: Cost indices per vehicle type (standard 40/44 tonnes configuration = 100)



(Source: K+P)

Following discussions with the technical committee, the 60t/25.25m LHV was considered as being subject to a €0.20 higher toll, whereas the other configurations were not additionally tolled.

As can be clearly seen, the 14.92m semi-trailer combination reaches a 5% higher total cost per kilometre, whereas the total costs per pallet space are 6% less than the reference vehicle, thus offering the most advantage cost situation per pallet space.

On the other side of the range, the total costs per km of the 60t/25.25m LHV are 28% higher, whereas per pallet space the costs are 19% (without specific toll), respectively 16% (with specific toll) lower.

Compared to the standard truck, the 44t/25.25m LHV offers the lowest costs per pallet space (- 22%).

To conclude, the 44t/25.25m LHV offers - compared to the reference truck - the most advantageous cost per pallet space.

Naturally, we have to point out that the costs per pallet space implicitly refer to a 100% use of capacity in terms of pallet space.

2.4 Literature review

Objective/ Definitions

(1) The objective of this working step is to give an overview of the current state of the art of freight modelling, in particular on the issue of elasticities.

Direct price elasticities (or "own elasticity") give the intensity of the demand reaction on variations of the price of the mode under consideration e.g. the changes of modal split for road as a result of the changes of the road prices. Cross price elasticities give the intensity of the demand reaction for road transport as a result of changes of the rail price. In the publications it was pointed out that cross price elasticities would be appropriate but difficult to interpret since they are very much depending on the mode share in the observed situation."

Literature

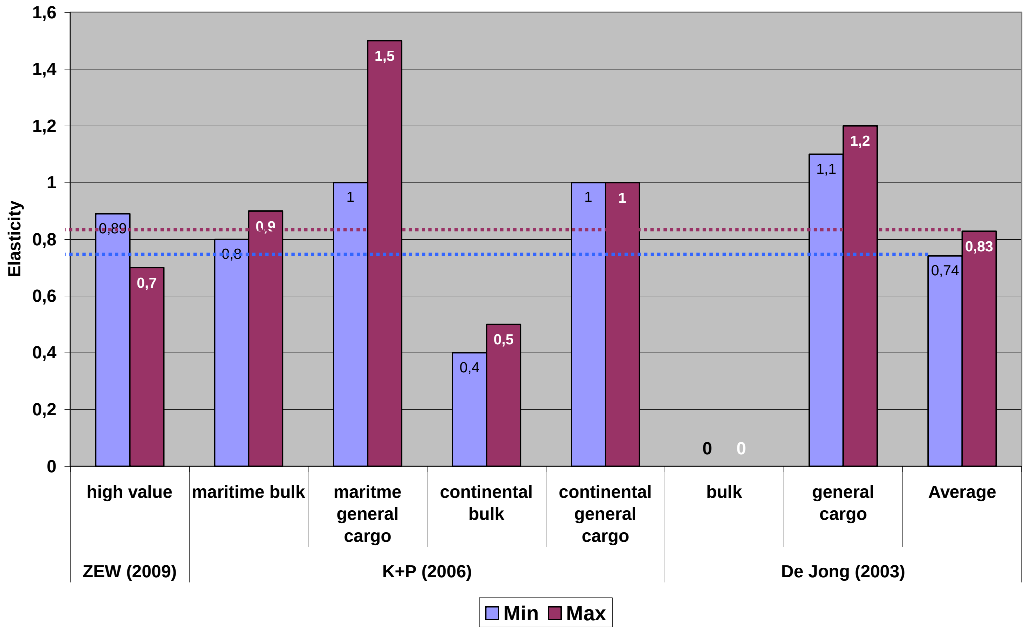
(2) We carried out a widespread and in depth analysis of 17 national and international publications. The detailed analysis and the results are presented in ***annex 2*** of this report.

"K+P elasticities"

(3) As mentioned before, K+P carried out various studies dealing with the reaction of rail transport (conventional and TC) on road price decrease as a result of road cost decrease.

The following ***figure 2.9*** is presenting a comparison of the elasticities for Combined Transport per segment of the K+P model with other publications:

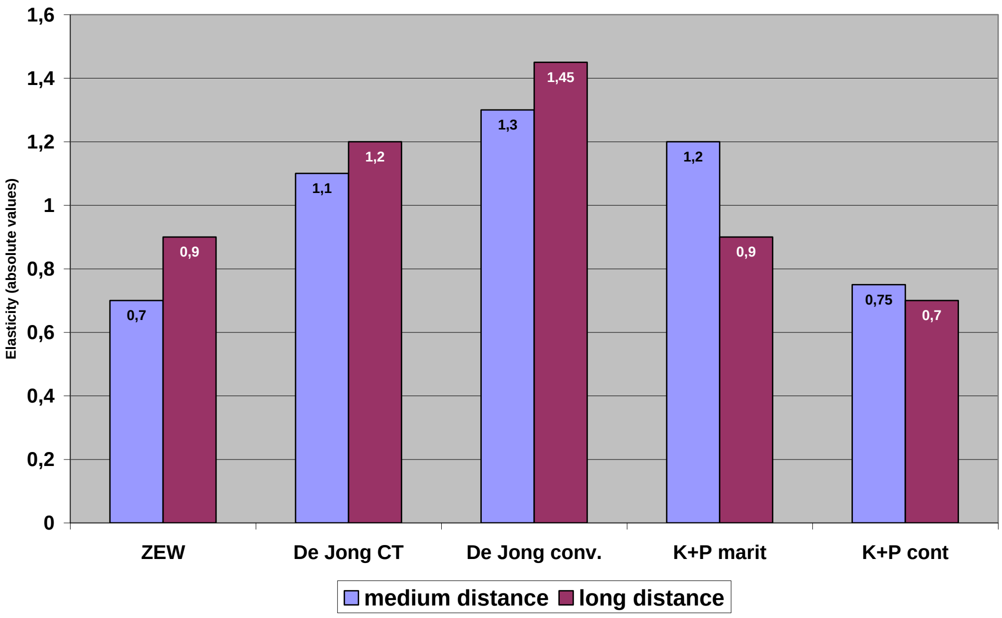
Figure 2.9: Comparison of price elasticities for Combined Transport per market segment



(Source: K+P Analysis)

The following ***figure 2.10*** presents the results of the comparison of K+P elasticities per distance class with other sources.

Figure 2.10: Comparison of price elasticities per distance class for rail transport (conventional (De Jong conv.) and CT (ZEW, De Jong CT and K+P)



(Source: K+P Analysis)

The comparisons bring to evidence that generally spoken, K+P elasticities fit with the order of magnitude of other studies. This was clearly confirmed by De Jong (2010) when stating that "76% of all direct price elasticities range between -1.27 and -0.41" and the recommendation in the same publication to start from the average of -1.0 as "best guess".

Figure 2.9 points out that the K+P elasticities for general cargo in Combined Transport range between the values of the other publications for continental transports (1.0 compared to 0.7/0.89 (ZEW 2009) and 1.1/1.2 (De Jong 2003)). The maritime market reacts more elastically than the continental market. Given that De Jong (2003) estimates that the bulk CT is non-elastic to price changes (Elasticity = 0), the K+P results show a much more elastic reaction (0.8/0.9 (maritime) and (0.4/0.5 (continental)).

From ***figure 2.10,*** it can be seen that K+P results per distance class show a lower elasticity for long distance CT transports (0.9 (maritime)/0,7 (continental)). Even though these results are in contradiction to other publications, we strongly believe in the validity of the K+P results because it is evident that the longer the distance in CT transports, the more competitive CT is compared to road transport.

Finally we are using the following elasticities for the model runs for the single wagonload

- Medium distance (200 – 400km) ε = 1.3
- Long distance (> 400km) ε = 1.46

As well as the following for CT

- Maritime Container (light) ε = 1.0
- Maritime Container (heavy) ε = 0.8
- Continental swap bodies (light) ε = 1.0
- Continental swap bodies (heavy) ε = 0.4

Compared to CT the elasticities for the single wagonload are relatively high. This reflects the extreme importance of fixed costs in this rail freight production system.

The model reacts solely on relative cost/price variation between road and rail transports. Given the general assumption that road cost decrease will be will be entirely transferred by the road hauliers to their clients, these elasticities could be interpreted as cross price elasticities. Hence a cost decreases in road transport of x% lead to an increase of the relative price difference between road and rail of x%. This – in turn - leads to a decrease in rail volumes of:

$$\varepsilon * x \%$$

3. Impact Modelling

3.1 Forecast of market volumes – scenarios for 2015/2020/2030

Forecast market volumes

(1) The forecasts of market volumes for the periods 2015, 2020 and 2030 were calculated by using different sources. DIOMIS I and II ("Developing Infrastructure use and Operating Models for Inter-modal Shift", UIC) was used for Combined Transport as the main source.

In addition to that, a study we carried out in 2010 for the Swiss BAV (Bundesamt für Verkehr, "Trends und Innovationen in und durch die Schweiz") was used for the forecast of the CT flows transiting Switzerland.

For single wagonload we used the "Bundesprognose 2025". Since all the corridors with single wagonload traffic (1, 3a, 3b and 4) are touching Germany, we used this most recent official forecast of the Federal Ministry of Transport.

In ***table 3.1*** all data sources for calculating the forecast market volumes are mentioned.

Table 3.1: Data sources for forecasts 2015/2020/2030

Segment	Data source
CT in Western Europe	**UIC Etude de capacité** **DIOMIS I**
CT in CEE countries	**DIOMIS II**
CT transiting Switzerland	**Trends und Innovationen im unbegleiteten Kombinierten Verkehr in der und durch die Schweiz**
CT transiting Austria	**DIOMIS II**
Wagon load	**Bundesprognose 2025**

(Source: K+P)

Growth rates

(2) ***Table 3.2*** shows forecasted growth rates for Combined Transport and single wagonload for the years 2015, 2020 and 2030. For single wagonload, the Bundesprognose 2025 assumes a linear growth of 0.78% per annum from 2008 to 2030

For Combined Transport different growth rates for each market (maritime and continental, domestic and international traffic) were used according to the sources indicated in ***table 3.1***

Table 3.2: Growth rates for CT and single wagonload 2008-2030

	2008-2030	Until 2015				2015 - 2030			
	Single wagon load	CT maritime		CT continental		CT maritime		CT continental	
Countries	international	domestic	international	domestic	international	domestic	international	domestic	international
Germany	0,78%	14,02%	17,53%	8,03%	11,19%	6,24%	6,24%	6,14%	6,14%
Czech Republic		1,54%	10,00%	1,54%	47,85%	1,54%	6,24%	1,54%	6,14%
Benelux		*12,60%*	12,60%	4,10%	4,10%	6,24%	6,24%	4,10%	4,10%
France		*11,47%*	*11,47%*	*12,77%*	*11,47%*	6,24%	6,24%	6,14%	6,14%
Spain			*12,60%*		*4,10%*		6,24%		4,10%
Sweden			*17,53%*		*11,19%*		6,24%		6,14%
Danmark			*17,53%*		*11,19%*		6,24%		6,14%
Switzerland		2,27%	8,87%	0,75%	8,99%	2,27%	6,24%	0,75%	6,14%
Austria		7,25%	*13,00%*	4,28%	*13,00%*	6,24%	6,24%	4,28%	6,14%
Italy		11,45%	*11,90%*	9,56%	*11,90%*	6,24%	6,24%	6,14%	6,14%
Hungary		8,46%	15,54%	8,46%	15,54%	6,24%	6,24%	6,14%	6,14%

(Source: K+P)

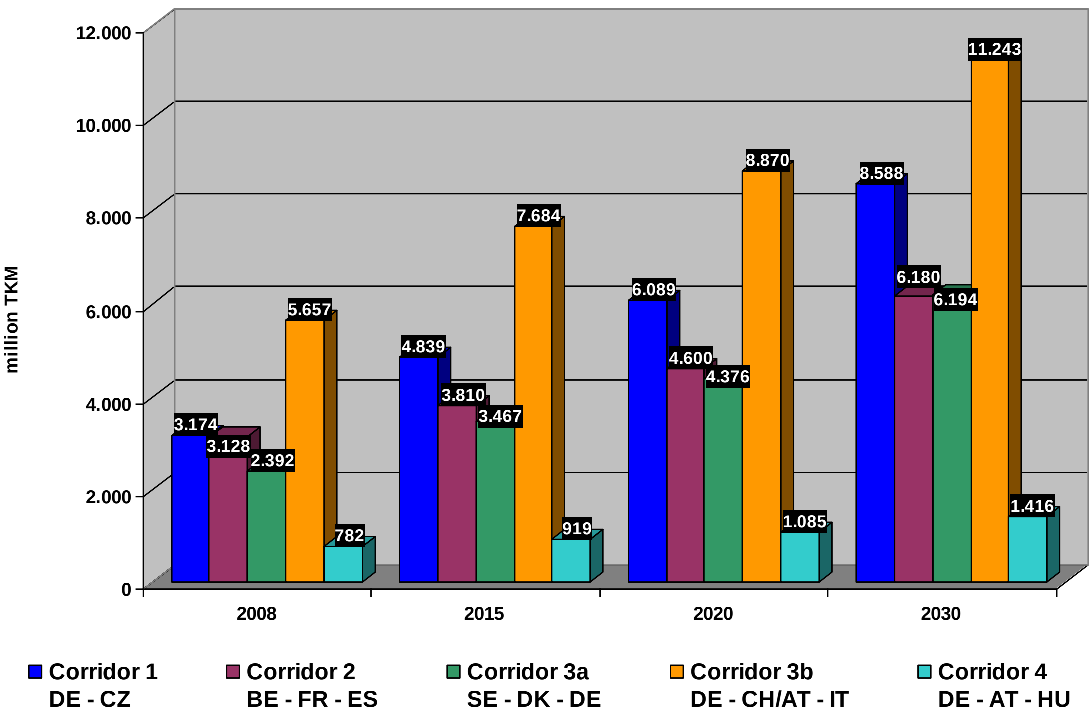
The enormous growth rate for international continental CT (47.88%) in the Czech Republic is due to the fact that in 2008 this market was practically non-existent.

Volumes on corridors

(3) As a result of these forecasts ***figure 3.1*** (Combined Transport) and ***figure 3.2*** (single wagonload) show the development of 2008 – 2030 corridor by corridor.

The predominance of Corridor 3b becomes obvious as well as the important growth of Corridor 1 due to the development of continental CT in the CEE countries, in particular the Czech Republic in the period between 2015 and 2030.

Figure 3.1: Total Rail CT in million tonne-kilometres 2008 - 2030

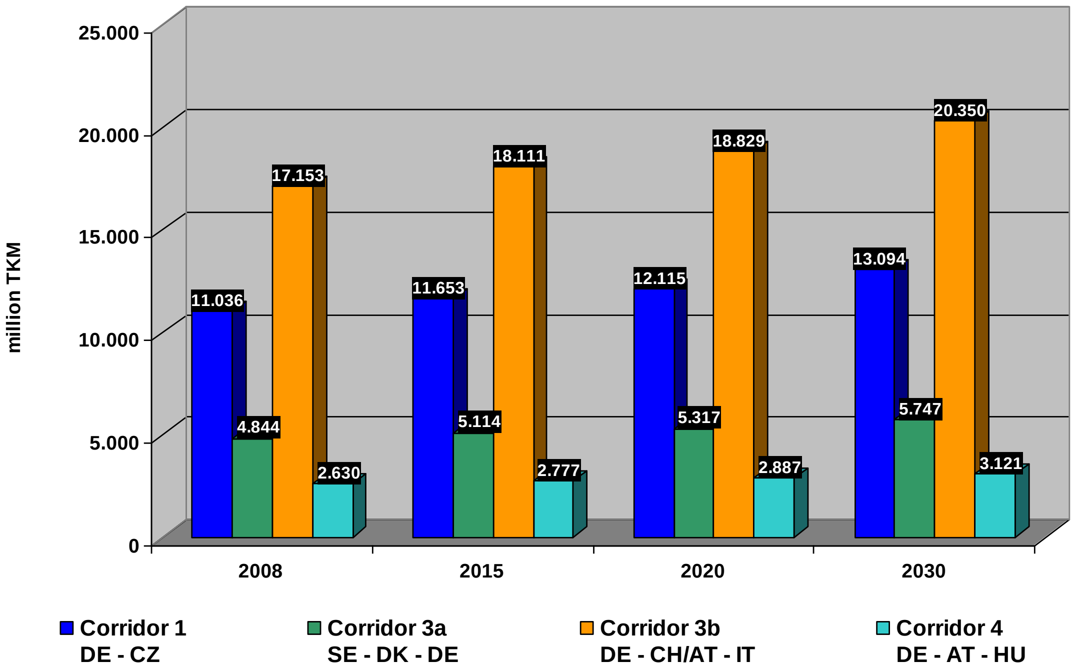


(Source: K+P)

Figure 3.2 gives an overview of the corridor specific development for single wagonload. According to the relatively low growth expectations for this market in the forecast of the "Bundesprognose 2025", single wagonload transports will deliver modest growth over the forecast period.

Again corridor 3b is the most important one followed by corridor 1. As mentioned previously, we did not get any data on single wagonload traffic for corridor 2.

Figure 3.2: Total Rail wagonload (including block trains) in million tonne-kilometres 2008- 2030



(Source: K+P)

This corridor specific approach was chosen to take into account all the particularities of each corridor i.e. repartition of single wagonload, block trains and CT trains as well as the commodity mix on each corridor, As a consequence the results are only valid for the specific corridor considered and may not be transferred to other corridors. But, as mentioned above, these corridors cover the most important rail axes in Europe.

3.2 Cost model and downward spiral

Cost Model

(1) In order to determine the relative cost advantages/disadvantages for each corridor, a cost-model was set up, containing the cost factors significant for the calculation. For road transport in particular should be mentioned:

- Distance
- Fuel price

- Road toll (only for 60t/25.25m LHV)
- Load capacities (tonnes, pallet spaces)
- Kilometric and hourly costs per truck type (including higher acquisition and operating costs of LHVs)

According to expert discussions with the automotive industry, we considered for LHVs a 25% higher acquisition cost plus 3% higher cost for additional safety features, thus in total 28%.

Concerning operating costs (disregarding fuel costs), we assumed 5% higher costs than for the standard HGV.

Finally we started from the assumption of a 22% higher fuel consumption per vehicle as weighted average for heavy and light loads.

This cost model was used to compare the costs per pallet space for a standard HGV to the different LHV types. Compared to the standard 40/44t/18m HGV, the cost advantage of the 14.92m semi-trailer ("Big Maxx") amounts to 6.1%, the 44t/25.25m LHV to 22.4% and finally the 60t/25.25m LHV to 15.6% (€0,2/km additional toll included) (***Table 3.3, see also Figure 2.8).***

Table 3.3: Cost advantage compared to standard truck

Vehicle type	Cost advantage compared to standard truck
BigMaxx (14,92m)	**-6,1%**
LHV 44 tonnes	**-22,4%**
LHV 60 tonnes (incl. road toll)	**-15,6%**

(Source: K+P)

The different prices for road and rail transport were calculated with these input data and the back-shifted transport volumes from rail to road were determined with the inclusion of elasticity models. This model results in different market specific elasticities for Combined Transport and single wagonload which are highlighted in ***Table 3.4*** (see also ***chapter 2.4***)

Table 3.4: Elasticities for single wagonload and Combined Transport

Single wagon load	Elasticities
medium distance (200-400km)	1,3
long distance (>400km)	1,46
CT	
maritime (light)	1
maritime (heavy)	0,8
continental (light)	1
continental (heavy)	0,4

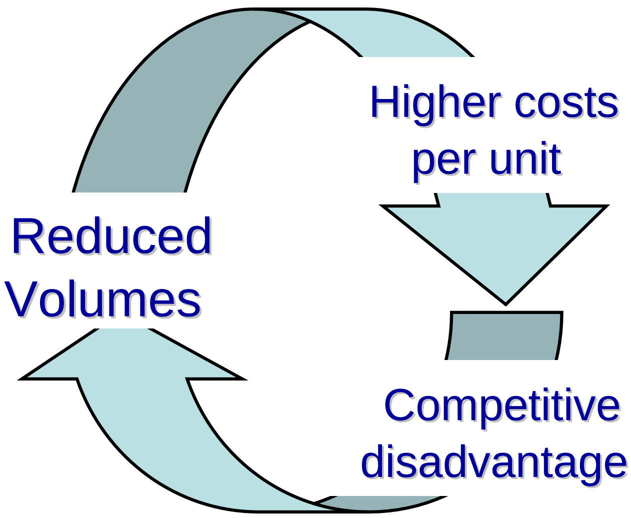
(Source: K+P)

Downward Spiral

(2) Rail transport in general and single wagonload in particular suffers from high fixed costs. Hence, for Combined Transport and single wagonload traffic an additional effect was calculated, based on the assumption that a first back-shift of transport volumes to road (caused by the price advantage of the new LHV vehicles) is generating higher costs per remaining transported unit and consequently a competitive disadvantage for rail transport.

This means that even a slight reduction of volumes on a given service would lead to higher costs per unit, which in turn leads to a further reduction of the competitive advantage of rail transport compared to road transport and – in consequence - to further back-shifts from rail to road. This “downward spiral” effect is illustrated in the scheme in ***Figure 3.3***

Figure 3.3: Scheme of the downward spiral



(Source: K+P)

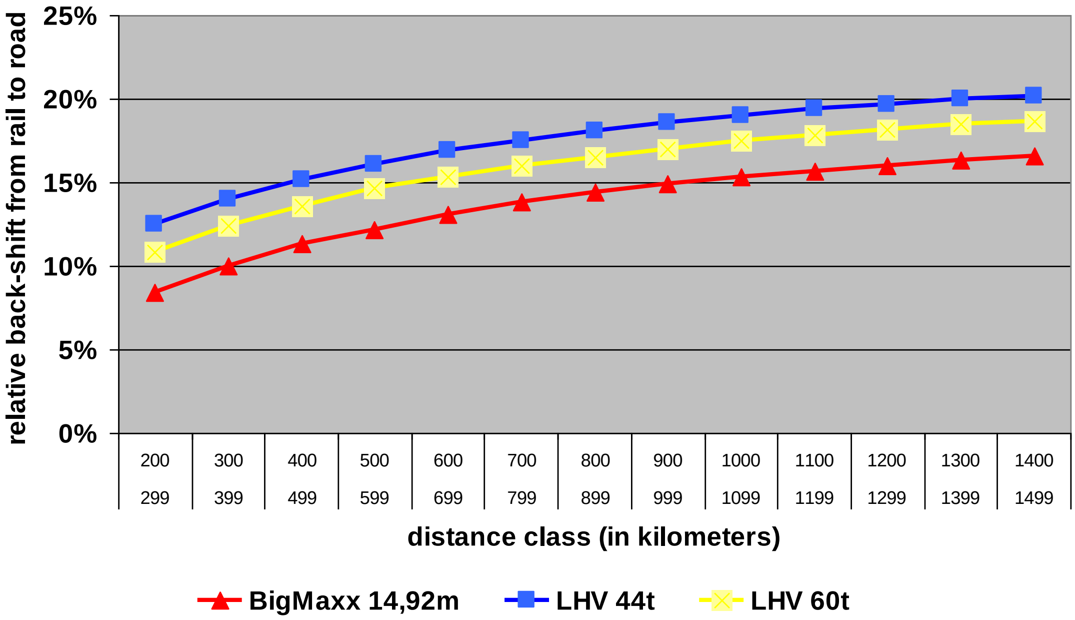
For this study a model was used with the objective of quantifying this effect for Combined Transport as well as for single wagonload.

When calculating the downward spiral for single wagonload traffic starting with the relatively high elasticities of 1.3/1.4 (***table 3.4***), we assumed for the following "rounds" a lower elasticity of 0.58. This takes into account that a considerable part of single wagonload is –at least in medium terms- captive to rail.

Talks to railway companies revealed that in single wagonload the situation is even worse than the situation in Combined Transport, due to the very low margin of profit in this market. Hence, it can be assumed that single wagonload is very sensitive to volume reductions: given the very low economic threshold it is highly probable that volume reductions would lead to a complete suspension of the service. It has to be pointed out that this microeconomic decision, to completely suspend a service, cannot be modelled.

Figure 3.4 shows the results of the downward spiral effect on transports in the segment of light continental CT per distance class, as an example. This figure can be interpreted as follows: the relative back-shifts are nearly the same for relations with a distance of 900 to 1,000 kilometres as for relations with a distance of 1,500 km, which reflects the growing competitive advantages of CT on long distances. One has to keep in mind that the back-shifts are calculated on the base of tonne-kilometres. This means that on shorter distances the potential for back-shifts is relatively low, thus the relative back-shifts are lower.

Figure 3.4: Relative back-shifts from light continental CT to road caused by the downward spiral effect



(Source: K+P)

Generally, one has to critically mention that the methodology of the downward spiral is not fully appropriate for corridor studies. The reason is that the corridor study considers only origin/destination pairs along the corridors (origin **and** destination within the corridor), whereas the single wagonload production system generally is a network-type production system.

3.3 O/D matrices for the different corridors

Development of O/D matrices

(1) The O/D matrices for this project were developed with input data from different sources. For single wagonload, most of the data was provided by the national railway undertakings (***table 3.5***). Regarding CT we used the database developed for the UIC DIOMIS project, dealing with Combined Transport in Europe.

The different data sets were analysed and converted into a consistent form based on tonnes and tonne-kilometres for the base year 2008 by calculating average distances between regions on NUTS-2 level, single wagonload transports were segmented by NST-R 10 commodity groups, whereas CT was segmented in 4 markets (heavy and light maritime as well as heavy and light continental).

Table 3.5: Data sources for O/D matrices

	single wagon load	Combined Transport
Germany	DB	DIOMIS I
Czech Republic	DB	DIOMIS II
Benelux	no data available	DIOMIS I
France	no data available	DIOMIS I
Spain	no data available	DIOMIS I
Sweden	SJ	DIOMIS I
Danmark	DB	DIOMIS I
Switzerland	DB/FS	DIOMIS I
Austria	ÖBB	DIOMIS I/II
Italy	FS	DIOMIS I
Hungary	ÖBB	DIOMIS II

(Source: K+P)

3.4 Base assumptions

Assumptions

(1) Before entering into the description of the model results, we clearly have to point out some base assumptions made during in the modelling process.

Firstly, we assume that the road cost decrease attributable to the introduction of LHVs will be entirely transferred by the road hauliers to their clients. This assumption seems realistic given the current level of competition in this business. Giving up this assumption would reduce the modal back-shift effect from rail to road since in that case the cost advantage of the LHV would be reduced.

Given the high road-damaging potential of the 60t/25.25m LHV, it was decided by the technical committee of this study that these vehicles are subject to an additional toll of €0.20 per kilometre for this specific vehicle type.

Regarding the reaction of the railways on the introduction of LHVs, our model is based on the ceteris paribus assumption, meaning all other things being equal. This means that we don't assume a price reaction of railways on the variation of road prices as well as no productivity improvements of railways which could lead to railway cost reductions (cf. chapter 7.5).

Impact on the model results

(2) With the exception of the specific toll for 60t/25.25m LHV, the assumptions described above impact the model in the same direction: to a maximum back-shift from rail to road.

Giving up these assumptions, the relative cost advantage of the LHV compared to rail transports would decrease, turning into a reduced back-shift.

As mentioned in ***chapter 2.3*** the impact of each LHV type was evaluated in separate scenarios, meaning that the modal back-shift in the case of the 60t/25.25m LHV does not contain the impact of the 44t/25.25m and the 14.92m semi-trailer. In reality, however, the homologation of a 60t/25.25m LHV in Europe would also include the authorization of lighter LHV, e.g. the 44t/25.25m LHV.

The model results have to be observed in this light, i.e. in reality the back-shift from rail to road might be higher in the case of a "cumulative scenario" where the 60t/25.25m LHV and all other LHV types were admitted. Nevertheless, to avoid double countings it is not possible to simply add the scenario results.

4. Back-shifted volumes per corridor

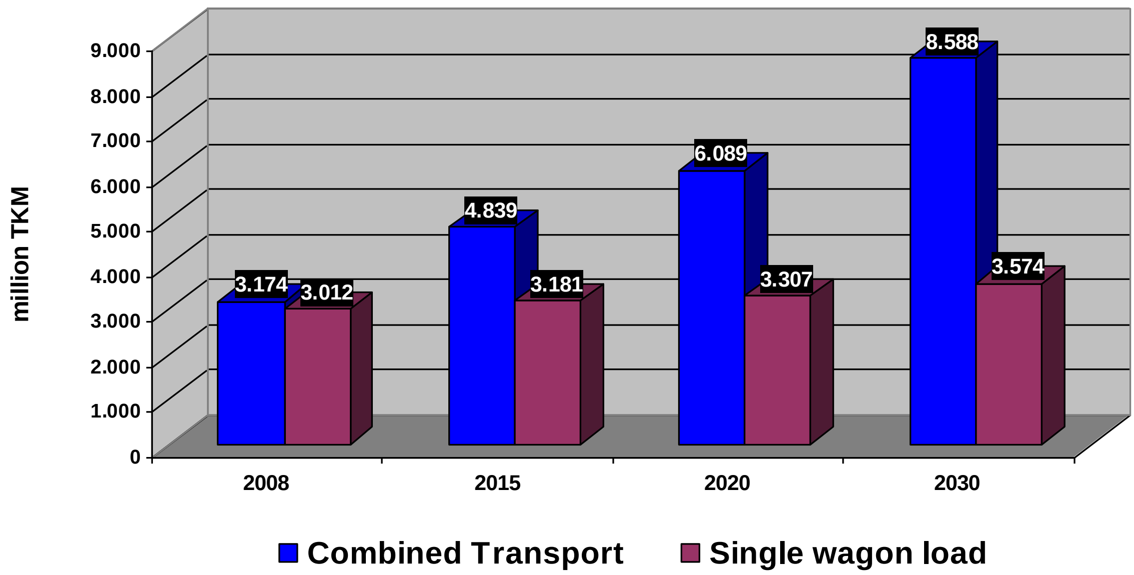
4.1 Germany seaports - Czech Republic (Corridor 1)

Total volumes

(1) ***Figure 4.1*** shows the total volumes for Combined Transport and single wagonload for the base year 2008 and the forecast years 2015, 2020 and 2030.

In 2008 single wagonload transports amounted to 3.0 billion tonne-kilometres, whereas CT volumes reached 3.7 billion tonne-kilometres. These levels will change significantly by 2030 because of the inferior growth of single wagonload (0.78% per annum) while Combined Transport growth rates on this corridor is prospected between 1.5% and 48% (see ***Table 3.2***). This leads to a CT transport volume of approximately 8.6 billion tonne-kilometres, a growth factor of 2.7, while single wagonload increases by 19% to approximately 3.6 billion tonne-kilometres.

Figure 4.1: Corridor 1: Total volumes (CT and single wagonload) 2008-2030



Back-shifted volumes CT

(2) ***Table 4.1*** illustrates the back-shifted volumes for Combined Transport. In these figures the downward spiral effect (cf. ***Chapter 3.2***) is included

Table 4.1: Corridor 1: Total back-shifted volumes of CT 2008- 2030 per LHV scenario

		Corridor 1: German Seaports - Czech Republic			
		2008	2015	2020	2030
BASE: No LHVs					
Combined Transport (total)	million TKM	3.174,0	4.838,9	6.088,6	8.588,0
14.92m semi-trailer					
Combined Transport shifted volumes	million TKM		23,4	30,6	44,9
	in %		0,48%	0,50%	0,52%
44t/25.25m LHV					
Combined Transport shifted volumes	million TKM		544,7	714,4	1.101,4
	in %		11,26%	11,73%	12,83%
60t/25.25m LHV					
Combined Transport shifted volumes	million TKM		442,2	579,9	893,4
	in %		9,14%	9,52%	10,40%

(Source: K+P)

According to the model results, the modal back-shifts amount to 0.5% in the 14.92m semi-trailer scenario, a range of 11 – 13% in the 44t/25.25m LHV and 9 to 10% in the 60t/25.25m LHV scenario.

Generally spoken, the modal back-shift on this corridor is relatively limited because of the high amount of transports on relatively short distance for which the LHV´s cannot play out their advantages.

Back-shifted volumes single wagonload

(3) In ***table 4.2*** the back-shifted volumes are displayed exclusively for single wagonload on Corridor 1. According to these results, the modal back-shifts including the downward-spiral effect are by far higher than for CT (11.5% in the 14.92m semi-trailer scenario, 30.5% (44t/25.25m LHV) and 26% (60t/25.25m LHV). As pointed out in ***chapter 3.2,*** this is due to the high share of fixed costs in the single wagonload market, which is reflected in the higher elasticities.

In addition, Corridor 1 could be characterised by relatively short average transport distances.

Table 4.2: Corridor 1: Total back-shifted volumes of single wagonload 2008- 2030 per LHV scenario

		Corridor 1: German Seaports - Czech Republic			
		2008	2015	2020	2030
BASE: No LHVs					
Single wagon load (total)	million TKM	3.012,2	3.180,6	3.306,5	3.573,7
14.92m semi-trailer					
Single wagon load + downward spiral shifted volumes	million TKM	-	365,1	379,6	410,2
Shifted volumes/Single wagon load	in %	11,48%			
44t/25.25m LHV					
Single wagon load + downward spiral shifted volumes	million TKM	-	971,0	1.009,4	1.091,0
Shifted volumes/Single wagon load	in %	30,53%			
60t/25.25m LHV					
Single wagon load + downward spiral shifted volumes	million TKM	-	819,7	852,2	921,0
Shifted volumes/Single wagon load	in %	25,77%			

(source K+P)

Qualitative evaluation of the results

(4) The model results for corridor 1 can be summarised as follows:

- **Disproportionate growth for Combined Transport until 2030**
- **Relatively moderate back-shift from CT on the corridor**
- **Disproportionate high back-shift of volumes for single wagonload**
- **For CT as well as for single wagonload traffic, the 44t/25.25m LHV creates the strongest impact**

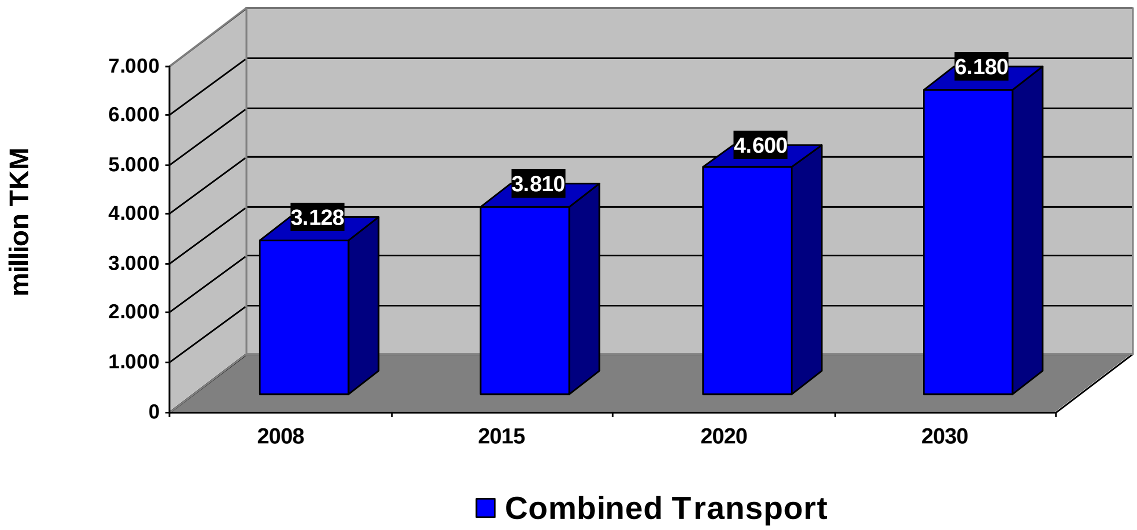
4.2 Belgium and Dutch seaports (Antwerp, Rotterdam) – Ile de France – Spain (Barcelona) (Corridor 2)

Total volumes

(1) ***Figure 4.2*** shows the total volumes for Combined Transport (for single wagonload no data was made available) for the base year 2008 and the forecasted years 2015, 2020 and 2030. The growth rates of CT are reaching from relatively moderate 4.1% for domestic continental CT in Benelux to 12.6% for international maritime CT in Benelux and Spain.

Total CT volumes would nearly double on this corridor from 2008 to 2030 (+97%).

Figure 4.2: Corridor 2: Total volumes (solely Combined Transport) 2008-2030



(Source: K+P)

Back-shifted volumes CT

(2) ***Table 4.3*** illustrates the back-shifted volumes for Combined Transport on Corridor 2 including the downward spiral effect.

As can be seen from this table, the 44t/25.25m LHV shows also the strongest impact on rail markets with a rate of back-shifted volumes from 9.5% in 2008 to 16.4% of the CT tonne-kilometres on the corridor in 2030. Volumes back-shifted from rail to road are also growing disproportionately over time – from 2008 to 2030 by 236% - whereas total CT volumes on this corridor grow by “only” 97%.

Table 4.3: Corridor 2: Total back-shifted volumes of CT 2008- 2030 per LHV scenario

		Corridor 2: Benelux-Seaports - Spain			
		2008	2015	2020	2030
BASE: No LHVs					
Combined Transport (total)	million TKM	3.127,6	3.809,6	4.599,7	6.179,7
14.92m semi-trailer					
Combined Transport shifted volumes	million TKM	-	56,3	72,3	104,3
	in %	-	1,48%	1,57%	1,69%
44t/25.25m LHV					
Combined Transport shifted volumes	million TKM	-	469,1	612,9	1.013,5
	in %	-	12,31%	13,32%	16,40%
60t/25.25m LHV					
Combined Transport shifted volumes	million TKM	-	389,0	508,2	838,8
	in %	-	10,21%	11,05%	13,57%

(Source: K+P)

Qualitative evaluation of the results

(3) Corridor 2 is the only corridor in the study which is not transiting Germany. A total of 3.1 billion tonne-kilometres of CT were transported in 2008.

- **CT tonne-kilometres would practically double in the period 2008 – 2030 if no LHV would be authorised**
- **The introduction of the 14.92m semi-trailer would lead to a back-shift between 1.2 and 1.7% of the total volume**
- **The 44t/25.25m LHV leads in 2030 to a back-shift of approximately 1 billion tonne-kilometres, which is more than 16%, whereas the 60t/25.25m LHV affects CT less (back-shifts forecasted up to 14%).**

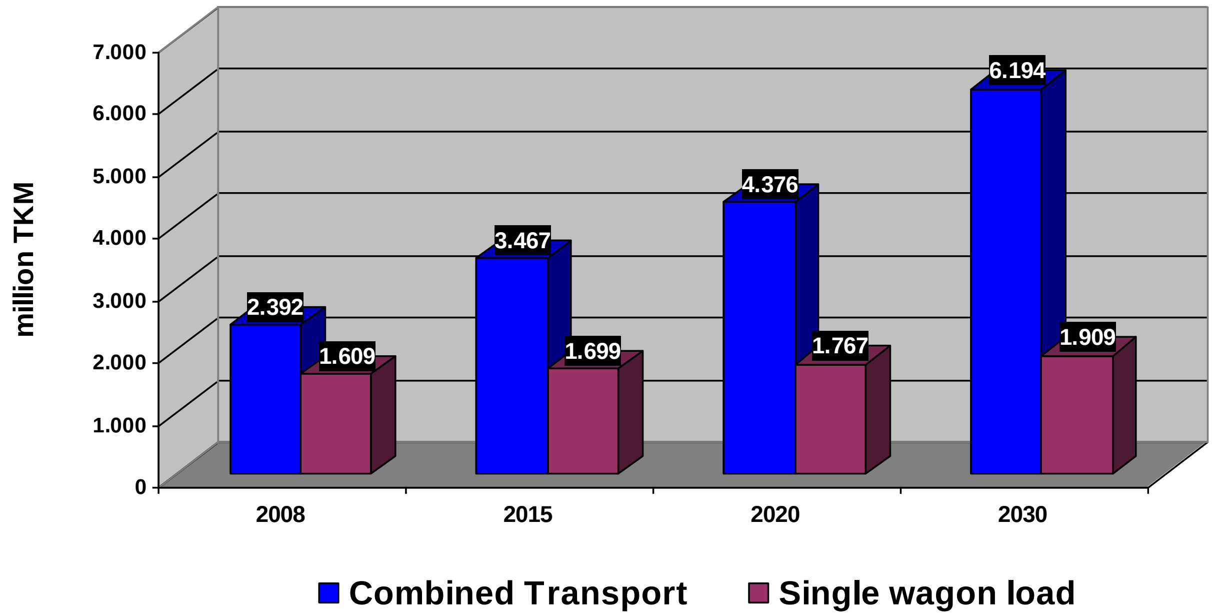
4.3 Scandinavia (Malmö) – Denmark – Germany (Ruhr area) (Corridor 3a)

Total volumes

(1) ***Figure 4.3*** presents the rail volumes on corridor 3a differentiated by CT and single wagonload.

As can be seen from this figure, CT is more important on this corridor than single wagonload. Given the expected relatively low growth for conventional single wagonload rail traffic and the much higher expected CT growth, it turns out that by 2030 CT tonne-kilometres will be more than three times higher than single wagon.

Figure 4.3: Corridor 3a: Total volumes (CT and single wagonload) 2008-2030



(Source: K+P)

Back-shifted volumes CT

(2) ***Table 4.4*** displays the back-shifted volumes of CT in Corridor 3a one can observe the same situation as for the other corridors: The 14.92m semi-trailer affects Combined Transport less than the other LHV types, (3% compared to 10%/13%).

Table 4.4: Corridor 3a: Total back-shifted volumes of CT 2008- 2030 per LHV scenario

		Corridor 3A: Southern Sweden - Ruhr Area 2008	2015	2020	2030
BASE: No LHVs					
Combined Transport (total)	million TKM	2.391,6	3.467,3	4.376,2	6.194,0
14.92m semi-trailer					
Combined Transport shifted volumes	million TKM		111,6	145,9	214,4
	in %		3,22%	3,33%	3,46%
44t/25.25m LHV					
Combined Transport shifted volumes	million TKM		403,1	527,9	825,2
	in %		11,62%	12,06%	13,32%
60t/25.25m LHV					
Combined Transport shifted volumes	million TKM		330,5	432,8	675,5
	in %		9,53%	9,89%	10,91%

(Source: K+P)

Back-shifted volumes single wagonload

(3) In ***table 4.5*** the back-shifted volumes are displayed exclusively for single wagonload on corridor 3a. According to these results, the modal back-shifts, including the downward-spiral effect, reach approximately 10% in the 14.92m semi-trailer scenario, 21% (44t/25.25m LHV) and 20% (60t/25.25m LHV).

Table 4.5: Corridor 3a: Total back-shifted volumes of single wagonload 2008 - 2030 per LHV scenario

		Corridor 3A: Southern Sweden - Ruhr Area 2008	2015	2020	2030
BASE: No LHVs					
Single wagon load (total)	million TKM	1.609,5	1.699,4	1.766,7	1.909,5
14.92m semi-trailer					
Single wagon load shifted volumes	million TKM	-	166,9	173,5	187,5
Shifted volumes/Single wagon load	in %	9,82%			
44t/25.25m LHV					
Single wagon load shifted volumes	million TKM	-	363,2	377,6	408,1
Shifted volumes/Single wagon load	in %	21,37%			
60t/25.25m LHV					
Single wagon load shifted volumes	million TKM	-	340,5	354,0	382,6
Shifted volumes/Single wagon load	in %	20,04%			

(Source: K+P)

In total the tonne-kilometres back-shifted from rail to road amounts to 167 to 188 million tonne-kilometres for the 14.92m semi-trailer and between 340 and in excess of 400 million tonne-kilometres for the other LHV types.

Qualitative evaluation of the results

(3) The summarised characteristics of corridor 3a are listed below.

- **High share of CT**
- **In 2030 CT volumes will be more than three times higher than single wagonload volumes in the reference case (without LHVs)**
- **In 2030 more than 13% of the CT volumes will be back-shifted to the LHV**
- **The back-shifts of single wagonload range from 10 to more than 20% according to the LHV scenarios**

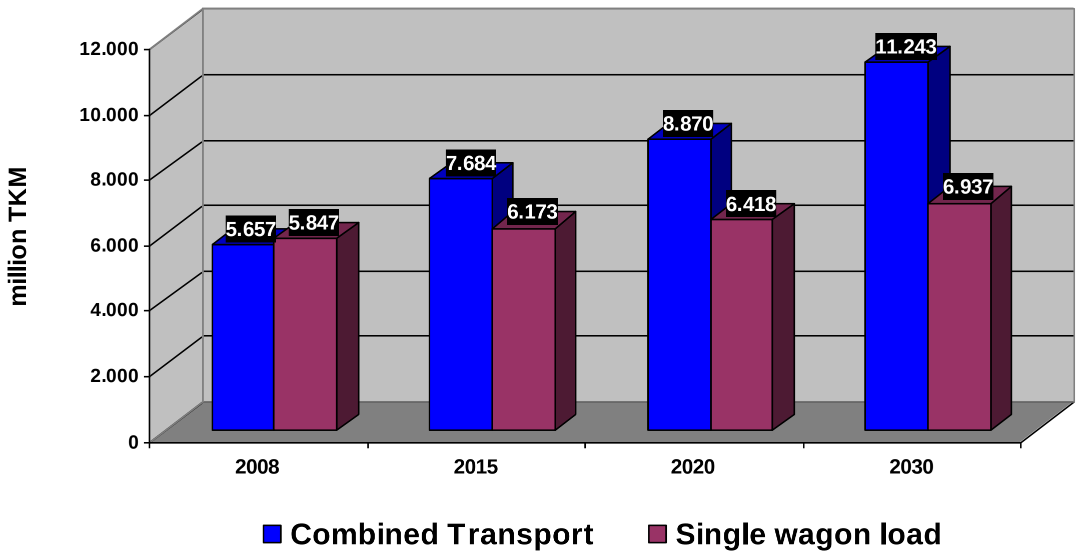
4.4 Germany (Ruhr area) – Switzerland / Austria – Italy (Corridor 3b)

Total volumes

(1) ***Figure 4.4*** shows the total volumes for Combined Transport and single wagonload for the base year 2008 and the forecast years 2015, 2020 and 2030.

The highest total volumes for Combined Transport and single wagonload of those examined in this study occur on this corridor. As one of the major routes for rail traffic in Europe - from the Rhine/Ruhr area crossing Switzerland and Austria to Italy – it shows in 2008 over 5.8 billion tonne-kilometres for single wagonload and more than 5.6 billion tonne-kilometres for Combined Transport. In the base year (2008) the volumes of Combined Transport and single wagonload are nearly equal, whereas in 2030 CT is forecasted to more than 60% higher volumes measured in tonne-kilometres.

Figure 4.4: Corridor 3b: Total volumes (CT and wagonload) 2008-2030



(Source: K+P)

LHV ban in Switzerland

(2) According to the estimation of the Technical Committee of this study and the authors it is most likely that Switzerland would not allow the entry or the transit of the 44t/25.25m and 60t/25.25m LHV.

The 14.92m semi-trailer was supposed to be allowed, since the total length of this combination does not exceed the total length of standard trucks with drawbar trailers.

This situation was integrated in the model in different ways as follows:

- For each origin-destination pair in this corridor, we calculated the additional costs of an alternative routing via Austria (Brenner). In the event that this route offered further (reduced) cost advantages for LHV (e.g. Köln – Emilia Romagna), this detour was integrated in the cost model.
- In the event that the detour costs were higher than the direct route via Switzerland, we assumed a reconfiguration of two LHV to three standard trucks at the German-Swiss border (greater Basel area). The flows between the Rhein-Main area and the Milan region (Lombardy) may serve as an example.
- On some relations, where both alternatives offer no cost advantage, we completely excluded the LHV alternative (e.g. Karlsruhe – Lombardy)

Back-shifted volumes CT

(3) ***Table 4.6*** displays the back-shifted volumes of CT in Corridor 3b.

Table 4.6: Corridor 3b: Total back-shifted volumes of CT 2008- 2030 per LHV scenario

		Corridor 3B: Ruhr Area - Northern Italy 2008	2015	2020	2030
BASE: No LHVs					
Combined Transport (total)	million TKM	5.656,6	7.683,8	8.870,3	11.243,4
14.92m semi-trailer					
Combined Transport shifted volumes	million TKM		383,6	501,4	736,9
	in %		4,99%	5,65%	6,55%
44t/25.25m LHV					
Combined Transport shifted volumes	million TKM		825,5	1.080,3	1.715,6
	in %		10,74%	12,18%	15,26%
60t/25.25m LHV					
Combined Transport shifted volumes	million TKM		690,4	903,5	1.432,2
	in %		8,98%	10,19%	12,74%

(Source: K+P)

According to the model results in the 14.92m semi-trailer scenario 380–737 million tonne-kilometres were back-shifted. In the 44t/25.25m LHV scenario the modal back-shift amounts to 825 million tonne-kilometres (2015), approximately 1 billion tonne-kilometres in 2020 and finally 1.7 billion tonne-kilometres in 2030. The 60t/25.25m LHV scenario results in a back-shift of 0.7 to 1.4 billion tonne-kilometres.

One has to keep in mind the reduced cost advantages of the LHVs in this scenario are caused by the LHV ban in Switzerland.

Back-shifted volumes single wagonload

(4) Regarding the back-shifts of the single wagonload traffic on this corridor, the model came to the following results (***table 4.7***):

Table 4.7: Corridor 3b: Total back-shifted volumes of single wagonload 2008-2030 per LHV scenario

		Corridor 3B: Ruhr Area - Northern Italy			
		2008	2015	2020	2030
BASE: No LHVs					
Single wagon load (total)	million TKM	5.846,7	6.173,5	6.418,0	6.936,6
14.92m semi-trailer					
Single wagon load shifted volumes	million TKM	-	782,8	813,8	879,5
Shifted volumes/Single wagon load	in %	12,68%			
44t/25.25m LHV					
Single wagon load shifted volumes	million TKM	-	2.346,6	2.439,6	2.636,7
Shifted volumes/Single wagon load	in %	38,01%			
60t/25.25m LHV					
Single wagon load shifted volumes	million TKM	-	1.504,1	1.563,7	1.690,0
Shifted volumes/Single wagon load	in %	24,36%			

(source: K+P)

The 14.92 semi-trailer scenario leads to modal back-shifts of nearly 783 million tonne-kilometres (2015) and 800/880 million tonne-kilometres (2020/2030), which amounts to 13% of the single wagonload traffic on this corridor. The LHVs (44t/25.25m and 60t/25.25m) impact the single wagonload traffic by far more: 24 – 38%, with a maximum of 2.6 billion tonne-kilometres.

The remark above concerning the reduced cost advantage caused by the LHV ban in Switzerland is also valid for single wagonload.

Qualitative evaluation of the results

(3) The model results for Corridor 3b can be summarised as follows:

- **Higher share of single wagonload in comparison to Combined Transport in 2008**
- **Growing market share of Combined Transport until 2030 (60% higher volumes than single wagonload)**
- **Highest amount of back-shifted volumes (absolute values) for Combined Transport of all corridors**
- **Highest amount of back-shifted volumes for single wagonload (absolute value) and second highest after Corridor 4 in relative values**
- **Relatively high back-shift of total volumes on the corridor because of mostly long distances (in comparison to other corridors)**
- **Until 2030 disproportionate high back-shift of volumes for Combined Transport compared to other corridors**
- **14.92m semi-trailer gains greater competitiveness on longer distances**

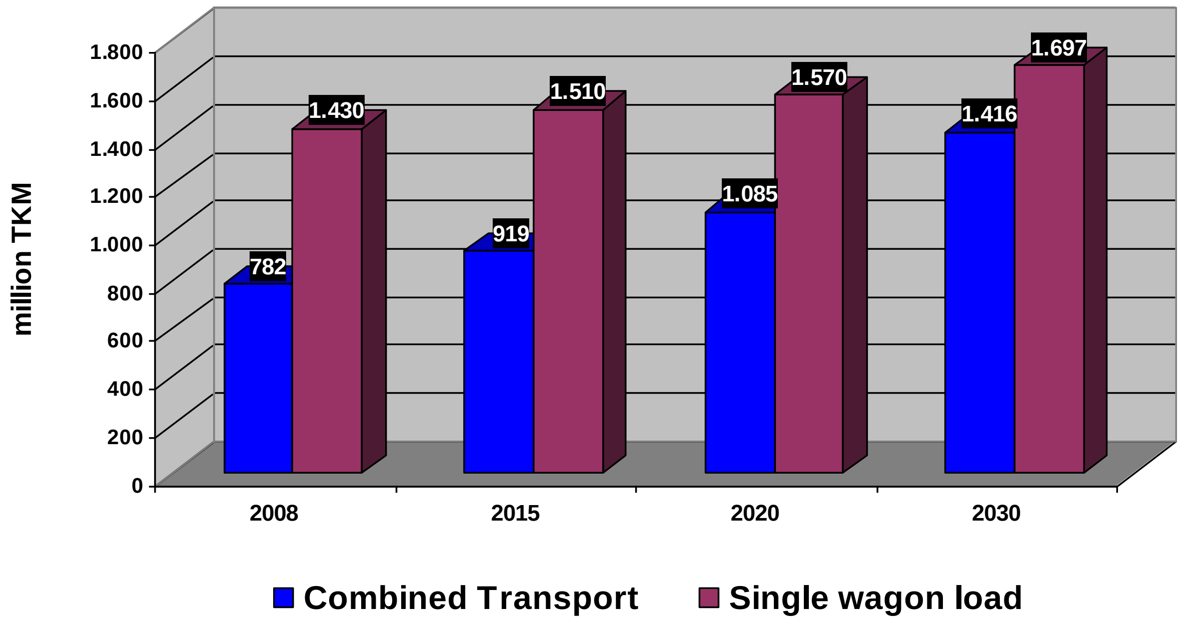
4.5 Germany (München/Nürnberg) – Austria – Hungary (Budapest) (Corridor 4)

Total volumes

(1) ***Figure 4.5*** presents the total rail performance in tonne-kilometres separately for CT and single wagonload for the years 2008, 2015, 2020 and 2030.

Compared to the other corridors (1, 3a and 3b), this 860km long corridor is the "weakest" with 0,8 billion tonne-kilometres (CT) and 1.4 billion tonne-kilometres (single wagonload) in 2008. Contrarily to other corridors, single wagonload has a higher market share than CT in 2030.

Figure 4.5: Corridor 4: Total volumes (CT and wagonload) 2008-2030



(Source: K+P)

Back-shifted volumes CT

(2) In ***Table 4.8*** the modal back-shift of Combined Transport per LHV type is presented.

Table 4.8: Corridor 4: Total back-shifted volumes of CT 2008- 2030 per LHV scenario

		Corridor 4: Southern Germany - Hungary 2008	2015	2020	2030
BASE: No LHVs					
Combined Transport (total)	million TKM	782,3	919,3	1.084,8	1.415,7
14.92m semi-trailer					
Combined Transport shifted volumes	million TKM		12,4	15,5	21,7
	in %		1,35%	1,43%	1,53%
44t/25.25m LHV					
Combined Transport shifted volumes	million TKM		88,3	114,5	191,5
	in %		9,61%	10,55%	13,53%
60t/25.25m LHV					
Combined Transport shifted volumes	million TKM		72,5	93,9	156,9
	in %		7,88%	8,66%	11,09%

(Source: K+P)

Due to the low absolute volumes on this corridor, the absolute modal back-shift turns out to be relatively moderate with values less than 200 million tonne-kilometres for Combined Transport in 2030 corresponding to 13.5%.

Nevertheless, ***table 4.8*** indicates that in 2030 nearly 14% of the Combined Transport will be back-shifted from rail to road. Compared to the very “strong” corridor 3b, where 15% of the volumes are projected to be back-shifted, it becomes obvious that the relative losses of rail freight are in the same order of magnitude, which is particularly threatening on “weaker” corridors like this one.

The total back-shifted volumes for single wagonload are displayed in ***Table 4.9*** (below). At first sight, the losses of single wagonload with the highest absolute back-shift of approx. 0.4 billion tonne-kilometres for the 44t/25.25m LHV, seem to be relatively limited on this corridor. Nevertheless this represents 25% of the total single wagonload traffic along the corridor. Given the low economic threshold for single wagonload, one can conclude that this "weak" corridor particularly affected.

Table 4.9: Corridor 4: Back-shifted volumes single wagonload 2008-2030

		Corridor 4: Southern Germany - Hungary			
		2008	2015	2020	2030
BASE: No LHVs					
Single wagon load (total)	million TKM	1.430,1	1.510,1	1.569,9	1.696,7
14.92m semi-trailer					
Single wagon load shifted volumes	million TKM	-	146,9	152,7	165,1
Shifted volumes/Single wagon load	in %	9,73%			
44t/25.25m LHV					
Single wagon load shifted volumes	million TKM	-	379,3	394,4	426,2
Shifted volumes/Single wagon load	in %	25,12%			
60t/25.25m LHV					
Single wagon load shifted volumes	million TKM	-	209,6	217,9	235,5
Shifted volumes/Single wagon load	in %	13,88%			

(Source: K+P)

Qualitative evaluation of the results

(3) The model results for corridor 4 can be summarised as follows:

- **Corridor 4 is the "weakest" corridor in this study regarding volumes measured in tonne-kilometres for CT as well as for single wagonload.**
- **Nevertheless, with losses of nearly 14% of CT and more than 25% of single wagonload this corridor is in particularly affected by the LHV especially when regarding the low profit margins of rail transport.**

4.6 Synthesis of the results for all corridors and comparison to the results of other studies

Synthesis

(1) After having described the results of the model runs for each corridor in detail, this section aims at giving a synthesis of the results and to compare them with the results of other studies, in particular the one carried out by Kessel+Partner Transport Consultants for the German Federal Ministry of Transport, Building and Urban Development: "Verkehrswirtschaftliche Auswirkungen von innovativen Nutzfahrzeugkonzepten II"

With the aim not to "overload" the synthesis, we decided to concentrate this analysis on the forecast year 2020.

Table 4.10 gives an overview of the absolute volumes (measured in tonne-kilometres) of Combined Transport along all corridors and the relative back-shifts per scenario (14.92m semi-trailer, 44t/25.25m LHV and 60t/25.25m LHV) in 2020.

Table 4.10: Modal back-shift from CT to road per scenario in 2020

Corridor	Total Combined Transport (million tkm)	volumes shifted (in %)		
		14.92m semi-trailer	44t/25.25m LHV	60t/25.25m LHV
Corridor 1 (DE, CZ)	6.088,6	0,50%	11,73%	9,52%
Corridor 2 (NL, BE, FR, ES)	4.599,7	1,57%	13,32%	11,05%
Corridor 3a (SE, DK, DE)	4.376,2	3,33%	12,06%	9,89%
Corridor 3b (DE, CH, AT, IT)	8.870,3	5,65%	12,18%	10,19%
Corridor 4 (DE, HU)	1.084,8	1,43%	10,55%	8,66%

(Source: K+P)

Regarding the CT volumes per corridor, one can summarise that corridor 1 and 3b show the highest volumes measured in tonne-kilometres, whereas corridor 4 is the weakest.

When comparing the relative back-shifts (downward spiral included), out of the three scenarios considered the 44t/25.25m LHV impacts most CT on the corridors: up to 13.32% of the tonne-kilometres on this corridor were back-shifted to road until 2020, which is not astonishing since this vehicle type offers the highest cost advantage per pallet space (more than 22% compared to the standard HGV).

According to the model results, the relative highest back-shift occurs on Corridor 2 (Belgian and Dutch Seaports – Spain), due to the high share of light maritime containers on this link, which react more elastically than continental load units. Given the relatively fragile situation of CT in France and the efforts of the Spanish government to invest in new railway links with UIC standard to connect the Mediterranean ports with France, this corridor seems particularly affected..

Table 4.11 (below) presents in the same manner the model results for single wagonload traffic.

Table 4.11: Modal back-shift from single wagonload to road per scenario in 2020

Corridor	total single wagon load (million tkm)	volumes shifted (in %, referred to single wagon load)		
		14.92m semi-trailer	44t/25.25m LHV	60t/25.25m LHV
Corridor 1 (DE, CZ)	3.306,5	11,48%	30,53%	25,77%
Corridor 2 (NL, BE, FR, ES)	no data available	-	-	-
Corridor 3a (SE, DK, DE)	1.766,7	9,82%	21,37%	20,04%
Corridor 3b (DE, CH, AT, IT)	6.418,0	12,68%	38,01%	24,36%
Corridor 4 (DE, HU)	1.569,9	9,73%	25,12%	13,88%

(Source: K+P)

Unfortunately for Corridor 2, which regarding CT was the most impacted, no data was made available for single wagonload.

Again, Corridor 3b is the strongest in terms of predicted traffic (more than 6.4 billion tonne-kilometres, followed by Corridor 1 (3.3 billion tkm). The volumes in Corridors 3a and 4 amount to 1.8 and 1.6 billion tonne-kilometres respectively.

When comparing the relative back-shifts per corridor and LHV scenario it becomes obvious that – downward spiral effect included - the impacts are far stronger than for CT. This general result reflects the high ratio of fixed costs in this rail freight production system.
As a reminder one has to point out that the model calculates the downward spiral effect with lower elasticities than the direct back-shift (without downward spiral) to take into consideration the captive markets for single wagonload (see ***chapter 3.2***).

The 44t/25.25m LHV impacts most the single wagonload traffic as well due to its low cost/load capacity ratio.

Contrary to CT, the 14.92m semi-trailer shows a significant impact on single wagonload, traffic, especially in case of light goods.

Even taking into account an LHV ban in Switzerland, which considerably reduces the cost advantages of the LHV, Corridor 3b is the most affected followed by Corridor 1. In the 60t/25.25m LHV scenario, Corridor 1 ranks first, followed by Corridor 3b in terms of modal back-shift. This is caused by the structure of goods transported being more appropriate for this LHV configuration (i.e. heavier goods).

Generally speaking, these results show that the introduction of LHVs would lead to losses in single wagonload traffic of between 14 and 40%. Again it has to be pointed out that the results do not consider the complete abandoning of single wagonload production on some markets, whereas this may occur even in the case of slight losses in volumes due to the low profit margins.

Comparison to results of other studies

(2) Given the above described results it seems worthwhile to compare these results with other studies.

In 2006, 2007 and 2008, Kessel+Partner carried out studies for the German Federal Ministry of Transport, Building and Urban Development, dealing with the impact of the so-called – at that time - “Gigaliner”. For the purpose of this comparison, the studies of 2007 and 2008 are of particular interest, since in these studies the back shifts were calculated on the base of tonne-kilometres and not on tonnes as in the 2006 study.

The back-shifts were calculated for the whole of Germany and not as in this study for specific corridors. When comparing the different figures, one has to keep in mind that LHV configurations were assessed slightly differently to the ones in this report. In addition, at that time we evaluated additive scenarios, i.e. each new LHV scenario included the impact of the LHVs of the other scenarios.

Nevertheless it seems interesting to compare the order of magnitude of the back-shift **measured in tonne-kilometres**.

For the maximal Scenario 4 (including 40t/25.25m, 48t/25.25m, 48t/16.5m and 60t/25.25m LHVs) in the 2007 study the following ***table 4.12*** presents the results.

Table 4.12: Modal back-shift from rail to road in Scenario 4 (source “Verkehrswirtschaftliche Auswirkungen von innovativen Nutzfahrzeug-konzepten (FE Nr. 96.900/2007/), Freiburg August 2007“ p53)

	Base scenario without LHV (billion tkm)	Scenario 4		
		(billion tkm)	Difference (billion tkm)	Difference (%)
Single wagon load	28,8	24,2	-4,6	-16,3%
Block trains	33,2	32,6	-0,6	-1,7%
Combined Transport	20,3	17,6	-2,7	-13,3%
Total	82,3	74,4	-7,9	-9,6%

(Source: K+P)

Out of this table one can summarise the following findings:

- It becomes obvious that the modal back-shift for CT reaches the **same order of magnitude as in this study**
- The **back-shift from block trains (-1.7%) seems negligible**, which justifies again the general exclusion of block trains in this study
- At first sight the back-shift from single wagonload seems considerably lower than in this study, but one has to keep in mind that the 2007 study dealt with the whole of Germany, where numerous single-wagon origin-destination pairs were not transferable to LHV for different reasons, whereas this study concerns specific corridors.

Finally one can conclude that compared to the results of the former K+P study, the results of this study can be seen as coherent.

5. Sustainability Assessment

5.1 Methodological overview

External effects

(1) This chapter estimates the external impacts of changing traffic patterns on society arising from the back-shift of freight volumes from rail to road due to the introduction of LHVs. Along the five corridors the classical components of transport's negative impact on society are valued in monetary terms. These are:

- Climate change (greenhouse gas emission)
- Air pollution (emission of CO, HC, NO_X and PM)
- Accidents and
- Noise

The assessment departs from the quantities of goods back-shifted from rail to road in the five corridors and estimates the external costs of greenhouse gas and air pollutant emissions, accidents and noise. Estimates are carried out for road transport considering the three different LHV types, as well as for single wagonload and Combined Transport. We thus balance the increased emissions in road haulage against the savings in rail emissions due to the loss in market shares.

The external costs are determined according to the average cost principle, following common cost benefit analysis standards. Only in cases where a differentiation between vehicle types is necessary and where we can assume linear exposure cost functions, namely in terms of air pollution and climate change effects, do we make use of more differentiated marginal cost values. In other instances, such as noise and in particular accidents, cost functions are strongly non-linear with traffic volumes, and thus marginal and average costs differ widely. A number of more general transport externalities are not quantified here as they either relate to the existence of infrastructure, such as the costs of land use, nature and landscape or biodiversity, or because they characterise the transport system as a whole, including the impacts of oil dependency. Although increasingly important, these categories of external costs will not basically change with inter-modal demand shifts. We discuss these impacts qualitatively in this report.

Cost values for 2008 are taken from the parallel study on the External Costs of Transport 2008 (CE Delft, Infras, ISI, 2011) commissioned by the International Union of Railways (UIC). The forecast values for 2015, 2020 and 2030 are determined case by case in the subsequent chapters.

5.2 Magnitude and development of external costs

Average unit cost values 2008

(1) The assessment of external effects of road and rail transport departs from the average cost values elaborated by CE Delft et al. (2011). We use average European values as the corridors should consider the problems of impacts of modal back-shift reactions from a strategic level rather than from national perspectives. The external cost values presented in Table 5.1 are selected as follows:

- Accidents: CE Delft et al. discuss alternative approaches concerning the degree of externality of the average risk per additional HGV kilometre. The low case assumes that risks are taken into account by drivers, and thus are not external. For this study we select average costs of HGVs on inter-urban roads according to the alternative high case assuming that drivers are not aware of the full risk they impose on other road users. In rail transport average costs are recommended as a proxy for marginal costs. With these assumptions the average external accident costs per tonne kilometre across the corridor countries for road haulage are roughly 50 times above those for rail transport. (The difference between HGVs and freight trains would only be a factor of four if we would instead apply the marginal costs approach, as this takes into account the speed-reducing effect of additional vehicles on the road.)
- As concerns air pollution, we consider a 40t truck with Euro-V exhaust emission standard on motorways. According to IMPACT (2008) for air pollution this implies marginal emission costs of €2.9/1000tkm, while the fleet average according to CE Delft et al. (2011) is twice as high (€6.2/1000tkm). Direct air pollution costs of rail are minimized as we consider freight trains minimal direct air pollution costs are considered due to brakes and wheel-track resistance. We use these marginal cost figures as differentiated average cost values.
- Climate change was evaluated by CE Delft et al. (2008) in two scenarios assuming different climate emission avoidance strategies, leading to a high estimate of €146/t CO_2-equivalent, and a low case with €25/t of CO_2-equivalent. Here we select the high case and consider 100% electric traction for all rail services in the considered markets. Including up- and downstream processes of electricity and fuel production we arrive at marginal costs of €4.20/1000tkm for rail versus €12.90/1000tkm for trucks. These are identical to the respective average cost figures. With 3.2:1 the share of road to rail is somewhat higher than it would be with the European share of diesel traction (22%), but is considerably lower than reported by previous studies (Infras/IWW 2004). This is partly due to a change in data bases, but also driven by efficiency gains in HGV propulsion technology.
- Finally, noise impacts vary considerably with time of day, traffic mix, traffic density and settlement structures. For both modes, we assume an average value between day and night and across all traffic density classes for motorways. The respective average noise costs per ton kilometre for HGVs are 80% above specific rail noise emissions.

In addition to these classical externalities, CE Delft et al. (2011) and proceeding studies consider a number of smaller effects, including nature and landscape, soil and water pollution, urban effects and the impacts of energy dependency. Besides the latter, these externalities rather refer to the existence of infrastructures rather than to their use, and will thus not change with portions of freight traffic being back-shifted to the road. For the case of energy dependency IMPACT (2008) cites a number of US studies quantifying the additional costs of oil imports due to world market monopolies, measures to prepare the industry from supply cuts and the potential impacts of such cuts between €0.17 and €10.63 per 100 litre of crude oil. In road freight transport this would be €3.30 per 100 vkm or €0.20 per 100 tkm. We do not specifically take these into account as parts of the costs are already priced in via risk premiums, the EU is far less energy dependent than the US and parts of the US costs are driven by military use, which is less significant for Europe.

For Europe TRT et al. (2008) finds that an increase of oil prices to €150 to €220 per barrel lead to a loss in GDP of up to 2% over a period of 10 to 15 years. Through the fostering of alternative energies and product, these changes appear rather moderate. Driven by this decline, however, freight transport, and here mainly road and shipping, may drop by 10% to 20%. On the basis of these findings we cannot derive economic shadow costs per litre of oil or diesel fuel.

In total, road appears to be three times more costly than rail freight transport. The basic average external costs values are presented in ***Table 5.1***

Table 5.1: Average external cost values for standard modes 2008

Average costs €/1000 tkm	Accidents	Air pollution	Climate change	Up&down-stream	Noise	TOTAL
Freight train	**0.20**	**0.90**	**0.00**	**4.20**	**1.00**	**6.30**
HGV 40t, Euro-V	**10.20**	**2.92**	**9.80**	**3.00**	**1.80**	**27.72**

(Source: Fraunhofer ISI (2011))

Average costs for LHVs 2008

(2) In a second step, the differentiated average cost values for the standard vehicles are transferred from 40t/16.25m HGVs to LHVs and from mixed freight trains to Combined Transport trains. For road haulage we use the HBEFA (Handbook on Emission Factors) database by Infras and IFEU (2011). This contains emission factors for various HGV settings in Germany, Switzerland, Austria, France and Sweden. The results of the database for the two countries and truck types are presented by ***Table 5.2***.

Table 5.2: Comparison of emission factors Germany and Sweden

Average value of EFA			Emissions (g/vkm)				
Weight	Truck Type	Country	CO_2(rep.)	CO	HC	NO_x	PM
7.5	Rigid	D SE	341.031 348.075	0.393 0.405	0.013 0.013	0.852 0.765	0.009 0.010
12	Rigid	D SE	459.380 473.524	0.583 0.590	0.020 0.019	1.250 1.108	0.014 0.015
14	Rigid	D SE	474.077 472.883	0.618 0.609	0.020 0.018	1.330 1.193	0.015 0.016
20	Rigid	D SE	535.243 526.822	0.769 0.733	0.025 0.022	1.665 1.560	0.018 0.019
26	Rigid	D SE	631.540 588.424	0.914 0.872	0.027 0.023	1.955 1.780	0.021 0.022
28	Articulated	D SE	641.389 569.495	0.865 0.808	0.029 0.025	1.911 1.729	0.020 0.021
	Rigid	D SE	670.521 611.243	0.936 0.874	0.030 0.025	2.002 1.797	0.022 0.023
32	Rigid	D SE	772.436 700.555	1.033 0.994	0.034 0.029	2.276 2.005	0.025 0.026
34	Articulated	D SE	672.516 593.656	0.877 0.829	0.029 0.025	1.955 1.728	0.021 0.022
40	Articulated	D SE	746.585 676.796	1.014 0.996	0.031 0.028	2.280 2.041	0.023 0.026
50	Articulated	SE	734.416	1.073	0.030	2.130	0.028
60	Articulated	SE	902.868	1.297	0.037	2.558	0.035

(Source: assessment of INFRAS (2010): HBEFA 3.1)

The data reveals that there are only small systematic differences between Swedish and German emission data for lorries and truck-trailer combinations up to 40t vehicle gross weight. We thus can use the dataset for deriving emissions for LHVs. For all emissions including CO_2 but NO_X we find emissions against standard HGVs of +3% for 40t/14.92m Semi-Trailer (Big Maxx), +9% for 44t/25.25m LHVs and +33% for 60t/25.25m LHVs. For NO_X the values are slightly lower as shown below.

The generalisation of statements on traffic safety on the basis of recorded accident rates appears vague. According to detailed data from CE Delft et al. (2011) the average accident costs of the two countries with LHVs permitted, Sweden and Finland, range around the European average (€102/1000tkm). Sweden is even well below this value. But as the topic of traffic safety is not finally clarified, we assume higher external costs per vehicle kilometre for 60t/25.25mLHVs of 50%.

The impact of longer vehicles on noise will be limited. The increase from 5 to 8 axles will, due to the logarithmic slope of human sound perception (dB-scale) only increase by 10%.

Unit costs 2008 road and rail

(3) Besides the vehicle or train specific differences in external impacts, we need to consider the different loading rates. In road haulage we assume +5% for the Big Maxx, +20% for 44t/25.25m and +50% for 60t/25.25m LHVs against standard 40t HGVs.

In Combined Transport we concentrate on the rail part of the transport chain as the road access traffic would be performed anyway. As the access by rail freight feeder services is omitted, we assume a higher average train load on the selected corridors than at European level. According to Eurostat data, average train load is roughly 500t. For Combined Transport along the main axes, e.g. across the Alps, we find figures from UIRR of 650t. Thus we have increased the train load rate in CT when compared to single-wagonload by 30%.

The resulting differentiated average cost values 2008 are presented in ***Table 5.3***. Under the assumption of load rates above average, Combined Transport excluding road access shows the least external costs per tonne-kilometre. Within road transport the difference between the three LHV types is relatively small. Per tonne of payload the 40t/14.92 m semi-trailer (Big Maxx) appears only 9% more costly than a 60t / 25.25m LHV.

Table 5.3: Average external costs per vehicle category 2008

Average costs €/1000 tkm	Accidents	Air pollution	Climate change	Up&down-stream	Noise	TOTAL
Rail-CT	0.15	0.69	0.00	3.23	0.77	4.85
Rail-WL	0.20	0.90	0.00	4.20	1.00	6.30
14.92m Semitrailer	10.69	2.87	9.61	3.14	1.71	28.02
LHV 25.25m, 44t	10.20	2.65	8.90	2.75	1.58	26.08
LHV 25.25m, 60t	10.20	2.59	8.69	3.00	1.32	25.80

(Source: Fraunhofer ISI (2011))

Forecast of accident costs

(4) For road *accidents* we basically follow the EC objective to cut road fatalities, which is the dominating factor of external accident costs, by half between 2000 and 2020. For 2050, the current Transport White Paper (EC 2011) even promotes a zero fatality vision.

For this study we carry forward the 50% fatality reduction target to the forecast period 2008 to 2030 for road and rail transport. But respecting that this might be rather ambitious we assume that only half of this, i.e. 25% reduction by 2030, will be realized. We further imply that accident costs and accident responsibilities develop proportionally to the number of fatalities and that the unit costs per tkm develop in the same order of magnitude. The intermediate goals for the years 2015 and 2020 are interpolated.

Forecast of air pollution costs

(5) With the regulations of *air pollutant emission* standards for motor vehicles much has been achieved to improve air quality along major roads and in urban areas in the last two decades.

Most impressively is the reduction of nitrogen oxides (NO_X) and particulate matter (PM). Against the Euro-I standard introduced in October 1992, Euro-VI standard compulsory from 2013 on will reduce NO_X by a factor 20 and PM by a factor 36.

Assuming that Euro-VI will play the role in 2020 that Euro-V plays currently, i.e. the HGV fleet has been renewed by one generation, we expect NO_X-levels in 2020 to be 20% of 2010 levels. In the coming decade, PM-levels may then be 50% of 2010 emissions. Looking to 2030 we assume a further decline of these values by 25%. The assumptions on the relative development of emissions are presented in ***Table 5.4.***

Table 5.4: Road emission standards and forecasts

Tier	Date	CO	HC	NOx	PM
HGV emission standards (g/kWh)					
Euro-I	**Oct. 1992**	4.5	1.1	8	0.36
Euro-II	**Oct. 1996**	4	1.1	7	0.25
Euro-III	**Oct. 2000**	2.1	0.66	5	0.1
Euro-IV	**Oct. 2005**	1.5	0.46	3.5	0.02
Euro-V	**Oct. 2008**	1.5	0.46	2	0.02
Euro-VI	**Jan. 2013**	1.5	0.13	0.4	0.01
Relative emissions to 2010 level					
2020 / 2010	**Euro-VI to Euro-V**	100%	28%	20%	50%
2030 / 2010	**Add. 25% to 2020**	75%	21%	15%	38%

(Source: EC (2009)

For electric freight trains no direct air emissions in noteworthy quantities are accounted. Reduction targets are thus discussed jointly with climate emissions including up- and downstream processes.

Forecast of climate change costs

(6) In the following we consider climate change and up- and downstream costs in a single step, as CO_2 emission costs constitute the dominating element of the external costs of fuel and energy provision processes.

The EC White Paper on Transport (Roadmap to a Single European Transport Area, EC 2011) sets the goal of reducing CO_2 emissions in the transport sector in 2030 by 20% compared to 2008 levels and the joint UIC/CER strategy (UIC/CER 2010) envisages a 50% reduction of rail CO_2 emissions from 1990 to 2030. In comparison to the big achievements in curbing air pollutants, the reduction of climate gas emissions has not made a sufficiently big step ahead in that direction in the past.

In road freight transport this is partly due to the increasing truck engine powers, compensating improvements in fuel efficiency. On the other hand, the tight EURO exhaust emission standards create a conflict of goals for engine manufacturers, as a further reduction of air emissions will reduce fuel efficiency. Nevertheless, in a study on fuel saving options, GHG-TransPoRD (Akkermans et al. 2010) come to the conclusion that with aerodynamics, low resistance tyres and oils, and alternative fuels, a 10%

reduction of CO_2 by 2020 is possible. By 2030 a reduction above 30% of CO_2 in road haulage is proposed, as indicated in ***Table 5.5***.

For the rail sector we consider the energy production sector as a whole. Following the 60% CO_2 reduction goal by 2050 set by the EC White Paper (EC 2011) we would have a 40% reduction target for 2030 with respect to 2005. But of course this could be much higher depending on the progress made in de-carbonising the power generation sector. Alternatively, we compare the up- and downstream costs for advanced countries using a high share of renewable energies, namely Switzerland and Norway, to the European average. Internal data from CE Delft et al. (2011) for the major European countries (Germany, UK, Netherlands, Austria) confirms the EC's long term reduction vision of minus 60%.

Table 5.5: Additional GHG reduction potential proposed by GHG-TransPoRD

Mode	[% relative reduction to reference]	2030	2050
Road	Technology car *	-43%	-64%
	Technology HGV	-33%	-60%
	Urban policy **	-43%	-70%
	National policy ***	-40%	-70%
Rail	Technology long distance	-10%	-42%
	Technology local trains	-8%	-55%
Aviation	Technology & policy	-15%	-41%
Shipping	Technology & policy	-5%	-23%
Biofuels	Technology ****	-16%	n.a.

(Source: Akkermans et al. (2010))

Moreover, the joint UIC/CER strategy for sustainable mobility (UIC/CER 2010) envisages 50% reduction of rail CO_2 emissions by 2030 compared to 1990. For freight transport the specific goal per tkm is a saving of 62% against 1990 or 55% reduction between 2005 and 2030. Considering a certain market growth of 1% per year the absolute reduction will be considerably lower, such that the three approaches come close to each other.

For estimating practical CO_2 reduction potentials, we assume 100% electric traction in rail transport and acknowledge two trends. First, the energy sector appears to be in a major transition phase towards more renewable primary energy sources, more efficient natural gas fired power plants and the possible application of carbon capture and storage (CCS) technologies. On the other hand the reduction of nuclear energy by Germany and other countries, which will require more combustion plants, challenges this positive trend. Taking additionally into account the political and economic pressure to increase independence from importing fossil energy sources and the various options of the railways to improve capacity utilization, we tend more towards the ambitious goals and expect a reduction of CO_2 emissions, including up- and downstream processes of 30% between 2008 and 2030 in absolute freight transport emissions. Per tonne kilometre we take into account a certain market growth and thus select the 40% reduction related to 2008, which is in line with UIC / CER (2010) goals.

Forecasting noise costs

(7) The reduction of noise levels is a generally difficult or at least expensive task. The logarithmic slope of human noise perception requires that all noise sources on a road or rail line along settlement areas are reduced simultaneously, otherwise a few remaining loud elements will keep up the noise equivalent level

In inter-urban road transport tyre noise and – with higher speeds – air resistance sounds dominate the sound picture. Reduction strategies thus need to address these elements rather than to set noise emission standards for motors. Options are quiet road surface materials, the erection of noise walls or speed limitations. All these measures are costly and will only partly solve the problem. We thus assume a theoretical reduction potential of 20%, but of which only 5% may be realized by 2030.

For the railways we assume a higher potential as currently much is invested in noise walls and the retrofitting of freight wagons with disc-, K- and LL- block brakes (UIC 2010). Moreover, freight structures are shifting from heavy industry goods towards containerized and lighter cargo. We thus assume a much higher noise reduction potential of -40% by 2030, of which half may be realized (-20%).This clear reduction is considered suitable to follow the rather general goal of “noise levels in 2050 being socially and economically accepted” formulated in UIC / CER (2010).

Overall development of external costs

(8) ***Table 5.6*** summarizes the assumptions on theoretical reduction potential by category of externality, mode and year. It is important to emphasis here that many of the values assumed are assumptions by the authors of this study.

A deeper insight into the development of future transport externalities, in particular as concerns traffic safety, would require in-depth technology forecast studies for public bodies and enterprises at European and Member State level. The table below summarises the discussions and assumptions taken in the previous paragraphs.

Table 5.6: Summary on the forecast of external unit costs per tkm until 2030

CO_2	Measure	Road haulage, incl. LHVs			Rail freight, incl. CT		
		2015	2020	2030	2015	2020	2030
Accidents	Theoretical	10%	30%	50%	10%	30%	50%
	Implemented	***5%***	***15%***	***25%***	***5%***	***15%***	***25%***
Air pollutants	Theoretical	30%	65%	73%	10%	25%	40%
	Implemented	**18%**	**39%**	**44%**	**5%**	**15%**	**30%**
CO_2	Veh. techn.	*7%*	*13%*	33%	*2%*	*5%*	10%
	Energy syst.	*3%*	*6%*	16%	*5%*	*15%*	30%
	Theoretical	*10%*	*20%*	49%	*7%*	*20%*	40%
	Implemented	**5%**	**10%**	**25%**	**10%**	**20%**	**40%**
Up&downstr.	Theoretical	30%	65%	73%	10%	25%	40%
	Implemented	**12%**	**25%**	**34%**	**5%**	**15%**	**30%**
Noise	Theoretical	4%	10%	20%	5%	15%	40%
	Implemented	**1%**	**3%**	**5%**	**2%**	**8%**	**20%**

(Source: Fraunhofer ISI)

Allocating the reduction potential from ***Table 5.6*** to the average external costs 2008 presented in ***Table 5.3*** leads to the marginal external unit cost values for 2030 as presented in ***Table 5.7***. As we finally did not arrive at fundamental differences in the cost saving potential between road and rail the structure remains more or less the same as for the 2008 unit cost values.

Table 5.7: Average external costs per vehicle category 2030

Average costs €/1000 tkm	Accidents	Air pollution	Climate change	Up&down-stream	Noise	TOTAL
Rail-CT	0.15	0.52	0.00	2.50	0.54	3.71
Rail-WL	0.19	0.68	0.00	3.26	0.70	4.82
14.92m Semitrailer	8.01	1.61	7.21	2.06	1.63	20.53
LHV 25.25m, 44t	7.65	1.49	6.68	1.80	1.50	19.12
LHV 25.25m, 60t	7.65	1.46	6.52	1.97	1.25	18.84

(Source: Fraunhofer ISI (2011))

In the following chapter, these average unit cost values are applied to the five corridors selected in cooperation with the technical committee to this study.

5.3 Results of the corridor applications

Results

(1) This chapter presents the results of the corridor calculations in euro per 100km of corridor distance. The kilometre values in this case denote the length of direct shipment by rail. The distances are taken from the EcoTransIT database, operated by UIC (EcoTransIT 2011).

In order to get an idea of the traffic density on the corridor, ***Table 5.8*** additionally shows the average number of tonnes per year on the corridors in total wagonload and Combined Transport. Here corridors 1 and 3b clearly hold the top positions.

Table 5.8: Corridor distances for normalization of results

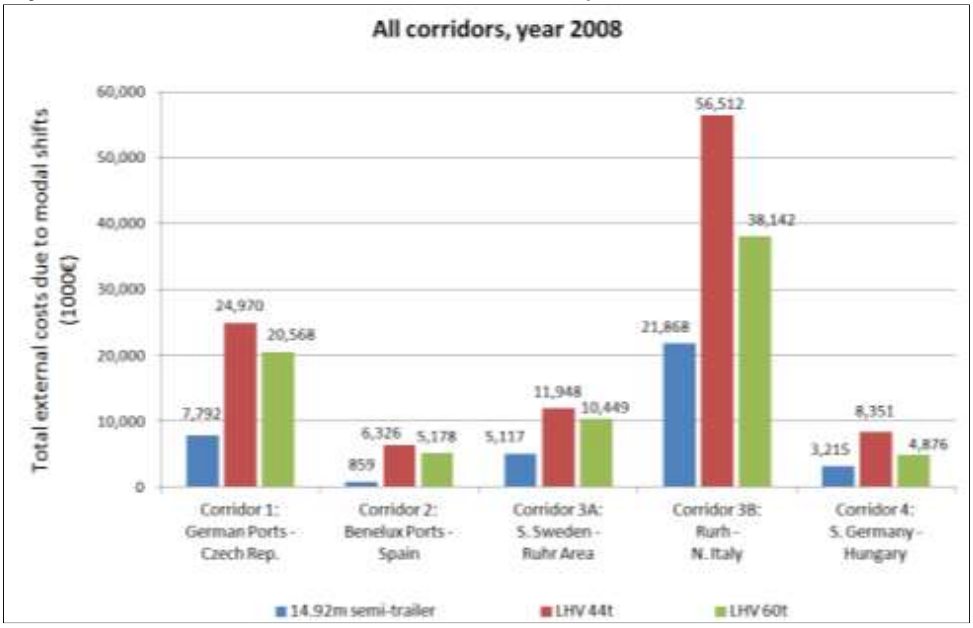
Corridor	Route	Rail distance (km)	Demand density 2008 (mill. t p.a.)
1	Hamburg - Prague	655.6	21.68
2	Rotterdam - Barcelona	1506	2.08
3a	Gothenburg - Cologne	1258.2	5.75
3b	Cologne - Milan	863.7	26.41
4	Munich - Budapest	718.4	4.75

(Source: EcoTransIT (2011))

Total cost balance

(2) Total annual external costs differ widely between the selected relations. But in all corridors and under all vehicle scenarios the external costs of freight transport increase against the case without LHVs. As we have applied average European cost factors, the difference in magnitude arises from the absolute amount of transport volumes back-shifted from wagonload and Combined Transport to road.

Figure 5.1 Additional annual external costs by corridor and scenarios 2008



(Source: Fraunhofer ISI)

Highest additional external costs are observed for Corridors 1 (Hamburg – Prague) and 3b (Cologne – Milan). This is unsurprising, as with roughly 12 and 23 billion tkm of rail volumes in the reference case, these connections are far busier than the remaining three corridors. Across all corridors, total additional annual external costs induced by modal back-shift range between €39 million with 40t/14.92m semi-trailer vehicles (Big Maxx) and €108 million where 44t/25.25m LHVs are permitted.

The results show the big differences between the LHV scenarios. Even when considering the higher accident and environmental costs for the 60t/25.25m LHV variant, the

44t/25.25m LHV remains the most dangerous alternative for the railways. This pattern remains roughly the same across all corridors.

Relative change of corridor external costs

(3) The comparison of total external costs per corridor in the base case allows for the drawing of conclusions on the relative change of external effects. This is not the entire picture, as the consideration of potential savings of external costs on road is missing. But one can say something on the violation of environmental and safety goals, as rail, as the commonly more ecological and safer shipment alternative, is curbed by allowing LHVs.

Table 5.9 reveals that the impact can be quite strong. With 2008 data and under the worst case scenario with 44t/25.25m LHVs, this would result in external costs between 25% and 51% above the reference case level. In 2030 this ratio would be somewhat lower due to the decline in external cost factors, but would still be of a significant level.

Table 5.9: Relative change in total external costs per corridor and scenario 2008

Scenario	Unit	Corridor 1: German Ports - Czech Rep.	Corridor 2: Benelux Ports - Spain	Corridor 3A: S. Sweden - Ruhr Area	Corridor 3B: Ruhr Area - N. Italy	Corridor 4: S. Germany - Hungary
Base case	1000 € p.a.	34358	15157	21730	64247	12801
14.92m s.-trailer	1000 € p.a.	7792	859	5117	21868	3215
LHV 25.25m, 44t	1000 € p.a.	24970	6326	11948	56512	8351
LHV 25.25m, 60t	1000 € p.a.	20568	5178	10449	38142	4876
14.92m s.-trailer	rel. to base case	22.7%	5.7%	23.5%	34.0%	25.1%
LHV 25.25m, 44t	rel. to base case	72.7%	41.7%	55.0%	88.0%	65.2%
LHV 25.25m, 60t	rel. to base case	59.9%	34.2%	48.1%	59.4%	38.1%

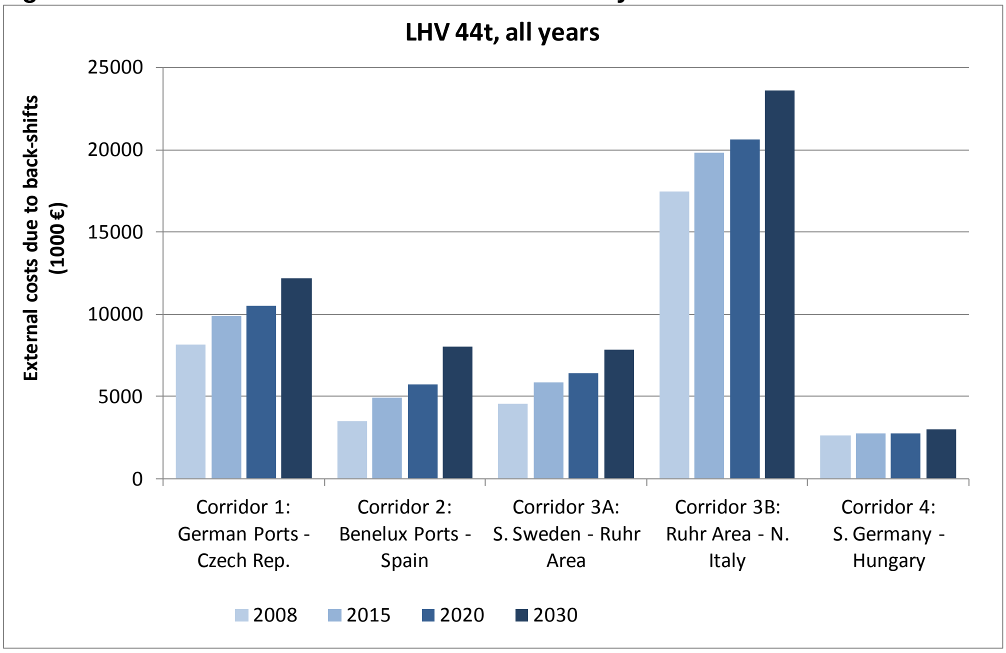
(Source: Fraunhofer ISI)

Total costs until 2030

(4) For demonstrating the different situations of the assessment periods 2008, 2015, 2020 and 2030, we pick out the 44 t/25.25m LHV setting.

We find developments of external costs between +130% (Benelux seaports to Spain) and +16% (southern Germany to Hungary). Accordingly, the declining external costs per transport unit are not able to compensate for the projected demand increases on the corridors until 2030. Most affected are again the major transport routes in seaport hinterland and trans-Alpine traffic.

Figure 5.2: Increase in absolute external costs by corridor until 2030



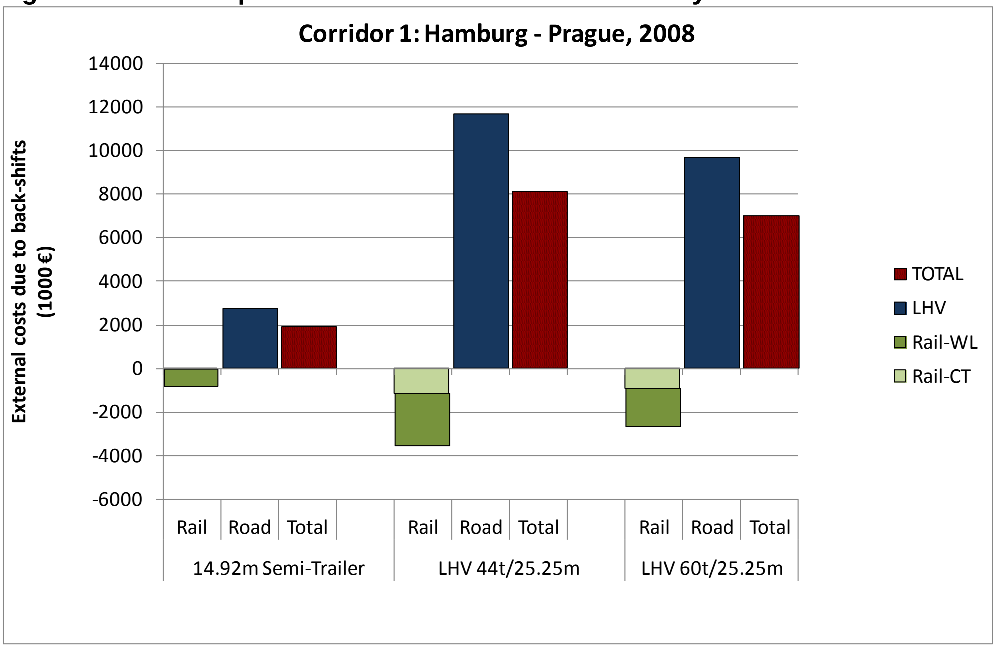
(Source: Fraunhofer ISI)

Details by mode

(5) For a closer look into the contribution of the single modes to the overall balance of external costs, we zoom a bit deeper into Corridor 1.

The bars indicate the savings of external costs due to declining rail movements in single wagonload and Combined Transport (negative) and the rise of external costs due to increases in road haulage (positive). This ratio of these two components is roughly 1:3 for all corridors. The hatched bars present express the balance of the two, which is in all cases positive, indicating rising external impacts for all LHV types.

Figure 5.3: Decomposed external costs of corridor 1 by mode



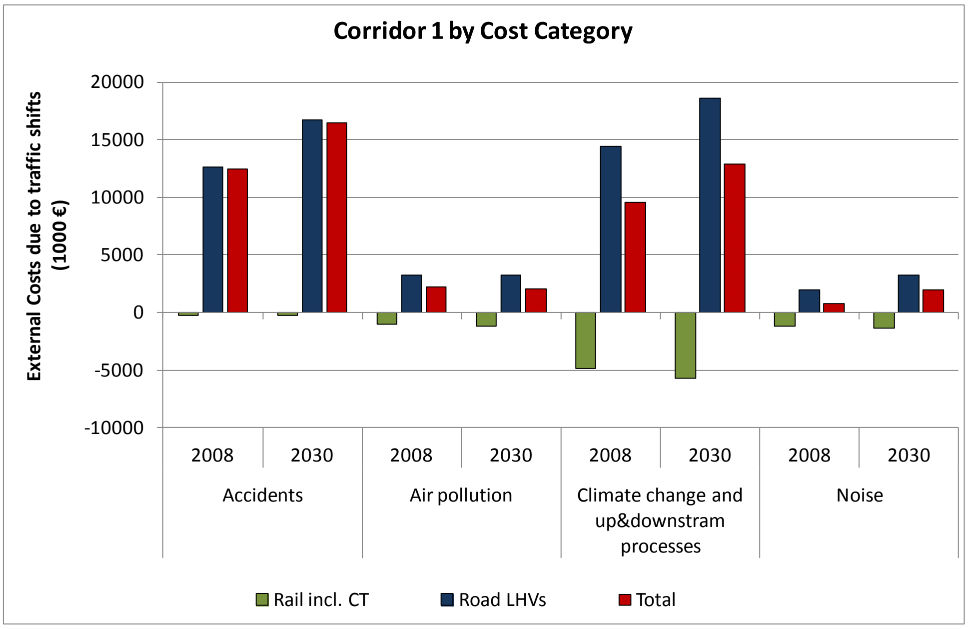
(Source: Fraunhofer ISI)

Details by cost category

(6) For a closer look to the role of each cost category we zoom again into Corridor 1. The dominating parts are accident consequences, direct climate emissions for road transport and the up- and downstream costs for fuel and energy production for rail.

Out of the latter two, direct climate emissions are much stronger, but up- and downstream effects play a considerable counterpart. For reasons of a balanced illustration of results, and as climate and up- and downstream costs are that closely linked, the two categories are merged in the graph below. Again, the single effect from rail decline (negative bars) and road increase (positive bars) are drawn against the balance of the two (hatched bars). The additional impacts of accidents and climate-related costs on road are remarkably similar, with the difference that the reduction in rail traffic does not entail a significant reduction in the overall external costs, as is the case for climate change. Across all cost categories the balance shows increasing marginal external costs.

Figure 5.4: External cost elements 2008 and 2030 in Corridor 1, scenario 44t, 25.25m LHVs



(Source: Fraunhofer ISI)

Conclusions

(6) The analysis reveals that if full external costs of transport are considered, the back-shift in demand from wagonload and Combined Transport to road can have serious economic consequences. Total additional costs range in the order of up to €117 million for the Transalpine Corridor (3b) and external costs related to that of rail transport in the base case may increase by 88%.

Most important cost drivers are accidents and greenhouse gas emissions either through the direct combustion of fossil fuels or through electricity generation. Noise has not been found to be significant and air pollution effects will likely decrease until 2030 through better road engine and filter technologies.

Important aspects omitted in this analysis are the direct improvements in external effects in the road sector. To get an idea of the order of magnitude of effects the following assumptions may be taken:

- With a relative external cost level of 44t/25.25m LHVs against standard HGVs of 91% and a market uptake of LHVs in road haulage of 20% at tkm, we receive savings of external costs within the road sector, i.e. excluding modal back-shift effects, of roughly 2% against the base case.
- Across all corridors the external costs of combined transport and single wagonload increase by 42% due to modal back-shifts where 44t/25/25m LHVs are permitted. Including block train markets, the relative increase of external costs is still at 19% in 2008.
- With a rail market share of 21% at tkm (EC average 2009) we finally receive a total external cost level of 2.5% above the base case.

These figures are very rough and depend on several critical assumptions, but they indicate that total social net effects of LHVs, at least in the worst case from the perspective of the railways is most likely negative. Further we should keep in mind the point that we have considered only scenarios with one particular LHV type permitted. This will not be the case in reality, as the permission of 60t/25.25m vehicles automatically includes the permission of 44t/25.25m LHVs and the Big Maxx concept. The negative social cost balance will thus be even more expressed.

These results indicate that the introduction of LHVs with a considerable likelihood will oppose two central objectives of the Commission's 2011 White Paper. These are

- "...enable rail to compete effectively and take a significantly greater proportion of medium and long distance freight" (§28) and
- "...transport has to use less and cleaner energy, better exploit a modern infrastructure and reduce its negative impact on the environment and key natural assets like water, land and ecosystems. " (§ 16)

Acknowledging that the achievements of the ambitious goals of the EC cannot be reached without enhancing the efficiency of road haulage, our results shed a rather ambivalent light on the concept of LHVs. In the event that modal back-shift impacts are not prevented effectively, their contribution to sustainability goals will most likely turn out negative.

6. Transport sector internal costs

Contents

(1) After having looked at the external costs of transport impacted by modal split effects, we now take a quick look at the entrepreneurial side. As concerns the impacts of introducing longer and heavier trucks for the transport sector, including its funding by public bodies, we concentrate on the following issues:

- Road infrastructure investments to accommodate LHVs
- Impacts on railway profit margins
- Consequences for the future development of Combined Transport services

These issues will in most cases be discussed generally as a breakdown to corridors is not usually possible. Exceptions are rail profit margins, which can be derived from the modal shift data.

6.1 Road infrastructure

Road infrastructure investments

(2) The impacts of longer and/or heavier vehicles on road infrastructure costs consist of three elements.

First, longer vehicles occupy more road space. Of the average HGV charge level of €15/100vkm one third (33.3%) can be allocated to capacity. Given the 50% longer vehicle body and a supplement on brake distance we can assume the capacity factor to be roughly about €5/100vkm for 44t/25.25m LHVs.

Second, the different axle configurations and weights impact the deterioration of road surfaces. Although road wear and tear costs increase by a factor of three to four with axle loads, this effect will be minor. The higher weight is distributed to eight instead of five axles, such that the maximum standard European axle load of 11.5t will not be exceeded. In the event of 40t/25.25m LHVs the impact on road surfaces may even decrease. By referring to TML (2009), Doll et al. (2010) arrive at additional wear and tear costs for small repair measures of €3/100vkm.

In the high case, parts of the road network need to be enabled to accommodate longer and heavier vehicles. Also with reference to TML (2009) and under the assumption of 20% LHVs of all lorries in long-distance haulage, Doll et al. (2010) arrives at €9/100vkm. These costs are required to widen curves, reduce gradients and strengthen bridges. This estimate is based on assumed total costs for bridge strengthening and repair of €3.1 billion. According to the study of Rapp (2011) the enhancement of the Swiss primary road network would cost up to €16 million for 25.25m/40t vehicles and up to €65 million for 60t LHVs. Factored up to the EU27 motorway network this would be € 0.76 billion for 44t/25.25m LHVs and € 3.13 billion for 60t/25.25m vehicles. Upgrading the secondary road network for LHVs would be much more expensive while safety standards cannot be guaranteed under all circumstances. Recent studies for Germany discuss the following issues:

- Bridges: Recent estimates of the German Ministry for Transport estimate bridge rehabilitation and replacement costs for accommodating LHVs on the federal road network at €4 to €8 billion (Kersten and Fläming 2010). Set in proportion to the European motorway network this would be €21.4 to €42.8 billion. Although ITF and OECD (2010) suggest traffic and access control mechanisms to protect bridges from major damages, e.g. by weigh-in-motion or GPS tracking, these options are criticised for being too complicated and hardly feasible (BASt 2010). On the contrary, advocates of LHVs call on their lower infrastructure – and thus bridge – damage potential.
- Rail-road level crossings: LHVs require roughly one second longer for clearing, which either imposes safety risks or demands for a re-configuration of signals and gate times with an entailed reduction of the crossing's capacity. Experiences or cost estimates are not available, but in the Dutch field trial LHVs must not use routes with level crossings for safety reasons.
- Road level crossings: most problematic are crossings without signalling. Here the longer passing times of LHVs and an increased safety distance of LHVs to make sure the crossing can be passed will impact the capacity of the node (BASt 2007). Problems may further occur with circles, although newer research suggests that curves do not necessarily have to be adapted (DVZ 2010).
- Parking facilities: Parking, rest or waiting facilities along motorways or at border crossings will get highly problematic in the event of the general approval of LHVs (Rapp 2011 and others). Besides bridge strengthening, their extension constitutes a major cost driver for infrastructure investments as these are required due to social regulations for truck drivers or border control procedures.

Overall we can conclude that the estimates for additional road user charges for infrastructure rehabilitation of €9/100vkm are most likely very conservative. But acknowledging the existence of more cautious cost estimates, we remain with this value.

Infrastructure costs and charges

(3) The above line of argumentation leads to additional infrastructure costs per 100vkm of €15 for 60t/25.25m LHVs.

This constitutes a rough average for Western European countries, of which many currently take HGV charge around €15/100vkm. For infrastructure costs alone the charge level for 60t/25.25m LHVs may thus double current charge levels.

From the assessment of external costs above and with load factors of 11.5t for standard-HGV and of 17.3t for 60t/25.25m LHVs (including empty headings and partial loadings) we receive vkm-specific unit costs of €15.6/100km for HGVs and €21.4/100vkm for LHVs. We thus receive another €5 additional costs – or potential charges – for LHVs. In total these are roughly €20/100vkm, which LHVs should pay more on motorways compared to 40t/16,50m HGVs. ***Table 6.1*** summarizes the numbers.

Table 6.1: Computation of road user charges for 60t/25.25m LHVs

Cost category	Unit	40t HGV	60t LHV
Basic road user charge	€/100 vkm	15.00	15.00
Additional capacity use	€/100 vkm		2.50
Additional wear and tear	€/100 vkm		3.00
Additional investments	€/100 vkm		9.00
Marginal external costs	€/100 vkm	15.63	21.37
Total charge level	€/100 vkm	30.63	50.87
Additional charge 60t LHV	€/100 vkm		20.23

(Source: Fraunhofer ISI)

6.2 Road congestion

Congestion effects

4) The argument of congestion reduction by LHVs is frequently brought forward, arguing that two LHVs replace three standard HGVs. With reference to German road transport legislation we assume the same clearance distance of 50m to be kept ahead of all heavy vehicles travelling above 50kph on motorways. Special conditions for LHVs only demand for the use of automatic clearance and speed control systems. Adding the clearance distance to truck body lengths we receive 200m road space required for the three standard HGVs against 150m required for the two LHVs. In the ideal case, road occupation can thus be relieved by 25%.

The clearance distance constitutes the key to the saving of road capacity. In case this is higher for LHVs than for HGVs, and the capacity utilisation advantage of LHVs would decline. With a LHV market share of 20% at tons shipped we arrive at a total reduction of capacity use of long distance haulage of 5%.

These positive impacts of road-internal productivity gains are challenged by the increase of road tonnage. We can list two effects: the increase of transport demand as induced by lower road shipment costs and the modal shift from rail. To reveal the order of magnitude of both effects we assume a cost advantage per ton shipped with 44t/25.25m LHVs of 22% (Table 3.3) and a direct price elasticity of road shipments of -0.5 to -1.0 (Annex 2). With a market uptake of 20% of road demand by LHVs we then receive an increase of 2% to 4% in truck volumes. Parts of this will origin from modal shift from rail, while the remainder is due to a growth in total shipments or shipment distances.

The impact of modal split on congestion levels can be roughly quantified by some general reflections. With an average European rail share of 16% at tkm and a loss of market share across the case studies of 8% (with 44t/25.25m LHVs) we receive an increase of tkm on roads of 1.3%. The modal split effect is part of the overall price reaction of road transport and must thus not be added up to it in order to avoid double counting. The magnitude of induced road demand thus appears to be in a similar order of magnitude than modal shift.

We thus conclude that with around 5% reduction the impact of LHVs on road capacity usage by trucks is considerable. But this positive road-internal effect will most likely be balanced out by modal shift and induced traffic to some extent. For the area considered by this study, i.e. for the central and densely populated countries of the European Union, we may see a net relieve of capacity use on motorways of up to 2%. This will partly have a strong impact on congestion levels, but will be irrelevant in peripheral regions or at times of low traffic demand.

From detailed German model applications we have indications that in 2020 31% to 42% of the motorway network will be seriously congested (IVV, Brilon 2004). As traffic conditions in regions located at the periphery of the Union are more relaxed, we take the lower estimate (31%) for Europe in 2020. Thus, truck operating costs may decrease by one percent or less. In front of the dynamic growth of road haulage these rather small savings in road occupancy contribute only little to a more efficient use of road space.

Finally, we have to point to the entailed environmental effects. Under congested conditions the emission of air pollutants and the consumption of fuel increases by a factor two or more. Starting from the 30% congested traffic on motorways expected for 2020, and with the roughly 50% share of climate change in the external costs of LHVs, we would have to slightly decrease the average external costs factor of LHVs. But the order of magnitude does not appear to be significant. .

These conclusions are, however, rather general and vague. In particular local estimates of traffic compositions and elasticity values are required to conclude with reliable statements on the net capacity and congestion effect of permitting LHVs on the Trans-European road network. Further studies applying detailed network models are thus recommended.

6.3 Railway operations

Rail business cost structures

(5) Presumably, the largest impact of the modal back-shift induced by LHVs is on the revenues, and by that on the profits, of the railway companies.

In particular in Combined Transport, where huge European and national programs have been funded to build up capacities and exploit markets, the downward spiral of less demand, service level reductions and entailed demand reduction may cause difficult conditions for single undertakings. This is finally not only a business-related problem but concerns public budgets as most railway undertakings are still fully or partly state owned.

In a first step we look at the revenue side of the railways. The average revenue per tonne kilometre was derived from the review of the annual reports of the freight segments of the major European rail carriers, private freight railways and operators of combined road rail transport. Incorporating the big integrated carriers is important due to their market share in particular in wagonload transport. But here separate reports for the freight branches are not always available. By distinguishing the three types of undertakings we can generate separate indicators for wagonload and Combined Transport. ***Table 6.2*** presents the ratios between turnover and tonne kilometres for the year 2008.

Table 6.2: Turnover to tkm ratio for selected railway undertakings

Company	Year	Performance mill. tkm	Revenues mill. €	Freight rates €/1000 tkm
National Rail Carriers		224'527.00	9'505.23	42.33
DB Schenker Rail	2010	105'794.00	4'393.00	41.52
	2009	93'948.00	3'888.00	41.38
SBB	2010	13'111.00	609.56	46.49
	2009	11'674.00	614.67	52.65
Combined Transport Operators		44'460.00	1'420.91	31.96
Kombiverkehr	2010	17'200.00	383.98	22.32
	2009	15'700.00	347.01	22.10
HUPAC	2010	6'205.00	353.15	56.91
	2009	5'355.00	336.77	62.89

(Source: Composition according to annual reports of the RU)

Railway revenues

The freight rates found by this analysis prove to be lower in Combined Transport than for conventional, integrated national rail carriers. Moreover huge differences are observed within the segments This is probably due to different production forms (HUPAC and Kombiverkehr) and national subsidisation policies.

Alternatively we can consider average traction costs, which are in the order of magnitude of 12 Euros per train-km for traction, 3 Euros per train-km for track access and 2.33 Euros per 1000 tkm for wagon rental. With an average load factor of 500t per train these are 32 Euros per 1000tkm.

The marginal cost coverage ratio, i.e. the share of variable production costs per unit of revenue, is decisive for the profit and loss situation of the railways. The higher the share of fixed production costs are, the more decisive will every unit of additional revenues be for maintaining (or achieving) the economic viability of the enterprise.

Looking at the ratio between depreciation (as a measure for fixed capital costs) and total production costs from the annual reports of selected undertakings leads to a very inhomogeneous picture. The ratios range between 53% (HUPAC) to 0.6% (Kombiverkehr). For big network carriers capital shares between 9% (DB) and 3% (ÖBB Rail Cargo Austria) are obtained. Network and terminal owners appear to be more capital intensive and will thus be more affected by fluctuations in demand and revenues.

With state owned railway undertakings these financial burdens directly impact public budgets, while for private organisations, either state subsidies need to compensate parts of the losses, or tax payments from the railway undertakings to the state are declining. From the perspective of public households, parts of the financial burden arising from losses of the railways will be compensated by rising profits of the road haulage business. But it is rather unclear to which extent and where they will be realised. However, this topic was not deepened in the course of this study.

Table 6.3 lists the potential revenue losses for wagonload and Combined Transport by year and corridor for the 44t/25.25m LHV scenario. In the corridors with the highest back-shift reactions (1 and 3b) we constitute annual revenue drops around one billion Euros annually.

Table 6.3: Revenue losses for the railways with 44t/25.25m LHVs (million €)

Year	Segment	Corridor 1: German Ports - Czech Rep.	Corridor 2: Benelux Ports – Northern Spain	Corridor 3A: Southern Sweden - Ruhr Area	Corridor 3B: Ruhr Area - Northern Italy	Corridor 4: Southern Germany - Hungary
2008	Rail-CT	101.44	99.96	76.43	180.78	25.00
	Rail-WL	127.52	0.00	68.14	247.52	60.54
	TOTAL	228.96	99.96	144.57	428.30	85.54
2015	Rail-CT	154.65	121.75	110.81	245.57	48.26
	Rail-WL	134.65	0.00	71.94	261.35	0.00
	TOTAL	289	122	183	507	48
2020	Rail-CT	194.59	147.00	139.86	283.49	34.67
	Rail-WL	139.98	0.00	74.79	271.70	66.46
	TOTAL	335	147	215	555	101
2030	Rail-CT	274.47	197.50	197.96	359.33	45.24
	Rail-WL	151.29	0.00	80.84	293.66	71.83
	TOTAL	426	197	279	653	117

(Source: Fraunhofer ISI)

Additional terminal infrastructure costs

The impacts of LHVs on Combined Transport infrastructure constitute another cost element for combined road-rail transport. Detailed studies on the subject are not available to date, but several issues can be discussed qualitatively:

- Loading and unloading of LHVs is not affected by longer vehicles as long as truck access lanes are situated in parallel to railway tracks and craning facilities.
- Turning inside terminals: According to German legislation (§32d Road Transport Act) HGVs must not exceed an outer turning cycle of 12.50m and an inner circle of 5.30m. We can assume that LHVs need to apply to these provisions and those modern CT terminals will in most cases apply to these measures. But as concerns older terminals turning space will be an issue and will require additional investment costs. In some cases the availability of space for enlargement will, however, be very critical as many terminals are situated within industrial or commercial areas. In these cases LHVs will have to be split outside the terminals, which reduces their economic advantage over conventional HGVs.
- Parking facilities: As in the case of road networks the size of parking or waiting facilities will not be suitable for longer vehicles. This will be problematic even in modern terminals. Decisive is the design of the parking, rest or wait areas.
- Access road capacities: terminals are frequently located inside built-up areas and thus have to be approached using lower level roads. Rapp (2011) and other sources, however, indicate that their upgrading to be able to accommodate LHVs is expensive and in some cases not even possible.

Although not expressed in quantitative terms, these issues have several implications on the impact of LHVs. First, infrastructure investment costs would need to be borne by the railway sector and second, the suitability of LHVs for the Combined Transport market is questioned even more. Thus, in the event that the EC and member states carry on implementation strategies for LHVs, an eye must be kept on the parallel development of CT infrastructures.

6.4 Conclusions

Summary

(1) The analysis in this chapter has shown that the consideration of external effects matters.

The huge difference in the impact of road and rail transport on climate, air quality, safety and noise disturbance exceed €30 million per year along the five corridors. The main components clearly are climate impacts followed by air pollution and safety. However, the degree of uncertainty concerning the real impact of LHVs on safety levels on roads in the densely occupied central European network is high. Considering the external costs of road congestion would add another significant cost category.

The impact patterns found are rather similar among the five corridors. The most costly LHV concept is the 44t/25.25m version as its purchase and operation per tonne of cargo is for most commodities cheaper than the 60t/25.25m variant. But given the different loading properties, the result by commodity group could be very different. Also we have to consider that the permission of 60t/25.25m LHVs automatically permits 44t/25.25m LHVs and the the44t/14,92m semi-trailer concept. Until 2030 the external costs in either mode will decrease due to technical improvements, but this does not alter the overall findings of this study.

The profitability of the railways appears problematic. In cases where the downward spiral applies, reductions in turnover may alter the profitability of certain services. In the corridors with the highest back-shift reactions (1 and 3b) we constitute annual revenue drops around one billion Euros. This roughly increases the external costs by eight times due to projected modal back-shifts. However, profit drops will be considerably lower, depending on the marginal degree of cost coverage of the respective services. In particular in Combined Transport additional investments in transhipment terminals will further put pressure on the competitiveness of rail services.

7. Discussion of potential further impacts/Sensibility analysis

7.1 Intra-modal shift

Order of magnitude

(1) This study was clearly focussed on the impact of the introduction of LHV on rail transport.

Beside this inter-modal back-shift, one can also expect an intra-modal shift from standard 40/44 tonnes HGV to 44t(60t)/25.25m LHV. In a study we carried out for the German Ministry of Transport ("Verkehrswirtschaftliche Auswirkungen von innovativen Nutzfahrzeugkonzepten II, Freiburg 2007), K+P estimated the net effects measured in vehicle-kilometres on the German road network of inter- and intra-modal shift for various LHV scenarios.

Impact of volumes shifted

(2) The following table gives an overview of the results.

Table 7.1: Net effects of intra- and inter-modal shift of the introduction of LHVs in billion vehicle-kilometres

Scenario	Standard HGV	Intra-modal shift	Inter-modal shift	Net effect
	(billion vehicle-kilometres)			
LHV 40 tonnes GVW	-2.9	+1.9	+0.2	- 0.8
LHV 40 and 48 tonnes GVW	-4.1	+2.7	+0.2	-1.2
LHV 40,48 and 60 tonnes GVW	-19.4	+12.3	+0.4	-6.6

(Source: K+P)

Impact on social costs

(3) According to these results, the intra-modal shift outweighs the inter-modal back-shift, which seems clear when considering the actual mode share of rail and road. Hence, when regarding both effects a reduction of total vehicle-kilometres on the road can be expected.

Nevertheless, when regarding the total vehicle (truck)-kilometres on the German road network, which amounted at that time to 63.2 billion vehicle-kilometres, the net effect of the maximum Scenario (LHV 40, 48 and 60 tonnes GVW) is in the order of magnitude of a 10% reduction in vehicle truck-kilometres.

7.2 Congestion

Order of magnitude

(1) In Section 6 we have concluded that, without modal back-shift and induced traffic 5% of road capacity could be saved, Due to market reactions, i.e. back-shift and additionally attracted traffic, in average 2% to 4% of this saving could be counter-balanced.

Congestion is, however, a locally very specific phenomenon and modal back-shift intensities strongly depend on commodities shipped, network configurations and the organisation of local as well as of inter-regional logistics markets. The net capacity effect might thus deviate considerably from these mean values. In this section we will give a short overview of the likelihood of further positive or even negative results for net capacity savings.

Impact of volumes back-shifted

(2) In the course of this study we have not collected road volume data along the five corridors investigated. Thus we will approach the sensitivity test of potential road capacity impacts by varying general parameters.

We start with the market uptake of LHVs in long distance road haulage. Past studies suggest a share of 20% of goods shifted from HGVs to LHVs. Here we additionally look at a lower bound of 15% and an upper share of 25% of LHVs at motorway capacity used by freight vehicles.

Second, we look at the impact of LHVs on modal back-shift and possibly on induced traffic. We start from the assessment of the demand for road freight transport with respect to road transport costs. E.g. the results form Graham and Glaister 2002 (Figure 28 in Annex 2) suggest an average direct price elasticity of -0,8 with a upper bound of -1.2 and low estimates of -0.4 and even -0.1. We take these four values to study the impact of several market settings.

Table 7.2 presents the results of the sensitivity tests. In the case of an average LHV market uptake of 20% and a mean direct price elasticity of -0.8 we receive a net reduction of road capacity use by trucks of -0.4%. This may not be visible in the annual development of vehicle volumes. The higher the market uptake is, and the lower the price elasticity gets, the more savings in road capacity will be achieved.

Table 7.2: Sensitivity analysis of road capacity impacts of LHVs

Road-internal market uptake	Price elasticity of road demand -0.1	-0.4	-0.8	-1.2
15%	-2.6%	-1.2%	0.6%	2.4%
20%	-3.6%	-2.2%	-0.4%	1.4%
25%	-4.6%	-3.2%	-1.4%	0.4%

(Source: Fraunhofer-ISI)

On the contrary, a low road-internal market uptake combined with a high price elasticity will lead to an additional load of the road network. These two extreme cases, however, seem to be less likely. We shall rather assume relevant combinations to be found the upper left part to the lower right. In this case the net effect ranges from a moderate relieve of road capacity to a slight increase. However, further studies shall provide more empirical evidence to this topic.

Impact on social costs

(3) The relief or increased use of infrastructure capacity is not identical to the level of congestion, as the functional relationship between capacity use and the mutual disturbance of vehicles (or simply travel times) is strongly non-linear. In cases of low traffic volumes a several percent change in demand will simply have no effect. On the contrary, a small demand change will have huge effects on travel times and congestion levels.

In the course of this study we cannot quantify the development of external congestion costs entailed by the introduction of LHVs. But from the above sensitivity analysis we can conclude that impacts on congestion in both directions are possible.

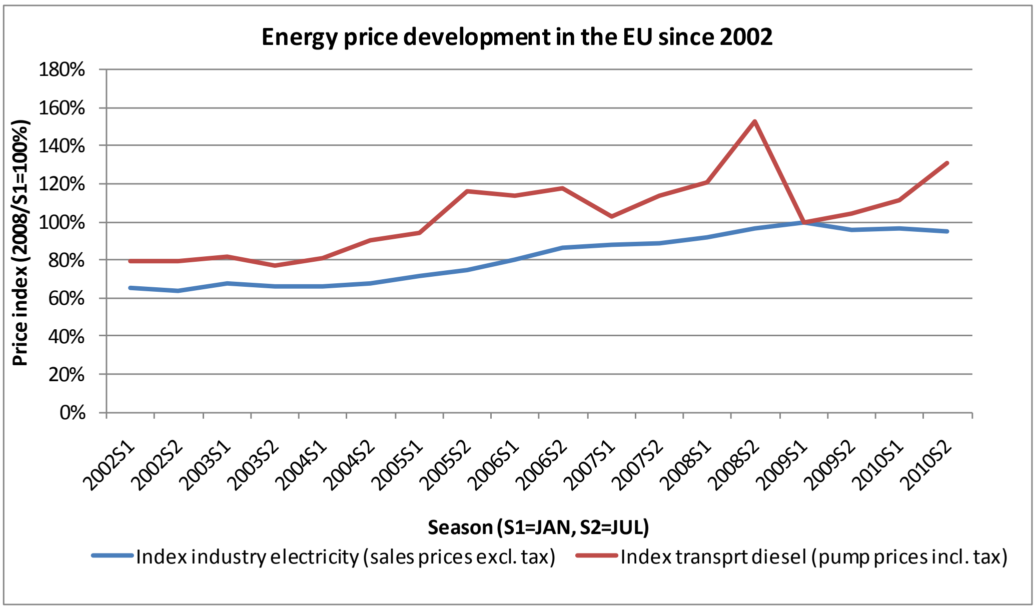
7.3 Energy prices (rail)

Order of magnitude

(1) During the last years, oil and gas prices have shown considerable ups and downs, reflecting prevailing demand and supply constellations on international trade markets.

The driving forces of these price fluctuations are the world market demand, the availability of oil resources and reserves as well as speculations to a large extent. ***Figure 7.1*** presents the market price development for electricity for industrial purposes and transport diesel. Over the eight year period both energy sources show a growth of roughly 20%. While electric power shows a rather stable slope, diesel prices are fluctuating extremely. This characteristic is expected to sustain in the coming decades.

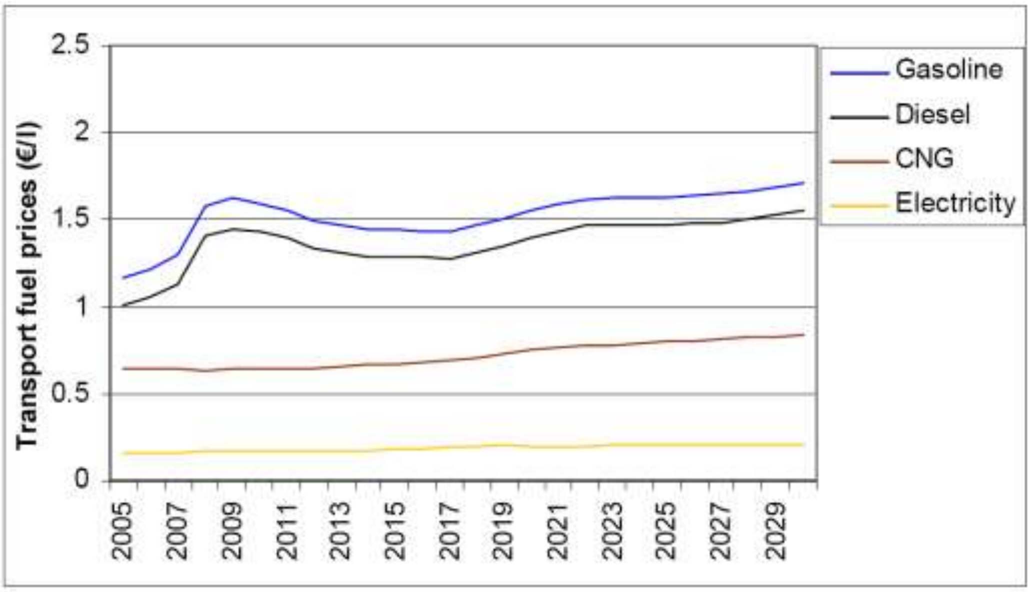
Figure 7.1: Development of electricity and transport diesel prices in the EU 2002 to 2010



(Data source: Eurostat)

With the rise of new global players like China, India and Brazil demand will rise rapidly, and it can be questioned whether the increasing use of renewable energy sources is able to balance this out. Simultaneously, oil supply gets more and more expensive and risky. In its integrated scenario (iTREN-2030, 2010) the study refers to IEA's World Energy Outlook (IEA 2011). Diesel fuel prices are expected to rise by 50%, while more stable coal prices will keep electricity prices at a lower increase of around 30% until 2030 (***Figure 7.2***).

Figure 7.2: Assumed development of energy prices until 2030



(Source: iTREN-2010 (2010))

Impact of volumes back-shifted

(2) In road haulage roughly 30% of costs are diesel prices. With the above assumptions we can expect this share to be at 40% by 2030. In rail freight the portion of energy costs may range in the same order of magnitude.

For impacts on the economic viability of road and rail transport the difference in energy price developments is responsible for induced shifts in market shares, rather than the absolute rise of energy prices.

Based on the development of traction energy prices we can assume a 5% to 10% increase in the competitive advantage of rail freight when compared to road if primary energy prices develop as projected. The effect is even amplified with higher rises in energy prices. Relative price changes appear to be in the order of magnitude of the competitive advantage due to the relaxation of lorry weight and size limits. We must thus constitute that the assumptions on energy price developments are decisive for the modal shift impacts in general. However, in rail markets which are heavily attacked by LHVs the energy price impact may not even be noticeable.

Impact on social costs

(3) The impact of energy prices on external costs is twofold. First, we have the demand impact via changes in the transport modes' competitive situation. This effect may – as discussed above – outweigh the negative balance of external costs caused by LHVs.

Second, higher energy prices put more pressure on operators and vehicle manufacturers to improve the fuel and energy efficiency of trucks and locomotives. Options are productivity improvements, slow and energy efficient driving, aerodynamics and lightweight materials, more efficient engines or the use of renewable energies. As shown by iTREN-2030 (2009) there are still considerable reserves in both modes. In particular the railways could profit from an accelerated renewal of the electricity production sector. But as soon as we assume a higher potential for reducing energy consumption and CO_2 emissions, LHVs get relatively more polluting. This effect then worsens the external cost balance from allowing LHVs.

It is difficult to quantify the latter effect as for this step we need to develop concepts of future energy saving options and their cost/benefit ratio. As this exceeds the mandate of this study we cannot say exactly which one of the two effects is stronger. Thus we acknowledge the importance of energy prices for the environmental performance of transport, but assume that the net effect in the specific case of introducing LHVs on the TEN-T road network is limited

7.4 Increase of road tolls (Eurovignette/Impact on volumes)

Order of magnitude

(1) With the amendment of the Directive on charging heavy goods vehicles (Eurovignette-Directive) from 1999, in 2006 the European Commission gave Member States more freedom to include lighter trucks on motorway trunk roads in national HGV charging systems (EC 2006).

At the same time the European Parliament asked the Commission to develop a strategy to internalise the external costs of transport to all modes. On the basis of the scientific study (CE Delft et al., 2008) the Commission worked out a proposal starting with road haulage. The proposed further amendment of the Eurovignette-Directive (EC 2008) which shall be in place from 2012 on, will allow for charging to take account of air pollution, noise and congestion costs. Internalisation of other external effects will be encouraged via insurance premia (accidents) or fuel charges (climate change). Furthermore, the White Paper on Transport (EC 2011) indicated the Commission's desire to see the full and mandatory internalisation of external costs in road and rail transport by 2020.
In ***Chapter 6*** we have derived infrastructure-related costs for HGVs of €50/100vkm, of which €20/100vkm are external costs excluding congestion (***Table 6.3***). Taking the 2030 values from ***Table 5.7*** air pollution and noise amount only to €1.56/1000tkm or €2.69/100vkm for 60t/25.25 m LHVs. As derived in ***chapter 7.2***, average European congestion costs range around €3 per 1000tkm which is twice the cost level of air pollution and noise. Under specific traffic situations the ratio of external cost elements will be very different. In total, the external costs allowed by the proposed amendment of the Eurovignette Directive range around €8 per LHV-km, and thus considerably below our previous assumptions.

But as the strategy of the European Commission not only foresees road user charges to internalise external cost elements but also fuel taxes and insurance premiums we may well take the full cost level as derived by ***Table 6.3*** to analyse modal shift effects.

Impact on social costs

(2) The productivity of the railways expressed in load rates of freight trains constitutes a key factor in not only the economic viability but also the economic performance of rail transport.

In contrast to road haulage where tonne- and vehicle-kilometres in certain markets are more or less coupled, a doubling or halving of shipment volumes in rail does not necessarily imply a similar change in locomotive-kilometres. In particular for lightweight goods the ratio of net to gross tonne miles, and thus the energy efficiency of rail transport, will increase with higher rates of productivity. This will directly impact the social costs of climate change up- and downstream processes.

From industry studies we can receive the saving in traction energy related to savings in gross train weight of 0.5. If we further assume an average 80t locomotive carrying 500t net cargo weight, we receive that a one percent improvement in net tonnage per train reduced the specific locomotive weight of 0.16 percent. This results in 0.08 – or roughly 0.1 – percent change in energy consumption and CO_2 emissions.

In this calculation we assume that the load per wagon and the share of empty wagons per train remains unchanged. However, the reduction of the latter could save a considerable share of gross tonne miles carried by freight trains. The ratio between CO_2 savings to productivity gains can in this case be much higher. The increase in social costs due to modal shifts from rail to road will then be considerably amplified.

7.5 Productivity gains of the railways

Order of magnitude

(1) As pointed out in chapter ***3.4***, the model results were estimated under the ceteris paribus assumption, i.e. no productivity gains of the railways were considered.

This assumption results in a significant back-shift from rail to road. Increased productivity leading to a decrease of rail freight prices may curtail the cost advantage of the LHVs.

When searching for productivity gains in the railway, various issues could be assessed e.g.

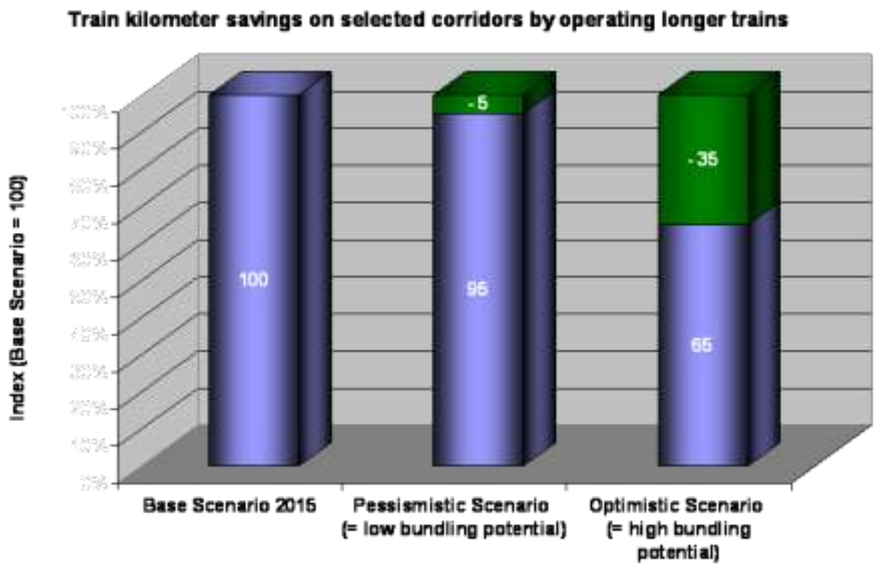
- Longer and/or heavier trains
- Increased use of capacity on CT shuttle trains
- Higher use of rolling stock
- Higher use of network capacity by an improved slot management
- Increased punctuality

Impact

(2) Within the DIOMIS study the impacts of some of the above mentioned issues were evaluated:

Figure 7.3 presents the impact of longer trains on the total number of train-kilometres.

Figure 7.3: Train-kilometre savings on selected corridors by operating longer trains



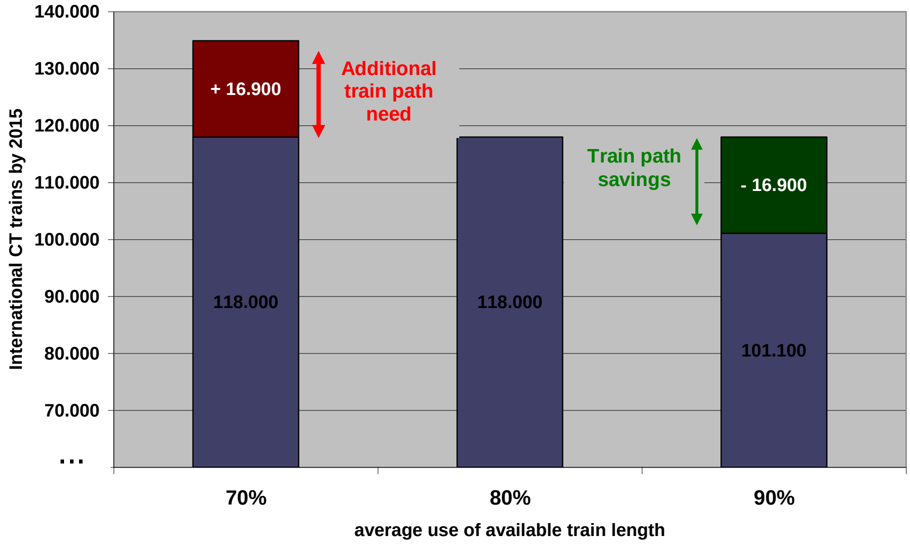
(Source: DIOMIS, K+P Transport Consultants)

It can be clearly seen that according to the scenarios up to 35% of train-kilometres could be saved, when employing longer trains on selected corridors.

It must be kept in mind that longer and/or heavier trains require additional technical and organisational efforts, thus this can be seen only as a mid-term solution.

As another example, K+P evaluated the impacts of an advanced capacity management for CT trains, in order to use to a maximum the capacity on the available train lengths. Without going further into details (for more information see DIOMIS reports (http://www.uic.asso.fr/diomis/spip.php?article11#outil_sommaire_0)) ***Figure 7.4*** below presents the following result: a 10 percentage-points increase of capacity load factor would lead to 15% less train paths, thus 12 million tonnes more carried with the same number of trains.

Figure 7.4: Impact of an advanced capacity management on the number of train paths



(Source: DIOMIS, K+P Transport Consultants)

Final remarks

(3) The objective of this section was not to calculate exactly impact of productivity gains of railways and to re-evaluate the cost advantages of LHVs in the light of a higher productivity of railways.

Nevertheless, it seems worth to illustrate that this study was carried out under the "ceteris paribus assumption" i.e. all other things being equal and to insist that – amongst others - these two examples may indicate that productivity reserves of the railway system may help to deal with the cost advantage of the LHV.

As a reminder, the cost average of the different/various LHV types considered in this study amounts to 6-22%.

7.6 Environmental performance road / rail

Order of magnitude

(1) In the following elaborations we concentrate on climate gas emissions as the most relevant category of social costs.

In road haulage we have discussed the technical challenges of reducing CO_2 emissions while sticking to current and future regulations of air pollutant emissions. In the very extreme case, fuel consumption could even increase when Euro-VI and further regulations are introduced. For the sensitivity analysis of the environmental friendliness of

LHVs we consider fuel and vehicle technology improvements to just balance decreases in fuel efficiency of truck engines and assume an overall stable CO_2 emission factor per tonne-kilometre in the rail-friendly case.

According to data of the German Environment Agency (UBA) the CO_2 intensity of electric power generation in Germany has been reduced from 792g/kWh in 1990 by 24% to 601g/kWh in 2008. According to its latest sustainability report, DB (2009) has reduced its specific CO_2 emissions by 40% and envisages a further reduction between 2006 and 2020 of 20%. Besides the increased use of renewable energies from 19% to 30%, modal shift from road to rail plays a decisive role in this concept.

These plans exceed the projected decrease in unit costs of climate emissions of the railways by roughly 25%. However, given that other railways already rely on renewable or nuclear power to a higher extent than Germany, we consider the projections developed in ***Table 5.6*** as a rather ambitious goal for European railways in general. On the other hand, the catastrophic events in Japan have already impacted European energy policy. A negative scenario may be that Germany's exit from nuclear power production cannot be adequately compensated by renewable sources. In this LHV-friendly case we would need to look at a considerably lower rate of reducing CO_2 emissions, e.g. of minus 10% between 2008 and 2030.

Table 7.3 compiles the above assumptions to revised external costs factors (all categories) for combined rail transport and 44t/25.25m LHVs in 2030. While the cost ratio between Rail-CT and LHVs was 3.3 for the above elaborations, sensitivity considerations arrive at a range between 2.9 in the LHV-friendly case and 4.0 in the rail friendly scenario.

Table 7.3: Sensitivity cases climate reduction potential until 2030

Sensitivity case 2030	Total external costs €/1000 tkm 2030		Ratio LHV 44t/25.25m to Rail-CT
	Rail CT	LHV 44t/25.25m	
Average estimate	3.22	10.63	3.3
Rail friendly case	3.22	12.85	4.0
LHV friendly case	3.63	10.63	2.9

(Source: Fraunhofer-ISI)

Impact of volumes shifted

(2) The concerns on differing environmental performance of the various transport modes will have no impacts on the volumes of shifted traffic per se. This might, however, be different when freight transport was charged for external costs.

Impact on social costs

(3) The impacts on the social cost balance are most obvious in the rail friendly case. If we do not assume improvements in the climate friendliness of road haulage, the additional social costs would increase by around 20%. In the road friendly case a reduction of 10% could be achieved.

These figures are considerable. But it should be noticed that the monetary valuation of climate gases emitted into the atmosphere is subject to major uncertainties. CE Delft et al. (2011) give a range between €20 and €146 per tonne of CO2. As climate change including up- and downstream processes constitutes the most costly externality in this study, different unit values per tonne of CO2 will impact the social cost balance of the chosen LHV scenarios considerably. Here we have applied the high value per tonne of CO_2 recommended by CE Delft et al. (2011). A lower value would considerably reduce the ratio of external costs between rail and LHVs, possibly down to a factor 2.

Further we have been rather cautious as concerns the reduction of LHV accident risks through regulation and driver assistance systems. However, as the concept of marginal external costs implies that accident impacts are less significant in relation to air and climate gas emissions, we do not see an important case for sensitivity analyses here. All in all we can conclude, that range of additional external costs between -10% and +20% appears to be reasonable. These ranges are considerable but will in no way alter the findings on the negative environmental balance through modal split effects as shown in ***chapter 5***.

8. Policy conclusions

Objectives and scope of the study

(1)) This study was commissioned by the Community of European Railway and Infrastructure Companies (CER) and conducted by K+P Transport Consultants (Freiburg) and the Fraunhofer-Institute for Systems and Innovation Research (ISI), Karlsruhe, between June 2010 and August 2011. Its core objective is to quantify the potential range and impact of modal back-shifts from rail freight to road due to the introduction of longer and / or heavier trucks (LHV). The two relevant rail markets "single wagonload" and "combined road-rail transport (CT)" are distinguished. For both markets the potential back-shifts by goods category and LHV setting are analysed in the short, medium and long run and including entailed back-shifts by the economic downward spiral.

For each of the selected European corridors

- Corridor 1: German North – Sea Ports – Czech Republic
- Corridor 2: Belgian and Dutch sea ports (Antwerp, Rotterdam) – Ile de France – Spain (Barcelona)
- Corridor 3a: Scandinavia (Malmö) – Denmark – Germany (Ruhr area)
- Corridor 3b: Germany (Ruhr area) – Switzerland/Austria – Northern Italy
- Corridor 4: South East Germany (Munich) – Austria – Hungary (Budapest)

and market segments, the study analyses the development of traffic volumes back-shifted to road by different LHV settings. Cost structures and the economic viability of road and rail carriers are approached by taking a rough look at network utilisation and infrastructure investments required. As concerns social impacts the study includes the latest knowledge on current and future levels of the classical externalities, including climate gas emissions, air pollutants, accidents and noise. By reviewing current policy documents, the future of Combined Transport and single wagonload is analysed in the light of the potential permission of LHVs on European roads.

The study focuses on inter-modal back-shift effects. Road sector internal processes, in particular intra-modal shifts, are addressed in less detail.

The following LHV configurations were considered in the study

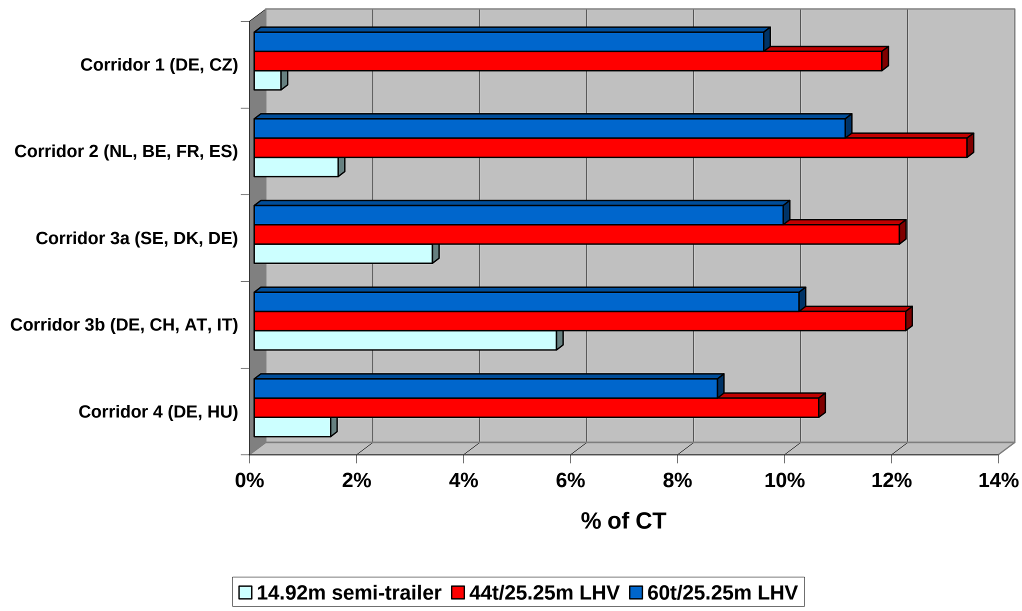
- 14.92m semi-trailer
- 44t/25.25m LHV
- 60t/25.25m LHV

According to the technical characteristics, in particular weight/volume ratios, different commodities relevant for modal back-shift were selected for each LHV type.

Back-shifted volumes per corridor

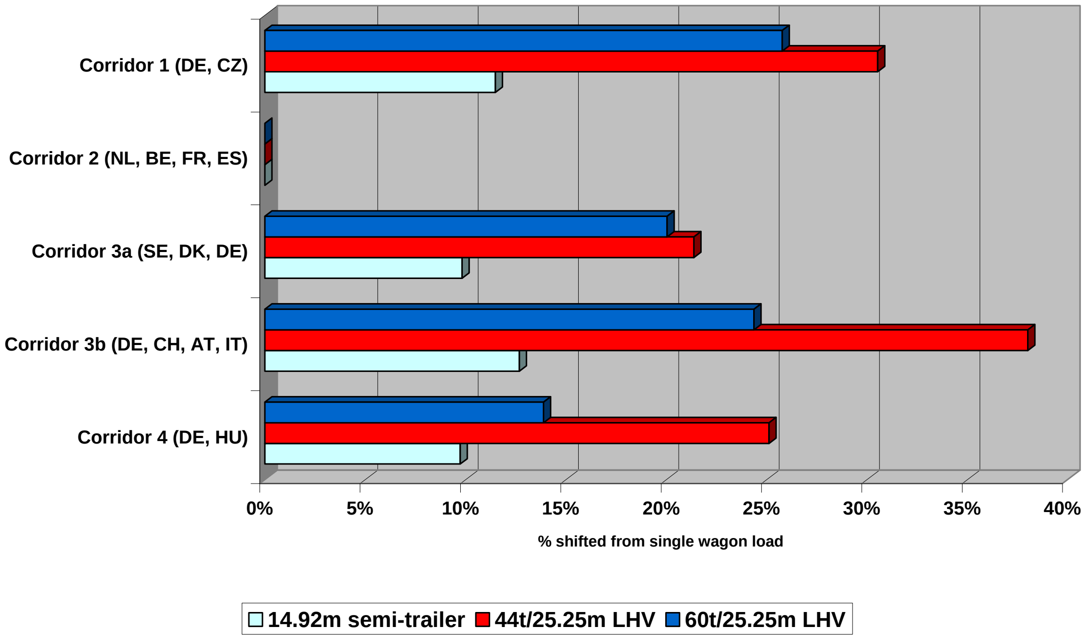
(2) The cost advantages of the different LHV configurations of up to more than 22% compared to the standard HGV for the 44t/25.25m LHV, lead to a modal back-shift from rail to road. Figure 8.1 presents the results of the model runs for Combined Transport in 2020, whereas figure 8.2 presents the results for single wagonload traffic.

Figure 8.1: Relative modal back-shift from CT to road per corridor and LHV scenario in 2020 (base: tonne-kilometres)



(Source K+P)

Figure 8.2: Relative modal back-shift from single wagonload to road per corridor and LHV scenario in 2020 (base tonne-kilometres)



(Source K+P)

From both figures one can draw the following general findings:

- The 44t/25.25m LHV causes the highest back-shift for CT as well as for single wagonload due to its cost advantage.
- Corridor 2 is the most affected for CT with more than 13% losses.
- Corridor 3b more than 35% of its single wagonload traffic is back-shifted to the road, even though we considered a LHV ban in Switzerland.
- Single wagonload is more affected than combined traffic, which results from the high share of fixed costs.

Across all corridors and with 44t/25.25m LHVs volume reductions of more than 30% in single wagonload and of more than 13% in Combined Transport are found. Given these results one has to keep in mind that railway traffic in general and single wagonload in particular can be characterised by a very low economic threshold, which in turn means that they are very sensitive to even slight decrease of volumes.

This was considered in the “downward spiral” effect, where decreasing transport volumes lead to higher costs per unit, which again is resulting in a competitive disadvantage for rail, which is consequently leading to even higher losses of market shares. Finally, it is highly probable that decreasing volumes would end up with a complete withdrawal of the service. This context is obvious for single wagonload, as the experience in many European countries has proven.

The situation of Combined Transport is in general the same: Combined Transport operators seeking to create CT networks, where in gateway terminals the services are linked to each other to feed high frequency shuttle services. This is in particular true for transalpine traffic. For example in the gateway terminal München Riem CT routes from various German and other European destinations were linked to feed the high frequency transalpine services to Italy (e.g. Verona). The results of the model runs in this study showed that the transalpine Corridor 3b is the most affected by the 44t/25.25m LHV.

We considered in the model an LHV ban in Switzerland, which results in a reduced cost advantage for LHV, thus the – at first sight - relatively moderate back-shift of more than 13% of the tonne-kilometres must be seen in this light. Contrary to the CT flows via Switzerland, the CT flows via Austria compete with LHVs' full cost advantages. Finally, this will lead to the same results as described for single wagonload: due to – at first sight - even moderate back-shifts, LHV impacts considerably the whole CT system, and in particular this might thin out feeder services for the gateway system.

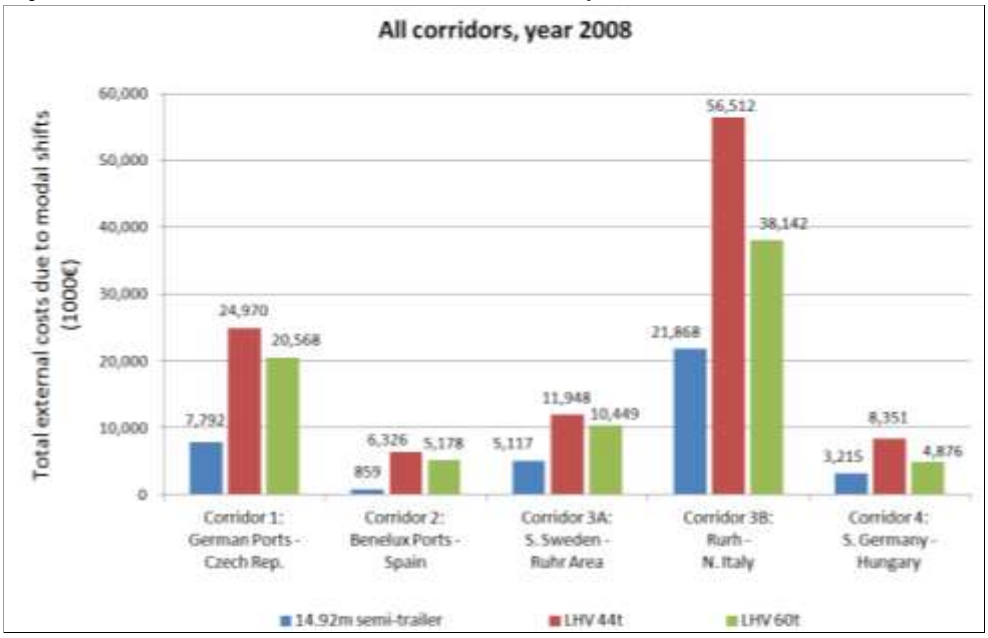
Assessment of external costs

(3) For road and rail transport we consider the major components of external costs, i.e. greenhouse gas emissions, air pollution, accidents and noise. Related per tonne kilometre the external costs of current standard HGVs are four times higher than in single wagonload and five times above Combined Transport. Across all categories of externalities the Big Maxx concept shows about the same performance than HGVs, while LHVs of both weight classes perform up to 10% more efficiently.

With regard to policy goals formulated in the EC White Paper on Transport and the UIC/CER sustainable mobility strategy, and with consideration of practical implementation issues, we expect that road transport can reduce its external costs by 27%, while rail can achieve 30% by 2030. With 50%, accidents dominate the entire picture of external costs in 2008 (49% by 2030), followed by global warming effects stemming from direct combustion, fuel production and energy generation with a total cost share of 38% in 2008 (39% in 2030). While air pollution effects are expected to decline from 9% to 6% of all external costs, the relevance of noise may increase from 3% in 2008 to 6% in 2030.

Total annual external costs differ widely between the selected relations. Highest additional external costs are observed for the Corridors 1 (Hamburg – Prague) and 3b (Cologne – Milan). Across all corridors, total annual external costs induced by modal shift range between €39 million with 40t, 14.92m semi-trailer vehicles (Big Maxx) and €108 million in the event that 44t, 25.25 m LHVs are permitted.

Figure 8.3: Additional annual external costs by corridors and scenarios 2008



(Source: Fraunhofer ISI)

Despite the higher accident and environmental costs of the 60t variant, the 44t/25.25m LHV appears to be the most harmful variant across all corridors. From 2008 to 2030 we find growth of external costs between +16% and +130%. Accordingly, the declining external costs per transport unit are not able to compensate for the projected demand increases on the corridors.

Taking crude assumptions on rail market shares and the uptake of LHVs in the road sector we arrive at net external costs in total freight transport by road and rail after the introduction of LHVs of +2.5%. In the context of the objectives of the EC White Paper the unrestricted introduction of LHVs thus has to be regarded problematic.

Assessment of transport internal costs

(4) Estimates on investment requirements on the primary European road network to accommodate LHVs range from four billion Euros for the EU up to eight billion Euros for Germany. Main cost drivers are bridge rehabilitation and the extension of park and rest areas. On this basis additional road user charges between 9 and 20 Eurocents per vehicle kilometre are estimated.

If restricted to the road sector, LHVs can help reducing road congestion. However, when including induced traffic and modal back-shifts in the order of magnitude as derived in this study, most of the capacity savings will be counter-balanced. Given the very local character of congestion there might even be cases were back-shift and induced traffic exceed the road-internal efficiency gains, leading to rising congestion levels.

Average revenues of rail carriers can be roughly estimated between 30 and 40 Euros per 1000tkm. Along the five corridors these lead to revenue losses of €484 million in Combined Transport and €504 million in single wagonload markets. In addition, the railway companies will face extra investment costs for terminal enhancement to accommodate longer vehicles. For capital intensive undertakings, and in particular for Combined Transport system providers, these challenges may be difficult to compensate.

Sensitivities

(5) The consideration of road-side intra-modal shifts (from standard HGV to different LHV types) and entailed congestion effects would certainly influence, but would not alter the results found in this study. More intensive effects of the sustainability balance are achieved with varying scenarios on the development of energy efficiency per mode and cost values per tonne of CO_2.

More decisive are assumptions on energy price fluctuations, which may regain some competitive advantage to rail. The same holds for productivity gains in the rail sector, e.g. through international co-operations, automated services etc. Combining this with specific road tolls for LHVs, the risk of modal back-shifts could be partly eased.

Conclusion

(6) The study has found much stronger effects for single wagonload transport than for Combined Transport services. Although both are considerable, the intensity of the downward spiral in single wagonload markets could lead to their complete or partial breakdown in specific regions or countries. The introduction of LHVs would then sharpen the discussion on single wagonload services that is already now ongoing in some Member States.

But the future of Combined Transport will also, at least in parts, be subject to the introduction of LHVs. Given that a percentage of terminals are not able to accommodate LHVs and due to the increasing relevance of transhipment costs as soon as road haulage becomes more cost efficient, Combined Transport will certainly lose market share. In the light of the huge investment programmes to establish Combined Transport in Europe, this effect needs to be carefully monitored.

This study has looked into detail into various product markets by considering specific transport cost. But due to this level of detail and the limitations of comprehensive European data sources, a detailed consideration of the entire European freight market was not possible. Thus, future studies should work on suitable databases as well as on expanding the corridor approach to network-wide analyses.

As concerns social and entrepreneurial sustainability aspects, work should be carried further in the fields of safety impacts and the economic consequences for railway undertakings. In particular the various studies on investment needs in the road and rail sectors should be unified to arrive at reliable European estimates.

9. Annex 1: References

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10. Annex 2: Literature review on Elasticities

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Study on the effects of the introduction of LHVs on combined road-rail transport and single wagonload rail freight traffic

Community of European Railways and Infrastructure Companies (CER)

Technical note on the Literature Analysis concerning Elasticities for Freight Modelling

Karlsruhe, Freiburg, November, 2010

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Karlsruhe, Freiburg, November.2010

1. Literature sources

With the aim of giving an overview of the current state of the art concerning the estimation of elasticities, we carried out a widespread analysis of the publications listed hereafter (cf. list below).

- (1) Price sensitivity of European road freight transport – towards a better understanding of existing results, A report for Transport & Environment, 2010, GERARD DE JONG (SIGNIFICANCE), ARNO SCHROTEN (CE DELFT), HUIB VAN ESSEN (CE DELFT), MATTHIJS OTTEN (CE DELFT), PIETRO BUCCI (SIGNIFICANCE) (www.transportenvironment.org/Publications/prep_hand_out/lid/595)
- (2) Wettbewerb und Umweltregulierung im Verkehr Eine Analyse zur unterschiedlichen Einbindung der Verkehrsarten in den Emissionshandel, ZEW - Zentrum für europäische Wirtschaftsforschung, 2009, (ftp://ftp.zew.de/pub/zew-docs/gutachten /Endbericht_WettbewerbundUmweltregulierungimVerkehr.pdf)
- (3) Entkopplung der verkehrsbedingten Umwelteffekte vom Wirtschaftswachstum, OECD, 2006 (http://www.oecd.org/dataoecd/26/20/37823836.pdf)
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- (5) Freight transport demand in the mechanics' sector of Friuli Venezia Giulia: the choice between inter-modal and road transport, Department of Economics and Statistics, University of Trieste, Italy, 2004, (http://www.istiee.org/te/papers/N25_26_2003_4/ZOTTI-DANIELIS.pdf)
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- (7) "Why are freight elasticities so problematic?", Keith Buchan, MTRU, paper for the Peer Group Meeting 9th November 2009
- (8) The transport economic impact of innovative vehicular concepts III; by order of the "Bundesministerium für Verkehr, Bau und Stadtentwicklung" (German Ministry of Transport), K+P Transport Consultants 2008
- (9) The transport economic impact of innovative vehicular concepts II; by order of the "Bundesministerium für Verkehr, Bau und Stadtentwicklung" (German Ministry of Transport), K+P Transport Consultants 2008
- (10) The transport economic impact of innovative vehicular concepts I; by order of the "Bundesministerium für Verkehr, Bau und Stadtentwicklung" (German Ministry of Transport),K+P Transport Consultants 2006
- (11) Market study for innovative vehicular concepts (25,25 meters, 60 tonnes) on the combined transport; by order of the "German Association for Research in Automo-bile Technology", 2006

- (12) Economic impacts of introducing LHVs in the EU (TML et al., 2009)
- (13) Das Problem der Internalisierung externer Kosten des Straßengüterverkehrs am Beispiel von CO2-Zertifikaten, EURES discussion paper dp-23, Sylvie Geisendorf, EURES, 1994
- (14) Elasticities and policy impacts on freight Transport in Europe, De Jong, RAND Europe, Paper for the AET 2003
- (15) Freight Transport Management, Increasing Commercial Vehicle Transport Efficiency, TDM Encyclopedia, Victoria Transport Policy Institute, Updated 25 January 2010
- (17) Essays in Road Pricing –Modeling, Evaluation and Case Studies, M. Winter, Berlin 2009

2. Overview of elasticities estimations

In the following chapter 2 the most relevant publications are presented more in detail:

2.1 Price sensitivity of European road freight transport – towards a better understanding of existing results (Source n° (1))

Source (1) provides a comprehensive overview of 32 publications dealing with freight elasticities and the so-called "response mechanisms" of these. In this context the term "response mechanisms" means the changes in road transport to which the model responds *("ways in which people react on price changes")*. The following response mechanisms can be distinguished for the effect of a change in the price of road transport on road transport demand:

- 1 change in fuel efficiency of the vehicle;
- 2 change in fuel efficiency of driving;
- 3 optimizing allocation vehicles to shipments;
- 4 change in number and location of depots;
- 5 change in shipment size;
- 6 change in consolidated shipments;
- 7 change in empty driving;
- 8 change in trip length;
- 9 change in mode;
- 10 change in production technology;
- 11 change in production volumes per location;
- 12 change in suppliers/customers (change in OD patterns);
- 13 change in commodity demand.

The following tables present the various models, their response mechanisms and the resulting elasticities:

Figure 2.1: Overview of elasticities (source (1))

Study	Country	Period	Dependent variable	Response mechanisms	Elasticity
Effect on road tonne-kilometres					
Beuthe et al. (2001)	Belgium		Tkm	9	-1.1 to -1.3
Bjõrner & Jensen (1997)	Denmark		Tkm	9/10/11/12	-0.5 to -2.4
				9	-0.2 tot -0.9
				10/11/12	-0.4 to -1.5
Friedlaender & Spadey (1980)	USA	1972	Tkm	9/10/11/12	-0.96 to -1.58
Friedlaender & Spadey (1981)	USA	1968-1972	Tkm	9/10/11/12	-0.59 tot -1.81
De Jong (2003)	EU	90ties	Tkm	9	-0.62
	Belgium	90ties	Tkm	9	-0.95
	Norway	90ties	Tkm	9	-1.01
	Sweden	90ties	Tkm	9	-0.4
Inabe & Wallace (1989)	USA	1984	Tkm	5/9/12	-0.3 to -0.9
NEI & CE Delft (1999)	Netherlands	1999	Tkm	5/9/11/12/13	-0.43 to -0.63
Oum (1989)	Canada	1979	Tkm	5/9/10/11/12/13	-0.69 (-0.05 to -1.34)
				9	-0.65
				5/10/11/12/13	0.04
Yin et al. (2005)	UK	2001	Tkm	8/9/11/12	-0.2
Effect on road tonnes					
Beuthe el al. (2001)	Belgium		Tonnes	9	-0.6

Figure 2.1 (cont.)

Chiang, Roberts & Ben-Akiva (1981)	USA	70ties	Tonnes	5/9/12	-0.00 to -9.86 [b]
De Jong (2003	EU	90ties	Tonnes	9	-0.13
	Belgium	90ties	Tonnes	9	-0.4
	Italy	90ties	Tonnes	9	-0.01
Jovicic (1998)	Denmark	1993-1997	Tonnes	9	-0.03 to -0.07
Marzano & Papola (2004)	Italy	90ties	Tonnes	9/11/12	-0.15
Windisch (2009)	Sweden	2003-2004	Tonnes	5	0 to -1.4
				9	0
Effect on mode choice for road					
De Jong & Johnson (2009)	Sweden	2001	Mode choice	5/9	-0.03
García-Menéndz et al. (2004)	Spain	1998	Mode choice	9	-0.32 to -0.49
McFadden & Boersch-Supan (1985)	USA	1977	Mode choice	5/9/10/11/12/13	-0.75

[a] See section 3.2 for a description of the various response mechanisms

[b] The relatively high values found by Chiang et al. (1981) are the result of changes in shipment sizes in reaction to changes in tonne prices.

Table 4 Overview of road tonne price elasticities

Study	**Country**	**Period**	**Dependent variable**	**Response mechanisms**	**Elasticity**
Abdelwahab (1998)	USA		Tonnes	5/9/13	-0.75 to -2.53
Nam (1997)	Korea	1988-1989	Mode choice	9	0.12 to -0.25
Winston (1981)	USA	1975-1977	Tonnes	9	-0.14 to -2.96

[a] See section 3.2 for a description of the various response mechanisms

This publication presents also a review of elasticities by commodity types (cf. ***Figure 2.2*** below):

Figure 2.2 Overview of road tonne or tkm price elasticities by commodity type (source (1))

Study	Country	Effect	Commodity type	Response mechanisms included[ab]	Elasticity
Abdelwahab (1998)	USA	Tonne price on tonnes	Food	5/9/13	-2.2 - -1.1
			Textile		-1.4
			Chemicals, Petroleum, coal		-1.7 - -0.9
			Rubber, plastic, leather		-1.1
			Metal products		-2.2 - -0.8
			Electrical and transportations equipment		-2.5 - -1.2
			Stone, clay, glass, concrete		-0.8
			Wood and paper products		-1.6 - -1.1
Beuthe et al (2001)	Belgium	Tkm price on tkm	Agricultural products and animals	9	-0.96
			Food		-0.69
			Solid fuel		-0.52
			Petroleum		-4.5
			Iron ore and scrpas		-1.67
			Metallurgical products		-2.09
			Minirals and building materials		-0.98
			Fertilisers		-0.72
			Chemical products		-1.1
			Diverse products		-1.18
			Agricultural products and animals		-0.95
			Food		-0.65
			Solid fuel		-0.39
			Petroleum		-3.98
			Iron ore and scrpas		-1.47
			Metallurgical products		-1.98
			Minerals and building materials		-0.77
			Fertilisers		-0.7
			Chemical products		-0.77

Nam (1997)	Korea	Tkm price on mode choice	Textile	9	-0.002
			Paper		-0.253
			Chemicals		-0.107
			Basic metal		-0.212
			Earthenware		0,.21
			Electrical houseware		0.085
Garcia-Mendendz et al. (2004)		Tkm price on mode choice	wood manufacture and furniture	9	-0.38
			Ceramics		-0.49
			Textiles		-0.32
			Agroindustry		-0.36
			Diverse products		-1.18
Jovicic (1998)	Denmark	Tkm price on tonnes	low value goods	9	-0.07
			high value goods		-0.03
De Jong (2003)	EU	Tkm price on tonnes or tkm	Tkm, bulk, 500-100m km	9	-0.5
			Tkm, general cargo, 500-1000 km		-0.7
			Tkm, bulk , >1000 km		-1
			Tkm, general cargo, >1000 km		-0.8
			Tonnes, bulk, all distances		-0.05
			Tonnes, petro, all distances		-0.13
			Tonnes, general cargo, all distances		-0.13
			Tkm, bulk, all distances		-0.18
			Tkm, petro, all distances		-0.35
			Tkm, general cargo, all distances		-0.39

To conclude, the authors of the study pointed out that

- A wide range of elasticities do exist, which is due to different response mechanisms, different market segments etc.
- Most of the publications deal with "own" elasticities (= "*impact (*of changes) *of an attribute of some mode on the demand for that same mode"*), whereas cross elasticities have to be interpreted with care since *"cross elasticities are not really transferable from one country to the other if these countries have different mode shares"*
- Finally, the publication (6) comes to the following recommendations

Figure 2.3: Results from the literature review on road own-price elasticities

Price change	Impact on		
	Fuel use	Vehicle kilometres	Tonne kilometres
Fuel price	-0.2 to -0.6	-0.1 to -0.3	-0.05 to -0.3
Vehicle kilometre price		-0.1 to -0.8	-0.1 to -0.5
Tonne kilometre price			-0.6 to -1.5

nost relevant. The publication (1) recommends a range of -0.6 to -1.5 with an average of -1.0 as a "best guess".

As cross elasticities are concerned, the authors recommend "*a transport cost (per tkm)* (cross-) *elasticity of rail tonnage of 1.1 to 1.6 and of rail tkm of 1.7 to 2.4."*

2.2 Das Problem der Internalisierung externer Kosten des Straßengüterverkehrs am Beispiel von CO2-Zertifikaten, EURES (Source n° (13))

In this source cross price elasticities are cited from "Baum, H. (1990): Aufbereitung von Preiselastizitäten der Nachfrage im Güterverkehr für Modal-Split Prognosen. Essen" (cf. ***figure 2.4***). When comparing the figures it must be kept in mind that these cross elasticities are estimated for the calculation of an increase of road volumes caused by a decrease of rail prices, hence a relative unlikely situation. In addition, the figures are relatively old (20 years). Finally, we came to the conclusion that this publication seems only relevant for comparative purposes.

This is even more true since – according to the experience - one can expect that the reaction on an increase of rail prices (which is much more likely) is by far more elastic than the reaction of a decrease of rail prices.

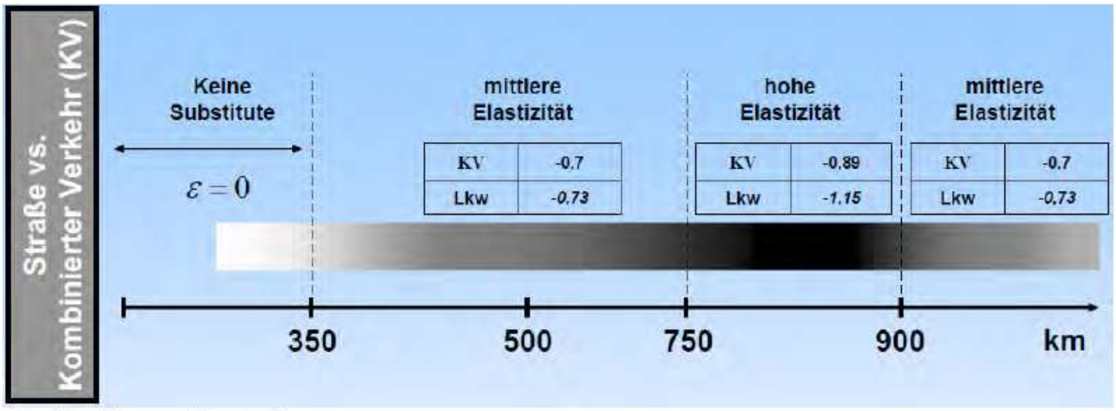
Figure 2.4 Cross price elasticities of the demand of road transport caused by a decrease of rail prices (source n° (13)

Gütergruppe	Elastizität
Landwirtschaftliche Erzeugnisse	-0,51
Nahrungs- und Futtermittel	-0,54
Kohle, Koks	-0,68
Rohöl, Mineralprodukte	-0,47
Erze, Schrott	--
Eisen, Stahl, NE-Metalle	-1,53
Steine und Erden	-0,58
Chemische Erzeugnisse, Düngemittel	-0,21
Investitionsgüter	-0,64
Verbrauchsgüter	-0,33
Quelle: Baum 1991, S. 41	

2.3 Wettbewerb und Umweltregulierung im Verkehr: Eine Analyse zur unterschiedlichen Einbindung der Verkehrsarten in den Emissionshandel (source n° (2))

This source deals with the inclusion of emissions trading in general and the competition between road and inter-modal transport in Germany. In this study direct price elasticities depending on the transport distance were estimated for manufactured high value goods (Kaufmannsgüter) for road transport as well as for combined transport. ***Figure 2.4*** below gives an overview of the results.

Figure 2.4: Direct price elasticities for valuable manufactured goods by distance class (source (2))



According to this graph

- For distances up to 350 km there is no substitution between road and combined transport
- Between 350 and 750 km the authors expect a medium cross price elasticity (combined transport -0.7/road transport -0.73)
- Between 750 km and 900 km, a range of relatively high cross elasticities is indicated (combined transport -0.89/road transport -1.15)
- Whereas distances above 900 km show again medium cross elasticities

When comparing these indications with source n° (1), where cross elasticities of rail tkm amounts to 1.7 to 2.4 and rail tonnes amounts to 1.1 – 1.6, it becomes obvious that the elasticities in figure 2.4 appear to be relatively low. This might be caused by several reasons e.g. that source (1) deals with rail traffic in general and not only combined transport or it reflects the fact that the mode share for combined traffic in Germany is relatively high.

Regarding the road elasticities and comparing them to the elasticities per commodity (***figure 2.2***), in particular De Jong (2003), gives the following results:

Figure 2.4 Comparison of sources (1) and (2) of road elasticities for valuable goods

Source (1)		**Source De Jong (2003) after (6) cf. figure 2.2 above**	
Valuable manufactured goods (medium elasticity) (350 – 750km)	-0.73	General cargo 500 – 1,000 km	-0.7
Valuable manufactured goods (medium elasticity) (750 – 900 km)	-1.15	General cargo > 1,000 km	-0.8
		Source Beuthe et al. (2001) after (6) cf. figure 2.2 above	
		Agricultural products	- 0.96
		Food	- 0.69

To conclude, contrarily to rail elasticities, the road elasticities for valuable goods don't differ too much. One can deduct the following general picture:

- The longer the transport distance, the higher the elasticity
- The higher the perishableness, the lower the road elasticity (e.g. food according to Beuthe et al)

2.3 Ökonomische Grundlagen des Verkehrs und Wirkung verkehrspolitischer Instrumente, Karl W. Steininger, Inst. für Volkswirtschaftslehre, Universität Graz, 2004, (Source (3))

Examples of road price elasticities for 3 commodities are presented in this source:

Figure 2.5 Price elasticities for road transport per commodity (source n° (3))

Commodity	Elasticity
Agricultural products	0.9
Machines	0.35
Chemical products	0.6

The following table 2.6 gives a comparison with the findings after De Jong (6) (cf. figure 2.2)

Source (3)		**Source Beuthe et al. (2001) after (6) cf. figure 2.2 above**	
Agricultural products	- 0.9	Agricultural products	0.96
Machines	- 0.35		
Chemical products	- 0.6	Chemical products	- 1.1

Whereas the elasticities for agricultural products seem to fit very well (0.9 – 0.96), the elasticity for chemical products vary considerably (0.6 – 1.1).

2.4 Elasticities used by K+P in "The transport economic impact of innovative vehicular concepts I; by order of the "Bundesministerium für Verkehr, Bau und Stadtentwicklung" (German Ministry of Transport), 2006 (Source (10))

The following cross elasticities have been used in source n° 10. According to the specific objectives of the study the elasticities have been differentiated by CT markets.

Figure 2.5 Cross elasticities for CT rail transports per CT market

		Weight critical	**Volume critical**
Maritime market	**National**	***0,9***	***1,5***
	International	***0,8***	***1,0***
Continental market	**National**	***0,5***	***1,0***
	International	***0,4***	***1,0***

According to this study the cross elasticities for volume critical goods are in general considerably higher.

Contrarily to the results of the direct road elasticities presented in figure 2.4, the cross elasticities for CT on road price changes are slightly lower on international flows (more or less “long distance”) than on national flows, which could be considered as more short distance flows. This reflects the relatively high competitiveness of CT on international trade lanes.

Compared to the cross elasticities from source n°(6) that amounts to 1.7 – 2.4 the elasticities of source (10) seem relatively low. This again might be caused by the fact that source (6) refers to rail transport as a whole and secondly (6) deals with average elasticities for all European countries.

2.5 Das Problem der Internalisierung externer Kosten des Straßengüterverkehrs am Beispiel von CO2-Zertifikaten, EURES discussion paper dp-23, Sylvie Geisendorf, EURES, 1994 (Source n° (13))

This publication refers to the same source as described in chapter 2.2 Baum, H. (1990): Aufbereitung von Preiselastizitäten der Nachfrage im Güterverkehr für Modal-Split Prognosen. Essen and presents the cross price elasticities per commodity. The weighted average of all commodities is indicated with -0.55.

2.6 Elasticities and policy impacts on freight Transport in Europe, De Jong, Paper for the AET 2003 (source (14))

This paper compares the results of model runs of different national models, expressed in elasticities. The following table compares the cost elasticities of road transport operating costs.
Again it becomes evident that the elasticities do vary tremendously. This is not only true for the cross elasticities, where different mode shares may serve as explanation but also true for "own elasticities". De Jong explains these variations by the fact that, for example in the Italian model, the short distance road transport is included, where no real alternative to road transport exist.
After having averaged the elasticities and having truncated extremely high or low elasticities De Jong gives the following average elasticities of road transport operating cost of the number of tonnes transported for two type of products and two distance classes

Figure 2.7 Averaged road transport operating cost direct and cross elasticities for bulk and general cargo at different transport distances for the EU (source n° (14))

	500 – 1.000 km		> 1.000 km	
	Bulk goods	General cargo	Bulk goods	General cargo
Mode				
Road	-0.5	-0.7	-1	-0.8
Conventional rail	1.5	1.1	1.7	1.2
Combined road – rail	0	1.1	0	1.2
Short Sea	0.3	0.2	0.3	0.1

It becomes evident that a variation of road transport costs do not affect combined transport of bulk goods (elasticity = 0), which, according to our experience, would lead to an underestimation of the effects of a cost decrease in road transport on the combined transport.

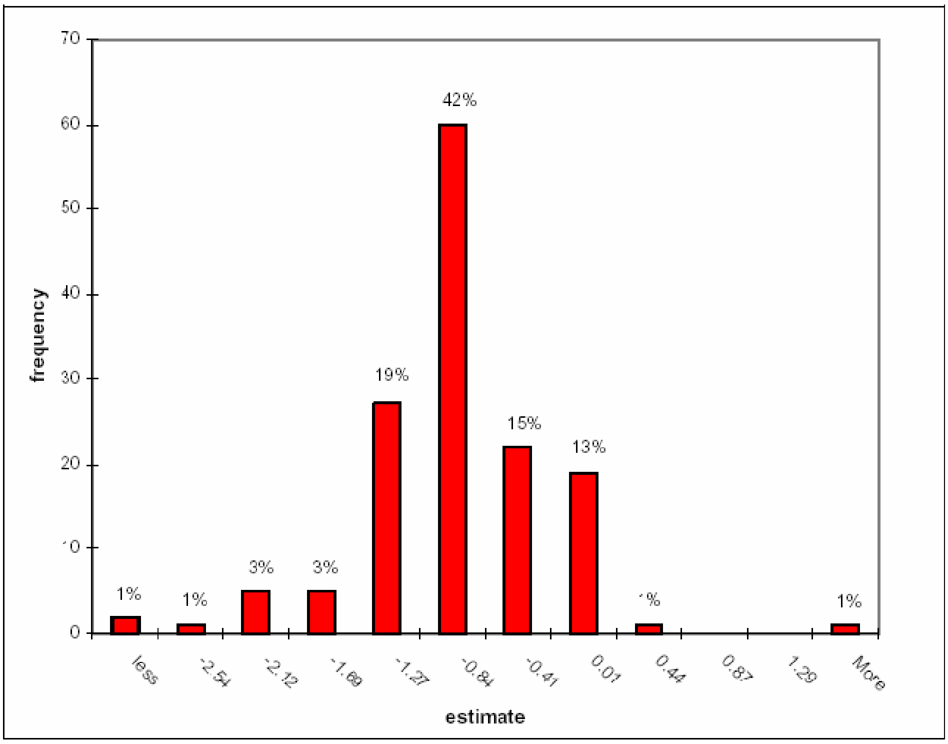
2.6 Freight Transport Management, Increasing Commercial Vehicle Transport Efficiency, TDM Encyclopedia, Victoria Transport Policy Institute, Updated 25 January 2010, (Source n° (15))

This source indicates some elasticities in Europe (Denmark) and Australia, thus of minor interest in our country. The direct price elasticity of road tonne-miles is indicated at -0.47 for Denmark

2.7 Essays in Road Pricing –Modeling, Evaluation and Case Studies, M. Winter, Berlin 2009 (Source n° (16))

Even though this publication deals with urban road pricing, the author cites a study of (Graham/Glaister Review of Income and Price Elasticities of Demand for Road, Traffic; Study commissioned by the UK Department for Transport, London, 2002 http://www.dft.gov.uk.), which gives a broad overview of elasticities in the literature.

Figure 2.8 Price elasticities of Demand for road freight services (source Graham/Glaister 2002, cited in source n° (16))



According to this source, 76% of all direct price elasticities range between -1.27 and – 0.41.

11. Annex 3: Technical committee

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12. Annex 4: Abbreviations

AT	*Austria*
BE	*Belgium*
bill.	*billion*
BMVBS	*Bundesministerium für Verkehr, Bau und Stadtentwicklung (Federal Ministry for Transport, Construction and Urban Development)*
CER	*Community of European Railway and Infrastructure Companies*
CH	*Switzerland*
CO	*Carbon monoxide*
CO_2	*Carbon dioxide*
CT	*Combined road-rail transport*
CZ	*Czech Republic*
DE	*Germany*
DfT	*Department for Transport*
EC	*European Commission*
EFA	*Emission factor*
ES	*Spain*
EU	*European Union*
FR	*France*
g	*gram*
HC	*Hydrocarbon*
HGV	*Heavy goods vehicle (40t, 16.75m)*
HU	*Hungary*
ISI	*(Fraunhofer) Institute for Systems and Innovation Research*
IT	*Italy*
K+P	*K+P Transport Consultants*
kg	*kilogram*
km	*kilometre*
kWh	*Kilowatt hour*
LHV	*Longer (>16.75m) and possibly heavier (>40t) road freight vehicle*
mill.	*million*
NO_x	*Nitrogen oxide*
NST/R	*Nomenclature uniforme de marchandise pour les Statistiques de Transport, Révisée (European commodity classification)*
PM	*Particulate matter*
SE	*Sweden*
t	*ton*
tkm	*ton kilometre*
UIRR	*International Union for Combined Rail-Road Transport*
vkm	*vehicle kilometre*
WL	*Single wagonload*