



Longer and Heavier Vehicles for freight transport

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1 Overview

The European Commission is considering the implications of allowing the use of Longer and Heavier Vehicles^a for road freight transport (abbreviated as LHV in this study), measuring up to 25.25 m and weighing up to 60 tons, for the whole of the European Union transport system. Such trucks are already in circulation in Finland and Sweden, while several Member States are considering their introduction.

The Directorate General Energy and Transport (DG TREN) commissioned a study to analyse the technical characteristics of LHVs and estimate the potential impacts [TML, 2008]. The findings were very positive as regards the impact of LHVs, both at the level of individual vehicles and as regards their level of adoption at EU level. Since the subject is both important in economic terms and complicated in technical terms, the Community of European Railway and Infrastructure Companies (CER), a major affected stakeholder, commissioned an additional study to focus on the impact that LHVs would have on railways [ISI, 2008]. Even though the ISI study forecasts concerning the uptake of LHVs were quite moderate, the resulting impact on railways raised some concerns as regards the environmental impacts and the continuity of EU transport policy favouring railways. In addition, studies at various levels of detail have been carried out at member state level. An example of such an extensive study is the one carried out for the Department for Transport of the UK [TRL, 2008]. Since the analysis was mainly focused on the impacts at UK level, the expected improvements in overall efficiency and the degree of uptake of LHVs were considered as limited to the UK transport system and not transferable to the rest of the EU.

The analysis of the impacts of LHVs is quite complicated since it entails the adoption of assumptions concerning the technical characteristics of future LHVs, the evaluation of costs at truck level, the estimation of the repercussions on costs for the transported goods, the prediction of the market share of LHVs and the calculation of the external impacts, including environmental damage, accidents and wear and tear. Since the three studies mentioned above used different assumptions and hypotheses, it is not surprising that their results differ significantly and no consensus can be found.

The Joint Research Centre, Institute for Prospective Technological Studies, carried out the present study in order to compare the assumptions of the three studies above and, after consulting additional sources of information, to identify the range of technical and economic factors assumed. Using these as input, an independent analysis was carried out, which encompasses both the scope of all three studies and the range of values used in their assumptions. Since the initial assumptions influence the final results to a large extent, a Monte-Carlo analysis was carried out to allow for different combinations of the various assumptions and to identify a range of potential costs and benefits at a lower level of uncertainty.

The results of this analysis suggest that the potential impacts of the introduction of LHVs at EU level can be positive in both economic and environmental terms. The increased payloads per vehicle are expected to reduce transport costs and lead to significant savings for operators, industry and consumers. Since fewer trucks would be required to transport the same volume

^a Also called Mega-Trucks (MT), European Modular System (EMS), Ecocombi, Eurocombis, gicaliners, etc. This report uses the term LHVs to encompass all freight vehicles exceeding the limits on weight and dimensions established in Directive 96/53/EC.

of trade, the environmental and other external costs of freight transport would also be lower, even though an individual LHV consumes and pollutes more than a conventional truck.

A successful policy for the introduction of LHVs would nevertheless need to ensure that they are used within specific boundary conditions. This would involve a combination of regulatory and economic measures to stimulate the use of LHVs in cases where they deliver real efficiency improvements. Defining suitable technical standards for LHVs would assist in limiting the external impacts of individual vehicles and the infrastructure requirements for the whole road network. Identifying the extent of the road network that they are allowed to use would influence their usability and uptake. Using a charging system that internalizes their external costs would be an additional safeguard against additional externalities and would stimulate the rational use of LHVs.

The analysis was carried out under the assumption that the use of LHVs would be allowed across the EU, without any distinction of the type of road network used. As a result, the trade flows that are expected to be served by LHVs are spread across Europe, although a higher traffic is expected in Germany, Belgium, the Netherlands, the UK and a number of specific corridors. The road network links where higher LHV traffic is expected would benefit from reduced total freight traffic and congestion levels, but may need to invest in infrastructure improvements, depending on the technical characteristics of the LHVs that would be allowed to circulate. It is also expected that the main competition with the other modes will occur along these corridors. Limiting the use of LHVs to specific Member States or corridors would probably reduce their environmental impact and infrastructure requirements, as well as the shift from other modes. But it would also limit their uptake and the potential overall benefit for the economy as a whole. A more detailed analysis would be needed to analyse the impacts of a more limited use of LHVs, but in principle they are expected to be positive regardless of the scale of their application.

Additional research would be also required in order to analyse short-distance road transport operations and estimate the potential overall efficiency gains from the introduction of LHVs serving that part of the market. Although theoretically there is margin for improvement, the diversity of economic, organisational and technical factors that affect freight transport planning at that level makes the estimation of the uptake of LHVs for shorter trips rather uncertain.

As is the case with most policy measures, introducing LHVs would produce winners and losers. The benefits would be spread among the economy and society as a whole, in the form of lower transport costs and environmental impacts. On the other side of the coin however, other transport modes -especially rail- would become less competitive and lose market share. In the road sector itself, increases in efficiency would mean that fewer drivers would be necessary, but the ones remaining would tend to be better trained and paid. At territorial level, there is also the case of possible imbalances between costs and benefits; where improvements in infrastructure are required, the costs for a specific region may exceed the benefits, which may be enjoyed by users in other regions.

Overall though, the potential benefits of LHVs clearly outweigh the associated costs. In addition, it is possible to introduce additional legislative measures to ensure that their introduction, in specific market segments and under certain conditions, maximises the benefits and compensates the stakeholders that would be affected negatively.

2 Comparison of main studies on LHVs

TML consortium [TML, 2008]

This study was commissioned by DG TREN and was released end of 2008. It provides analytical and model-based results on the impact of LHVs on the EU transport market (e.g. road freight demand, rail demand, environmental impact, safety and infrastructure). In broad terms, the TRANSTOOLS model is used for providing transport volume in 2020 (tonne-volume converted in tonne-km through the model RESPONSE) while the REMOVE model is used for assessing the environmental impact in the EU, based on the traffic volume (vehicle-km) obtained from assumed loading factors. A schematic overview of the methodology is given in Figure 1.

A set of four scenarios were developed for the year 2020:

- Scenario 1 or "Business as usual" scenario which assumes no changes to the road transport equipment constraints that were valid in 2000 and takes into account projected transport demand in Europe until 2020.
- Scenario 2 for which LHVs are allowed on all EU motorways (usage of LHVs in regional roads can be restricted).
- Scenario 3 for which LHVs are allowed in some countries only, the rest sticking to the current restrictions (40t, 18.75m).
- Scenario 4 or "intermediate" scenario where the EU allows the usage of up to 20.75m and 44t trucks.

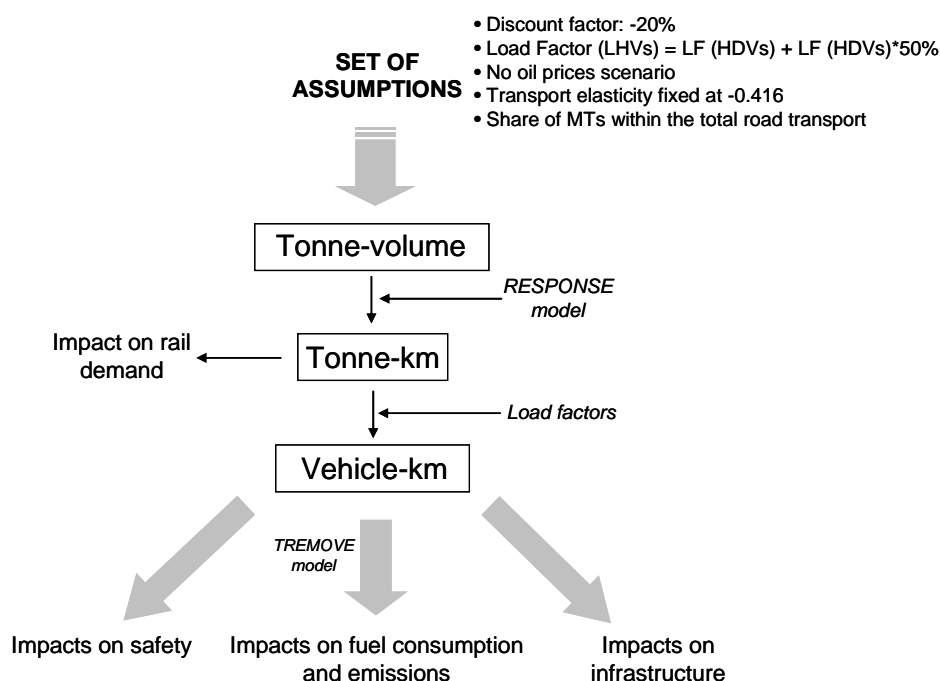


Figure 1: Overview of the approach used by TML

Limitations of the TML study approach

- Only one price elasticity was used (-0.416) and only one run was carried out. A sensitivity analysis would be required.
- Elasticity is suitable for modest price variations and for short term effects.
- Freight demand parameters (e.g. elasticities) are generally expressed in tonne-volume and not in tonne-km. It can be difficult to compare the results with other studies.
- Need to distinguish between the different rail market segments (commodity group and distances).
- Technological potential improvements not covered (e.g. aerodynamics, new safety systems).

Summary of results (scenario 2 vs. reference)

Road freight market	Modal shift	Environment	Safety	Infrastructure
$\varepsilon_{R/R} = -0.416$ (ton-volume)	Rail demand decreases by 3.8% (in ton-volume).	60 t vehicles are up to 12.45% more efficient in terms of fuel consumed per ton-km.	Impact depending on the vehicle-km (rather positive in this aspect).	Impact depending on the vehicle-km (rather positive in this aspect).
Tonne-volume rises by 0.99% (+0.76% in ton-km).		CO2 emissions reduction by 3.58%.		
30% of heavy cargo traffic is carried out by LHVs.		Reduction of NOx emissions by 4.03%.		
Traffic volume (veh-km) of LHVs decreases by 12.9% (depending on the country).		Reduction of PM by 8.39%.		
Road transport cost reduced by 15-20%, on average.				

ISI Fraunhofer [ISI, 2008]

This study was financed by the Community of European Railway and Infrastructure Companies (CER) and conducted by ISI Fraunhofer (Germany) in collaboration with TRT Trasporti e Territorio (Italy) and NESTEAR (France). The objective is to assess the effect of introducing LHVs on long-term perspective, with the emphasis put on modal shifts effects between rail and road freight transport.

After reviewing some key outcomes from the literature and from two representative case studies in the EU, this study used the LOGIS model (from NESTEAR) and developed a System Dynamics model (from TRT and ISI Fraunhofer) leading to the following conclusions for the EU-25 (plus Switzerland):

- The GIS analysis (LOGIS model) concluded that LHVs would account for 25% (in ton-km) of the total road market by 2020. LHVs would represent a 100% share in total HDVs for distances above 1000 km, concentrating on major corridors. On the other hand, LHVs will start playing a role in the road-road competition only for distances above 300 km. Rail container traffic may be reduced by up to 85% in case of EU-wide acceptance of 60 tons LHVs.

- The Vensim model (System Dynamics) was used to assess the long-term impacts of LHVs (time horizon 2025) which take place in three phases:
 - 1- From 3 to 6 years: decrease of CO₂ emissions due to efficiency gain on the road (0.5 million tons per year).
 - 2- From 5 to 20 years: counter-balancing of CO₂ reduction (2 million tons per year).
 - 3- From 15 to 30 years: road sector might re-gain overall CO₂ emission.

The study also concluded that reducing the maximum gross weight from 60 tons to 50 tons is not an efficient alternative.

Summary of results

Road freight	Modal shift	Environment
Between 20% and 30% cost saving potential from LHVs.	Container shipments may face losses of rail demand up to 50%.	The results from the Vensim model concludes that the introduction of LHVs will end up in a negative climate gas balance due in the medium term.
LHVs may take up to 20-30% HDV goods volumes (depending on the country).	Traffic volumes lost by the railways due to 60t LHV: [3-5%] reduction for bulk goods including heavy industry and chemical products [10-15%] reduction for food, food products and semi products [20-30%] reduction for continental container traffic [10-20%] reduction for maritime container traffic	Rebound effects will counter-balance the initial advantage of LHVs.

Limitations of the ISI study approach

- High uncertainties of the model parameters in Vensim. Therefore, results from the scenarios might be very different.
- Market-based analysis, focus on the impact on combined transport.

TRL study [TRL, 2008]

This mainly desk-based research assesses the likely effects of allowing LHVs in the UK with regard to road safety, environment, infrastructures, operating costs, congestion, and other social and policy issues. Different vehicle configurations in length and weight were analysed. Eight scenarios on the usage of LHVs in the UK were developed, based on a micro simulation freight model.

These scenarios present several combinations of maximum vehicle length (16.5m, 18.75m, 25.25m and 34m), weight (from 44t to 82t) and number of axles (6, 8 and 11).

Summary of results

Road freight	Modal shift	Environment	Safety	Infrastructure
One-third of articulated vehicle trips could be suitable for LHVs.	Important risk of shift from rail to road. Maximum of 8-18% of all rail tons-km (especially for the deep sea container market) would migrate to LHVs.	Decrease in veh-km Increase of fuel consumed per veh-km (up to 71% for 82 tons LHV). Decrease of fuel consumed per unit of goods by around 8-28% depending on the scenario. Internal operational costs per ton-km would then be reduced by 18-43%. Risks of adverse environmental effects due to the shift demand from rail to road (depending also on the configuration).	Increase safety risks per vehicle (depending on the configuration of the LHV). However safety risks per unit of goods are reduced. Risks could be mitigated by using new technologies.	Large investments are necessary to upgrade parking facilities and to manage road infrastructures. Increase or decrease of road wears depending on the configuration. Impacts on bridges need further research work.
LHVs expected to be specialist vehicle working in 'niche' operations.	No shift expected from waterborne transport.			
Around 5-10% of the ton-km carried by articulated vehicles could move to LHVs of 60 tons or more (i.e. a migration to around 11.8 bn ton-km per year).				

Limitations of the TRL study approach

- UK-specific study, cannot be extended to the rest of the EU.
- Wide range of effects obtained depending on the LHV configuration (max length, max gross weight).
- Are these technical combinations realistic for the rest of Europe?

Other results from literature

Apart from the three relevant studies briefly discussed above, a wide range of analyses and reports addressing LHVs is also available. Some focus on technical and/or economical issues while others discuss the results of pilot projects. It is out of the scope of the present study to provide a detailed literature survey on the impact of LHVs (see e.g. the literature review carried out by TML [TML, 2008]). The tables below present main outcomes from a (non-exhaustive) list of EU studies. The only comment that can be made from this comparison is that there is no consensus on the impact of LHVs across Europe, something that is also highlighted in a recent paper from Prof. McKinnon [McKinnon, 2008]. Depending on the country characteristics (road network, freight market, etc.), the model assumptions (road elasticities, cross elasticities, etc.) very different positive or negative results can be obtained.

GLOBALLY POSITIVE POSITION

Reference	Road freight demand	Modal shift	Environment	Safety	Infrastructure	Comments
[Aurell, 2007] (SE)			Fuel consumption and air emissions reduced by at least 18%.	Modular combinations show better dynamic stability compared to standard HDVs.	Modular combinations generally cause less pavement wear than standard HDVs.	Technical analysis on the advantages of the modular concept.
[Arcadis, 2006] (NL)	6000-12000 LHV's will replace 8000-16000 regular combinations. Increase of road transport by 0.05%-0.1% and reduction of traffic volume (veh-km). Cost price per mile for LHV's increase by 6.5% but it is compensated by the reduction of the number of rides. Total cost reduction in road transport amount to 1.8-3.4%.	Decrease in rail transport by 1.4%-2.7%.	Lower fuel consumption and CO ₂ emissions. Congestion reduced by 0.7-1.4%.	Traffic safety would increase (since lower veh-km). Decrease in fatal accidents by a factor 4-7 and injuries by 13-25 (no statistics-based approach was available).		Dutch pilot projects.
German Association of the Automotive Industry (VDA) ^b	If 23% of all conventional truck trips in Germany were made with EuroCombis (type of LHV's), 2.2 billion vehicle-km would be saved annually in long haul traffic. The savings would be 16% on operational costs when using EuroCombis instead of 40t trucks.		A fully loaded EuroCombi consumes 15% less fuel per ton-km compared to 40t trucks.	No safety risks from EuroCombis.	EuroCombis cause less pavement damage.	Germany-based analysis.
[VTI, 2008] (SE)	Model used for modal shift: SAMGODS (Swedish freight transport model).	Clear advantages of not going back to smaller trucks.	Model used for emissions: ARTEMIS Model used for noise: HARMONOISE Clear advantages of not going back to smaller trucks.	Clear advantages of not going back to smaller trucks.	Clear advantages of not going back to smaller trucks.	Modelling-based study: four scenarios were analysed.

NEUTRAL POSITION

Reference	Road freight demand	Modal shift	Environment	Safety	Infrastructure	Comments
T&E 2007 ^c	Cost reduction by 20-25% but greater demand.	Cross-elasticity: 1.8 (rail). Rebound effects due to modal shift.	Positive impacts only if loads under 50 tons, optimising loading capacity is key issue.	Best suited to high-volume, low-weight cargoes.	Adaptation required.	

^b <http://www.vda.de>

^c <http://www.transportenvironment.org/Downloads-req-getit-lid-453.html>

GLOBALLY NEGATIVE POSITION

Reference	Road freight demand	Modal shift	Environment	Safety	Infrastructure	Comments
[BAST, 2006] German Highway Research Institute		Important shift is expected.		Higher consequences of fires in tunnels due to larger loading volume. Increase of severity of accidents in the case of head-on collisions. This could however be overcome through the use of modern assistance systems (Lane keeping assistant, brake assistant with interval radar).	No increase in road damages expected from 8 axles (but will occur due to transport demand increase). Increase stress on bridges: it would cost €4-8 billion. Problem at roundabouts, road crossings and intersections, parking spaces due to longer vehicle lengths.	EMS in 60 tons version only. Focus on road infrastructure and safety risks.
K+P Transport Consultants ^d (DE)		7 billion tons-km would shift from rail to road in one year.	CO ₂ emissions reduction of 1.1% to 7.3%.			Focus on the impacts of LHVs on combined transport (in German).
TIM Consult 2006 ^e	Trucking costs reduced by 20-25%.	Decrease of intermodal traffic up to 55% with LHVs on the road (24% road freight increase).				
[UBA, 2007] German Federal Environmental Agency	Cost per load-tonne is reduced by 20-25%.	Significant shift demand from rail to road (e.g. up to 5% decline in rail-freight transport).	Energy efficiency gain only for load rate greater than 77%. Pollutants emissions only decline when fully charged. Increase of noise emission due to heavier motorization and higher number of axles.	Higher consequences in case of accident due to heavier weight.	Parking space capacity reduced by 20% at service stations. Negative impacts on bridges.	

^d <http://www.nomegatrucks.eu/deu/service/download/k-und-p-studie-2-langfassung.pdf>

^e www.timconsult.de

3 Main factors affecting the impact of LHVs

The starting point of the economic assessment is the increase in loading capacity brought by LHVs, typically 40-50% higher than for conventional (40 tons) trucks. As a consequence, the introduction of LHVs can trigger a chain reaction leading to a relatively complex dynamic process that will affect the different freight markets. A conceptual model of the main interactions is provided in Figure 2 below:

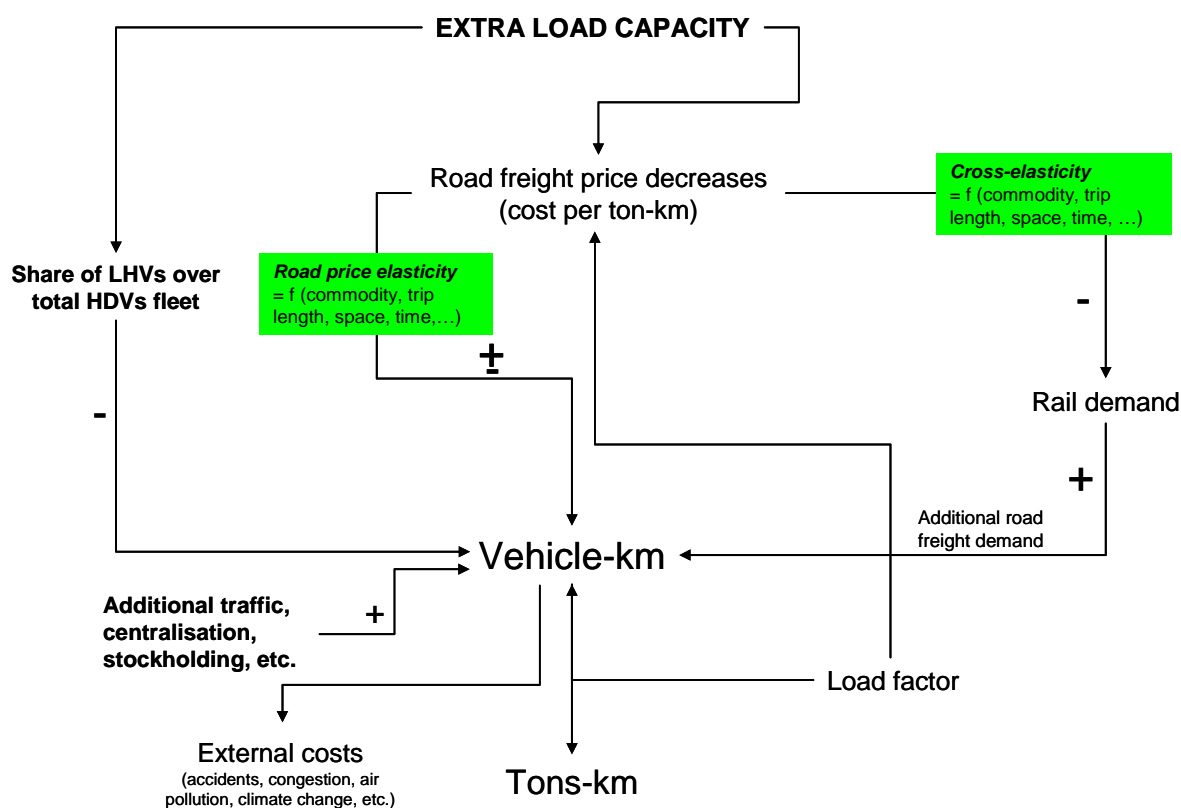


Figure 2: Schematic view of the different interactions

1- The road freight market would benefit from this extra loading capacity through a substantial cost reduction per tonne-km.

2- Depending on the price elasticity assumed, the reduction in price would generate an increase in road demand. This effect may be counterbalanced by the fact that more LHVs on the road would mean much fewer conventional trucks.

3- Losing market to road, the rail freight demand would be probably reduced, depending on the cross-elasticity assumed. A similar shift would happen, to a lesser degree, away from the inland waterway sector.

4- Special attention should be paid to the load factor that will impact both the road price and the traffic volume.

It has to be kept in mind that the impacts can vary considerably depending on the commodity type, the distance travelled, the geographical area, time, whether ton-volume or ton-km are

considered, etc. meaning that the degree of complexity, due to the number of dimensions involved is very high. In the following, some of the critical parameters are analysed.

Decrease in road haulage price

The split of cost to hauliers is available from several sources but it highly depends on the Member State, the distance travelled, the commodity type, etc. Globally, costs for wages and fuel account for more than half of the total cost, following by purchase, insurance and repair costs (Figure 3).

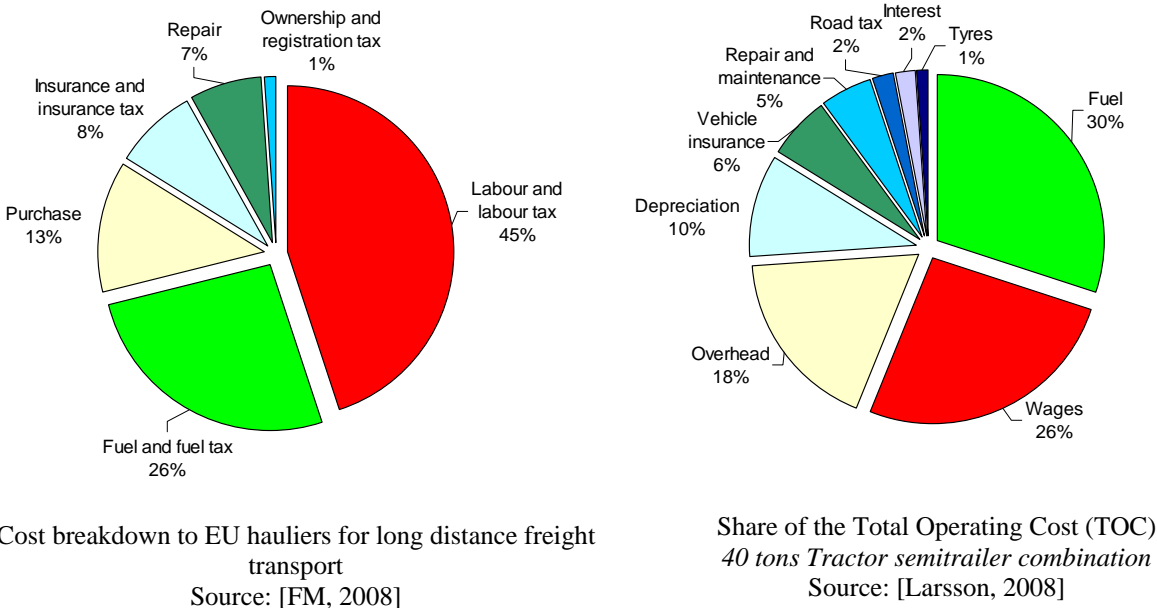


Figure 3: Examples of cost breakdown to EU hauliers

Increasing the truck loading capacity would initially reduce road haulage costs per tonne-km. As an example, McKinnon [McKinnon, 2005] reported that for the UK, the two historic weight limit increases from 38 tons to 40 tons (in 1999) and from 41 tons to 44 tons (in 2001) reduced road haulage costs by respectively 7% and 11%. Due to the much higher loading capacity (60 tons) offered by LHVs, cost reductions would probably range between 20% and 30% compared to conventional 40 tons HDVs.

According to the ISI Fraunhofer study [ISI, 2008], driver costs would decrease by one third while fuel costs would decrease by up to 25% if fully loaded. Oxera [Oxera, 2007] reported that the introduction of LHVs would reduce cost per ton-km by 14.2% to 15.3% depending on the scenario. A decrease cost in cost of around 23% was estimated for a 84-tonne truck.

Demand elasticities

Price demand elasticities i.e. the degree at which demand reacts at changes in prices, are key parameters and need to be carefully addressed. They are used to assess the impact of the price decrease expected from the introduction of LHVs on both road freight and non-road freight demand especially the rail sector which it will mainly compete with, depending on the trip length. Therefore two types of demand elasticities should be considered: the price elasticity of demand for road freight transport and the cross-elasticity for rail demand related to road freight price variation. A detailed description of these two quantities is given by [TML, 2008].

It is essential to bear in mind that these parameters are usually integrated values since they depend on a wide number of variables:

$$\text{Elasticity} = f(\text{trip length, commodity group, space, time...})$$

Road freight demand

There are many elasticity estimates available in literature leading to very different orders of magnitude, depending on the level of complexity assumed. A review of freight demand elasticities was undertaken by Graham and Glaister [Graham, 2004]. It was underlined that:

- A limited number of studies focused on elasticities for different trip length or have distinguished demand between freight transport (tonnage) and freight traffic (ton-km).
- Very different estimates were found across different commodities and for different geographical areas.
- Treatment of time and the distinction between long and short-run effects is rather vague.
- Road freight demand studies are relatively scarce.

Even if Graham and Glaister [Graham, 2004] concluded that "it would be imprudent to offer a firm conclusion about the order of magnitude of the price elasticity of demand for road freight movement", their literature reviewed provided a range of price elasticity estimates which is already a relevant source of information. It was estimated that the price elasticity given in literature range from -7.92 to 1.72, with a mean at -1.07. Two thirds of the estimates ranged from -0.5 to -1.3; 42% fall between -0.4 and -0.8 while only 13% of estimates were greater than -0.4 and 2% were positive. Overall, it was found that the price demand elasticity is likely to fall between -0.5 and -1.5, meaning that the elasticity is negative and rather elastic.

Cross-elasticity for rail demand

As in the case of road freight demand elasticity, literature provides a wide range of cross-elasticity values meaning that it is very difficult to get accurate and reliable data. The elasticity estimates are positive and typically range from 0.3 to 2 depending on the trip length and commodity type.

A brief literature review providing some ranges of road demand elasticities and cross-elasticities is given in Table 1 below:

Reference	Road freight elasticities	Cross elasticities (rail)	Comments
[Quinet, 1994]	[-0.9; -0.7]	1.3	Long distance
[UBA, 2007]		1.9	Assuming a 20% cost reduction
[TRL, 2008]		0.29 [0.4-0.9]	Rail bulk markets Assuming a 20% cost reduction
[Oxera, 2007]	-1.2	0.74	Tonne-km
[Beuthe, 2001]	SD: -1.06 SD: -0.58	SD: 0.11 SD: 0.08	Tonne-km Tonne-volume Assuming a 5% cost reduction
	LD: -1.31 LD: -0.63	LD: 0.67 SD: 0.14	Tonne-km Tonne-volume Assuming a 5% cost reduction
[Bonilla, 2008]	-1.42 (foodstuffs) -1.75 (building materials) -0.43 (oil and coal)		Tonne-km (for Denmark)
Setra ^f	SD: -0.7 LD: -1.0		Tonne-km Tonne-km
[TML, 2008]	-0.416 (TRANSTOOLS model)		Tonne-volume
	[-1.2; -0.3] (analytical approach)		Tonne-km
[Graham, 2004]	Typically [-1.5; -0.5]		Range from literature review. But it highly depends on commodity groups, trip length, etc.

Table 1: Example of elasticity range estimates

Loading capacity

The loading rate of LHVs is doubtless the most important factor. The challenge is to maximise or at least optimise the payload of LHVs in order to get the maximum benefits from them (e.g. in terms of cost per ton-km or energy consumed per ton-km).

With regard to energy efficiency, the UBA study [UBA, 2007] reported that the potential of LHVs to reduce fuel consumption per tonne loaded is highly dependent on the optimised use of loading capacity. As long as the payload is not clearly above 77% of the full capacity (i.e. corresponding to 40 pallets out of a maximum 52), the average fuel consumption per pallet-km would be lower than for a fully loaded standard HDV. This point will be discussed in chapter 4.

Moreover, it is difficult to get data about the share of empty running on the total vehicle-km. This will depend on the distance travelled, the availability of backloads and the type of commodity transported. However, due to the economical disadvantages of running an empty LHV over long distances, one can expect that hauliers would optimise their routes in order to get maximum profit.

^f See e.g. the position paper of the European Rail Infrastructure Managers (EIM) at: http://www.eimrail.org/documents/EIMStatementonLHVspresentation06082008_000.pdf

There is debate about a potential minimum payload required for LHV. A close monitoring of the payload of LHVs seems to be unavoidable (weight-based or volume-based measurements by means for instance of weigh-in-motion systems might be a solution).

External costs

Broadly speaking, external costs can be defined as costs that result from the transport users activity but affect the rest of the society.

External costs associated to heavy duty vehicles are generally attributable to accidents, congestion, infrastructure, noise and emissions (climate change and air pollution). The study carried out by Piecyk and McKinnon [Piecyk, 2007] reported the total external costs of heavy goods vehicles (HGVs) activity in the UK. The cost breakdown is shown in Figure 4. It was found that 40% of the total external costs is due to congestion, 23% to infrastructure, 19% to traffic accidents, 15% to air pollution and greenhouse gas emissions and 2% to noise (note also that climate change costs would represent around 8% of the total external costs of road freight transport in the UK).

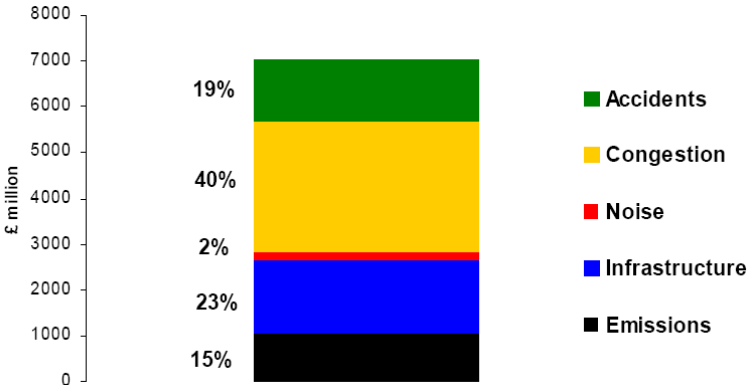


Figure 4: Total external costs of HDV activity in the UK

Source: [Piecyk, 2007]

Also, the INFRAS/IWW study [INFRAS, 2004] provides data about the external costs related to road freight transport, for different years and at European level (EU15 + Switzerland and Norway). In this study, external costs are attributable to accidents, noise, air pollution, climate change, nature and landscape, urban effects, congestion and up/downstream processes.

There is limited literature analysing the impact of LHVs on external costs at European level. As a first order analysis, it is expected that LHVs would have lower external costs per ton-km compared to standard HDVs. This is discussed by Piecyk and McKinnon [Piecyk, 2007]. But the equation is more complex since second order effects need to be taken into account.

In its study on the impact of LHVs on external costs of UK freight transport, Oxera [Oxera, 2007] concluded that although the introduction of LHVs would seem to reduce external costs, this benefit will be counterbalanced by taking into account the switch of demand from rail to road, as discussed previously. They estimated that the additional road freight demand generated by LHVs will cost around £907 million per year, to be supported by the society. The results are presented in Table 2 below.

Change	Cost (£ million)
Switch from HDVs to LHVs	-44
Switch from rail to road	+71
Road freight generation	+907
Net overall impact of LHVs	+934

Table 2: Impact of LHVs on the external costs of UK freight transport

Source: [Oxera, 2007] (see also [UIC, 2008])

However, as underlined by Prof. McKinnon [McKinnon, 2008], Oxera "give no indication of the likely source of this large amount of additional freight traffic. Its econometric analysis is detached from the real world of production and logistics management. There is strong counter evidence too to suggest that it grossly exaggerates any traffic generation effect."

4 Monte-Carlo simulation

Based on the analysis above, a model following the structure described in Figure 2 was built. The model covers most factors mentioned in literature that may affect the uptake and impact of LHVs. Given that the values for these factors differ significantly, the model developed allows for the use of different combinations of assumptions, covering the full range of possible values given by the studies consulted, literature, historical data and model projections.

An additional input to the analysis came from the projections of the TRANSTOOLS model (v. 1.7.4) for year 2020. The demand for freight transport between all combinations of origin and destination at NUTS 2 level (region) across Europe was differentiated according to product group (following the NSTR 1-digit classification system used by TRANSTOOLS) and distance band. Three distance bands were selected in order to test the impact of different levels of uptake of LHVs depending on the distance. Accordingly, different elasticities were used for each combination.

The main parameters, their range of values and the sources used to define their range are given in Table 3 below:

Parameter	Mean	Assumptions/comments
Cost decrease of LHVs	20%	Cost per tonne-kilometre would be reduced by 20-25% over long-haul runs (see e.g. [TML, 2008], [TRL, 2008], [UBA, 2007]). 5-30% is assumed as a consistent range for cost decrease (but it depends of course on the load factor and distances). A normal distribution is assumed with a mean of 20%.
Average payload	14 t (<800 km) 21 t (>800 km)	Refers to average payload of HDVs. Range distribution has been adapted from literature.
Elasticity road (<800 km)	From 0 to 50% of elasticity for distances between 800 and 1500 km	As for the longer distances, but due to the uncertainty concerning the degree of competition with rail at shorter distances lower values are used.
Elasticity road (800-1500 km)	-0.8	In their literature review, Graham and Glaister [Graham, 2004] reported a mean of -1.07 which was obtained from values ranging from -7.92 and 1.72. Most of the estimates fall between -0.5 to -1.5 but this range should be somewhat extended e.g. from -0.3 to -2. Mean value estimated at -0.8. Distribution has been designed accordingly (see e.g. [Graham, 2004]).
Elasticity road very (>1500 km)	-1.1	Same approach as above, except that the elasticities will be moved to higher estimates. One can assume the range [-0.5; -2.2] with a mean value fixed at -1.1. Distribution has been designed accordingly (see e.g. [Graham, 2004]).
Increase of payload per trip	percentage increase of current payload, ranging from 20% to 50%	Payload of LHVs (depending on the configuration) can range from 0 (totally empty) to 38-40 tons (fully loaded). - For standard HDVs (i.e. tractor + semi-trailer and truck semi-trailer), the maximum payload is around 24-26 tons (see e.g. [Aurell, 2007]). - For LHVs, the maximum payload can vary between 37.5 tons and 40 tons (see e.g. [Aurell, 2007]).

Parameter	Mean	Assumptions/comments
		A maximum additional payload of 50% is assumed (Note that in volume terms, LHVs can carry up to 160 m ³ instead of 101 m ³ i.e. more than 50%.)
Increased external cost per veh-km	25%	See e.g. the impact of LHVs on the external costs of UK freight transport [Oxera, 2007].
Share of LHVs in total tons lifted (road)	2-15% (<800km) 10-40% (800-1500 km) 5-75% (>1500 km)	It is e.g. estimated that around 10% of the total long-haul fleet in Sweden are modular vehicles [CEDR, 2007]. Different shares are available from literature, but 5-10% seems to be a minimum for long haul trips. See also the ISI study [ISI, 2008].

Table 3: List of variables and their associated ranges assumed in the present study

The mean value for the average payload of conventional trucks for year 2020 is assumed to be 14t for short distance trips and 21t for long distance trips. The range used in the Monte Carlo simulation was 11t to 17t and 16t to 26t respectively. Since the actual increase in payload does not depend only on the increase in capacity, a range between 20% and 50% was used. In order to take the share of LHVs into account, a normal distribution with a mean of 8%, 25% and 50% was used for the three distance bands, assuming that the level of uptake would increase with distance.

As regards elasticities, an important reason for differences in the results of other studies, the present analysis uses the ones referring to original demand for freight, i.e. the tons lifted at the point of origin. It was considered that using the price elasticity of demand referring to transport performance, i.e. ton-km, can lead to distortions in the analysis by addressing an output indicator instead of the real demand. The range of values used was based on the values and probability distribution available from literature.

Distance band	mean	min	max
< 800 km	-0.21	-0.79	0
800 – 1500 km	-0.83	-1.79	-0.31
> 1500 km	-1.15	-2.44	-0.22

Table 4: Price elasticities per distance band (road transport, demand in tonnes)

The simulation results suggested that the degree of uptake of LHVs in the short distance band (<800 km) affects the overall results significantly, since their large scale introduction would imply an increase in the load factors for that distance band. This hypothesis has been discussed extensively in the literature and it seems rather improbable that such a development is plausible. In order to remove the distortion of that assumption and to make the analysis comparable to the ISI study [ISI, 2008], an additional simulation was made assuming that the penetration of LHVs for short distance trips would be 0% (i.e. a sub-scenario of the general simulation).

5 Simulation results

Given the increase in payload brought by LHVs, the number of vehicle-km needed to move the same volume of transport decreases in all combinations of penetration rates and elasticities. The simulation trials for year 2020 show an average decrease of 2.3% (although it ranges from close to 0% to over 4%) with trips over 1500 km being more affected (average decrease by 16.7%). The short distance trips are expected to have a decrease of 2% on average but, since they constitute the largest part of the trip, bring most benefits in absolute terms.

The significant cost reductions would also attract traffic from other modes, especially rail. The exact volume of modal shift depends on the reaction of the market in the various geographic and product market segments and aggregate approaches based on simple elasticities can obviously give just an indication. The range of results of the simulation does however suggest that LHVs can be very competitive towards railways, especially for long distance bands and for non-bulk products. On average, the simulations show a shift of 73.3 million tons lifted/year from rail to road, corresponding to 18.1 billion ton-km of transport volume per year. For railways that would represent a 2.1% decrease compared to its expected traffic in year 2020, while for road it would represent an increase of 0.6%. For long trip distances the effect on rail can be even more negative though, with losses on average of 56%, reaching 100% in many trials of the simulation (that combine extreme values of elasticities and cost reductions from LHVs).

The overall share of LHVs in the fleet is expected to be 8.2% (mean value). This value depends on the assumptions concerning the uptake in the various distance bands and the expected freight demand for each segment. Load factors would increase from 21 tons to 23.9 tons on average for trips over 1500 km, and from 14 tons to 14.4 tons for trips below 800 km.

The main benefit from the introduction of LHVs would be the decrease in transport costs as a result of higher payloads per truck. The average of the simulation trials indicates potential savings of almost €3 billion/year, but with a high level of uncertainty caused by the underlying assumptions. Excluding trips below 800 km from the analysis gives a smaller -but less uncertain- figure of €500 million/year.

The environmental benefits of using fewer trucks -even though many would be bigger than they are today- are also important. Accounting for higher external costs per km for LHVs, still gives a positive balance. On average it is estimated at about €400 million/year (€130 million/year if short distances are excluded).

There would be negative impacts as regards external costs though, as a result of the shift of traffic from other modes to road. Since trips with LHVs would replace trips with (cleaner and safer) rail, the external costs of the traffic shifted would rise. On average this would amount to €13 million/year, a significant amount but still lower than the decrease in external cost brought by the reduction of trips.

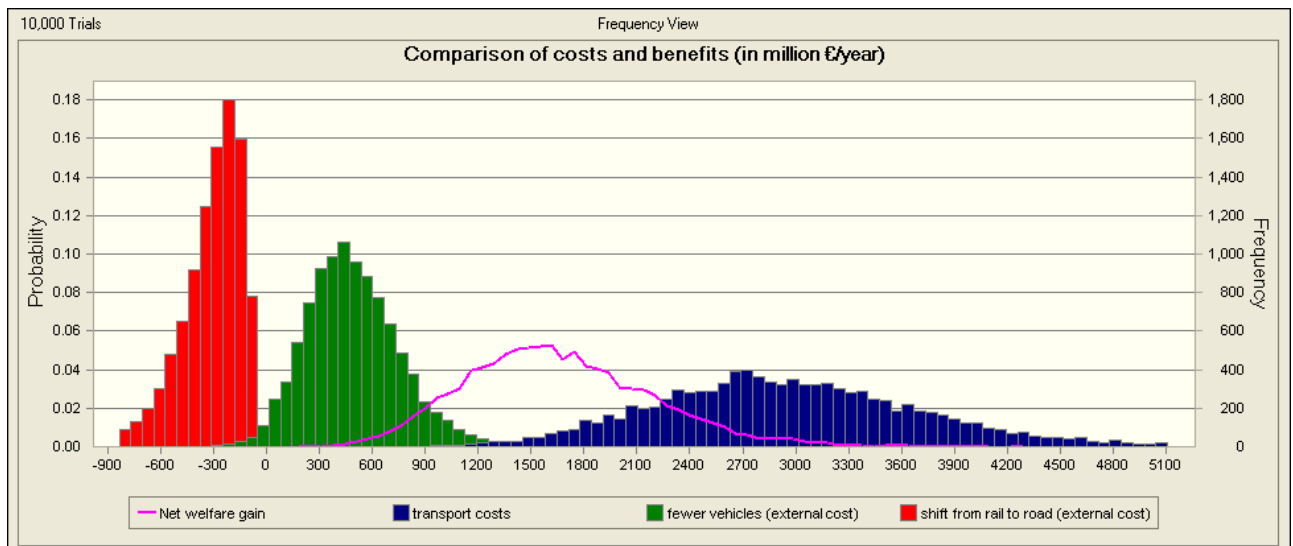


Figure 5: Comparison of costs and benefits

The net welfare impact of a large scale introduction in the EU would be positive in all possible combinations of values for the input variables. If the use of LHVs for all distance bands is assumed, the total net welfare would be €1.5 billion per year. However, the range of possible values would be very wide, from 0 in the case of minimal introduction to over €5 billion when the maximum level of LHVs for all distance bands is assumed.

The sensitivity analysis allows the identification of the variables that contribute most to the variance of the estimated total net welfare gain:

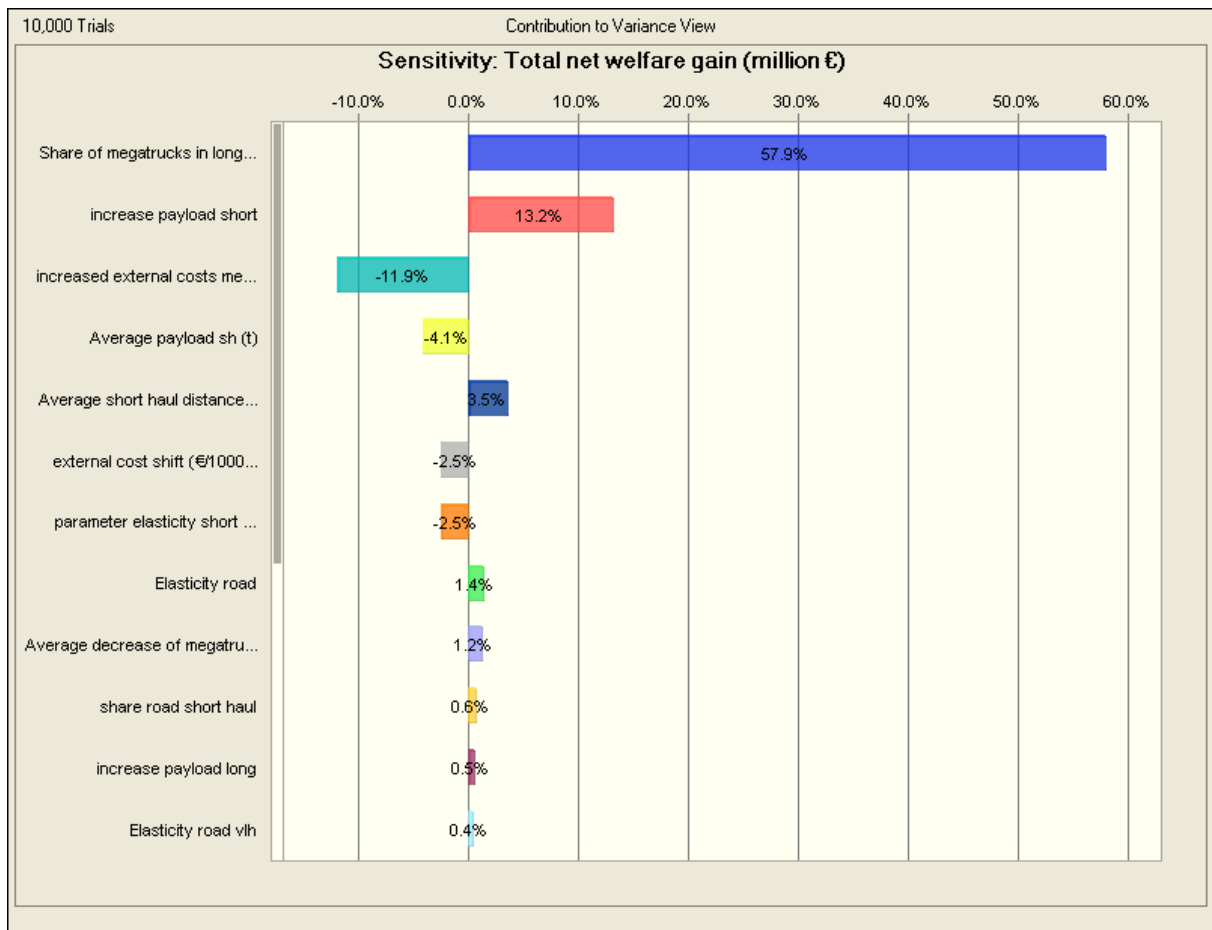


Figure 6: Sensitivity analysis of the total net welfare gain

Three main messages can be found in the results of the sensitivity analysis:

- The net welfare gain has a high correlation with the level of uptake of LHVs. Since higher numbers of LHVs would imply higher savings in transport costs, maximizing the share of LHVs would be positive for the economy as a whole. The maximum level however can not be set by policy makers, since it is up to the market itself to find the optimum level. Most studies analysing the issue doubt the possibility of LHVs reaching high shares of the market since a small part only of shipments are of sufficient size to exploit the advantages of LHVs.
- The average increase in payload (in absolute terms, i.e. tonnes) is also an important factor, especially in the case of shorter trips (<800 km). The reason for this is that the current average payload for such trips is very low and increasing it would lead to important transport cost savings. The same point though leads to a more pessimistic estimate of the potential uptake of LHVs for short distances: given that the actual fleet is used rather inefficiently for this distance band, shippers and operators will not have the incentive to use LHVs. This effect has been highlighted in some of the studies reviewed and the results of the present analysis also support it. It is therefore proposed to assume that the share of LHVs for shorter trips is assumed as minimal.
- The third important variable is the assumed increase of external costs of LHVs compared to conventional trucks on a per km basis. This affects the increase or

decrease of environmental damage, accidents and infrastructure use costs from the change of the fleet mix but also the overall increase in external costs from the shift of transport activity away from rail and inland waterways.

The above considerations imply that a more moderate scenario for the introduction of LHVs is most probable. Assuming that the share of LHVs will be higher at higher distance bands the range of the expected impacts would be the following:

Variable	Unit	Mean value	Min	Max
Share of LHVs in road freight		3.2%	0.5%	5%
Decrease in road transport activity	veh*kms	2.3 billion 1.1%	0.4%	3.2 billion 1.6%
Increase in road transport volume	Tonnes lifted	33 million 0.15%	10 million 0.05%	50 million 0.30%
Decrease in rail transport activity	Ton*kms	13 billion 1.5%	10 billion 1.2%	15 billion 1.8%
Decrease in external costs from more efficient shipments	€	230 million	180 million	260 million
Increase in external costs from modal split	€	230 million	130 million	300 million
Decrease of transport costs	€	1.4 billion	500 million	2 billion
Net welfare gain	€	700 million	200 million	1 billion

Table 5: Summary of results, LHV uptake depending on trip distance, year 2020

The mean values of the above table as regards cost reductions and the new average shipment sizes that would result from the introduction of LHVs were used as input for the TRANSTOOLS model (applying a road transport assignment for the revised O-D matrices that correspond to the distance bands and product groups affected). This allowed the identification of the main corridors where increased traffic of LHVs is expected. The following messages can be derived from the resulting map:

- Given the level of economic integration expected by year 2020, the trade flows that can be served by LHVs are spread across Europe. There is a higher concentration in Germany, Belgium, the Netherlands and the UK, but several important corridors are also visible in other Member States.
- The areas where these corridors belong to will benefit from the decreased traffic and congestion levels resulting from the replacement of conventional trucks with LHVs. They would also bear though the costs of improving the design characteristics of infrastructure where necessary in order to accommodate the special requirements of LHVs. However, the benefits of decreased transport costs will be enjoyed by users and consumers and the origin and destination of the shipments.
- The corridors where rail will lose traffic coincide to a large extent with the main LHV corridors.

- It is assumed that LHVs will be allowed for all trade inside the EU and with neighbouring partners. Opt-outs by some member states or prohibition by some trading partners would probably change the picture significantly. In a similar fashion, different charging schemes for LHVs could lead to additional distortions.
- The impact on combined transport and especially Ro-Ro is unclear. It depends on several factors, including organisational issues of road and other mode operators, as well as on pricing policies.

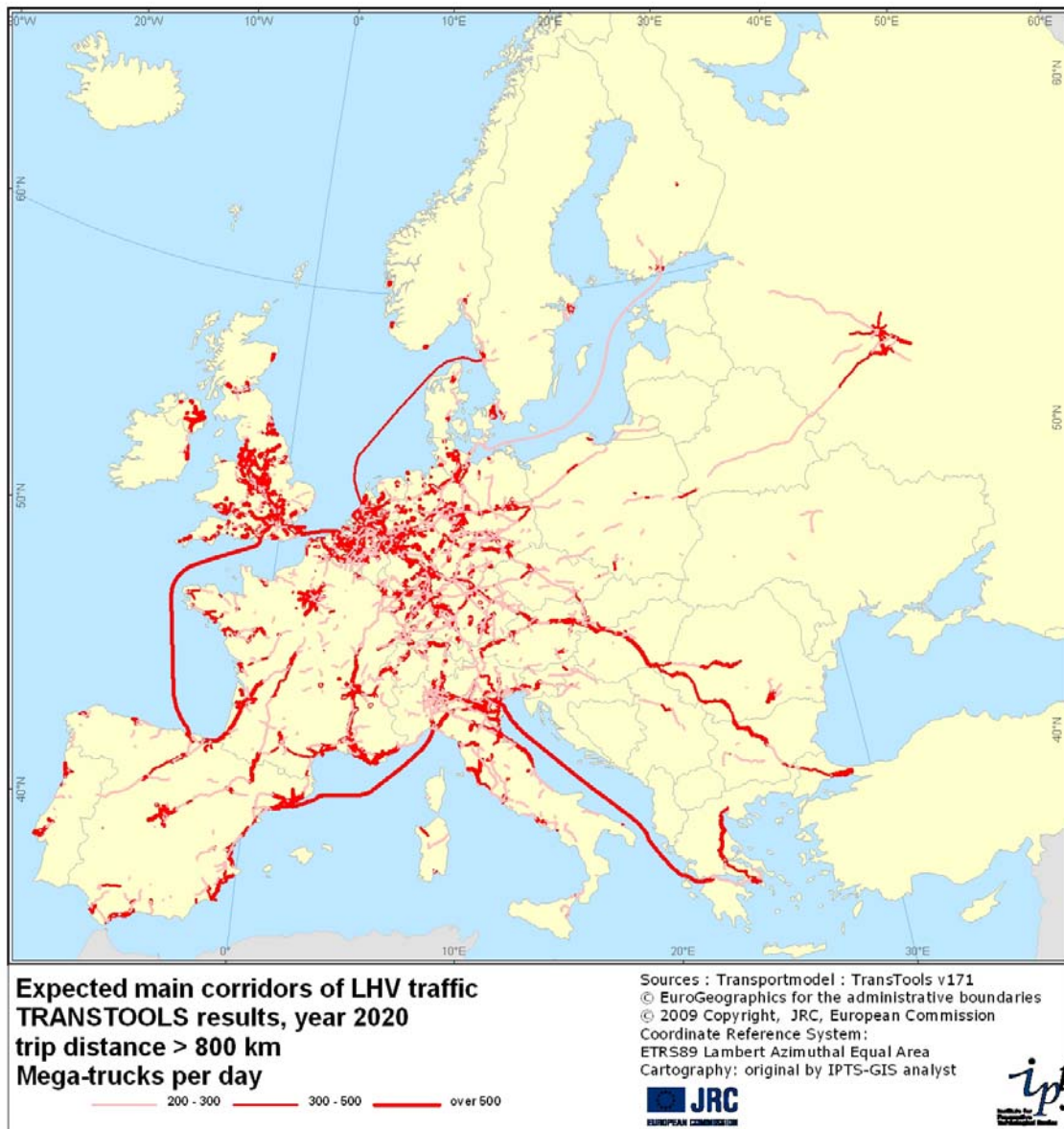


Figure 7: Expected main corridors of LHV traffic, TRANSTOOLS results for year 2020

6 Limiting the external impact

From the economic point of view, there seems to be a consensus concerning the benefits that LHV's can bring for operators and the economy as a whole. Even though there is no conclusive evidence concerning the external impacts of LHV's on a vehicle basis, the results of the present analysis imply that at aggregate level the net impact would be positive: the total external cost of freight transport would decrease. However, some of the studies reviewed identify potential problems raised by the introduction of LHV's that in most cases concern their external impacts.

The question of the impact on CO₂ emissions from transport was highlighted in the ISI report [ISI, 2008]. Even though a reduction of emissions is expected as a result of the improvement of the efficiency in road transport in the short-term, the study warns that in the medium term the effect on modal shift may lead to a rebound and even an increase in total CO₂ emissions. Our analysis elaborated on the factors that influence the net balance. There is naturally consensus on the fact that LHV's would still emit more than rail per ton of goods transported and that modal shift from rail to road would lead to an increase of emissions. However, our simulations for the long term (2020) suggest that the main benefits of LHV's –and their main market- would come from the replacement of conventional trucks and the reduction of emissions as a result of fewer conventional trucks on the road clearly outweighs the increase as a result of modal split. Additionally, two measures could ensure that the impact from modal shift is limited:

- Introducing a minimum load for LHV's: improving the degree of utilization of loading capacity tends to limit the increase in emissions from modal shift. The Monte-Carlo simulations suggest that setting a minimum of 70% of loading capacity would limit the increase in CO₂ emissions and other externalities significantly⁷.
- Internalizing the real external cost of LHV's through a suitable vignette/charge: the "right price" for LHV's would help optimize their use. The shift from rail to road would be moderated as a result, while operators would have an additional stimulus to opt for more efficient solutions in the use of LHV's.

The second main area for concern raised in some studies seems to be the need to adapt infrastructure for the use of LHV's, mainly as regards road surface, bridges, geometric design and parking areas. The current definition of LHV's is broad enough to allow for a wide range of possible vehicle setups, each having different weight and length combinations. Estimates on the total cost of infrastructure for specific road segments or the system as a whole are as a result difficult to make. There are however certain factors that can be controlled and/or standardized in order to minimize the external cost of infrastructure use, most notably the maximum allowable weight per axle. Although the findings from theory and laboratory experiments do not yet allow for a clear answer, it seems that several designs of LHV's can actually decrease surface wear. Where technical solutions are not enough to limit the externalities and their cost, it is important to design suitable schemes that would allow the providers of infrastructure to recover the investments needed or the costs incurred as a result of LHV's.

⁷ Such a measure is technically feasible, but would entail control measures that would increase the costs of LHV's and should be also taken into account. Additionally, if such a measure is applied for LHV's, the applicability and impact of a similar measure for conventional trucks as a means of increasing efficiency would also need to be addressed.

7 Designing specific policy measures

The impact of LHVs depends to a large extent on the conditions under which they will be introduced. Although the economic impact is in principle expected to be positive and environmental consequences would be limited in most cases, a complete impact assessment can be performed only when specific policy measures for their introduction are available.

This analysis can serve as a preliminary comparison of the range of costs and benefits of LHVs. The results suggest that the efficiency gains brought by LHVs are significant and that, overall, the impacts on welfare are positive. It also identified the areas of uncertainty, as well as technical and economic aspects that influence the final impact. These aspects can form the basis for the design of more detailed policy measures that aim at improving the expected result and the acceptability of LHVs. The main elements of such policy measures that have been revealed from the present analysis are:

- Geographical coverage: expected costs and benefits may vary significantly depending on the economic structure, transport industry conditions or geographic position of each EU member state. It can be expected that some member states may wish to opt out from the introduction of LHVs. The overall benefits for the EU would be different in that case and the efficiency of the measure would probably be lower.
- LHV typology: the introduction of specific types of LHVs can be considered to serve specific market requirements. For example, the cases of two-vehicle combinations weighing up to 44 tonnes on 5 axles, or 48 tonnes on 6 axles, or vehicles that can accommodate 45ft containers can be specifically analysed.
- Efficiency/utilization standards: technological solutions such as aerodynamic improvements or utilisation requirements such as minimum load limit can be enforced in order to limit fuel consumption and emissions.
- Internalisation measures: the level of internalisation of the external cost of LHVs and the schemes to allow infrastructure providers to recover their costs would influence the uptake of LHVs by the market and equity in the distribution of costs and benefits.
- Infrastructure requirements: the typology of LHVs that would be allowed to be used would influence the requirements for infrastructure, ranging from the geometric design of roads to parking and refuelling areas. In case a design that cannot be served by the current networks EU-wide is selected, the usable road network would be limited and- as a result- both the uptake and the benefits of LHVs would be reduced.
- Efficiency in logistics and distribution: Apart from the improvement of transport operations, the introduction of LHVs can also influence the efficiency of operations in either end of the road trip as a result of the changes in shipment size and frequency. The direction and the order of magnitude of the impact is, however, rather unclear.

The results of the simulations suggest that the success of the introduction of LHVs depends to a large extent on the degree of substitution of conventional trucks with LHVs. As long as the price signals are correct, LHVs should increase the overall efficiency of the transport system and the net impact would be positive.

8 Conclusions

The analysis presented here explored the range of potential impacts using the rationale and the assumptions of several studies that have analysed the issue extensively. The objective was neither to forecast the precise share of LHVs in the future, nor to provide an exact evaluation of their impact. Instead, the analysis aimed to address the uncertainty in the technical and economic aspects of LHVs and derive some policy relevant messages through the identification of the main factors that influence the potential impacts.

The main conclusion of the analysis is that the introduction of LHVs would be beneficial for the EU economy and -under certain conditions- environment and society as a whole. LHVs can increase the efficiency of the EU transport system and reduce friction. From an EU policy point of view, facilitating the introduction of LHVs is in line with the objectives of the Common Transport Policy and would help improve the internal market. Naturally, improving road transport would worsen the competitive position of other modes, but a balance can be found through investments and improvements in the other modes as well. Limiting the use of LHVs to specific member states or corridors would pose practical obstacles and greatly reduce the uptake and positive impacts of LHVs.

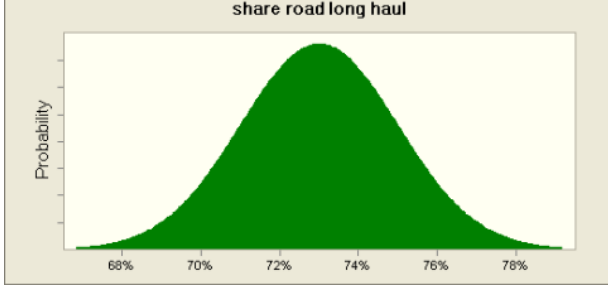
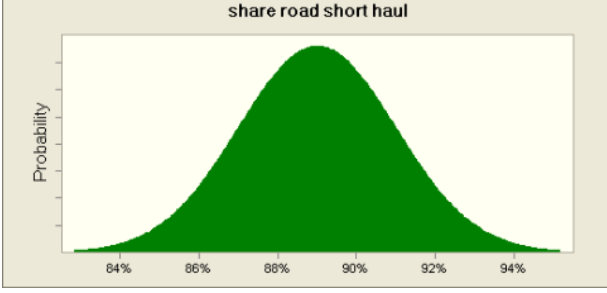
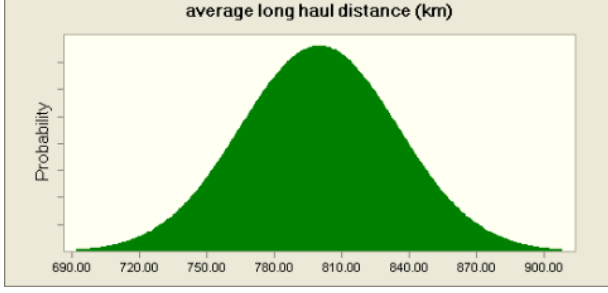
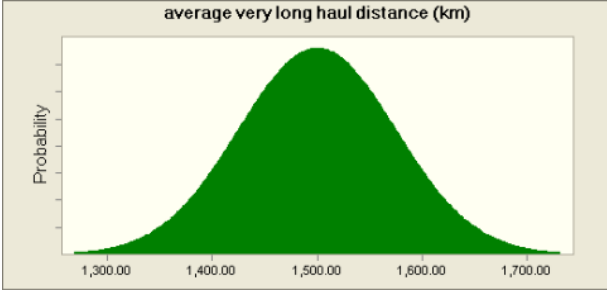
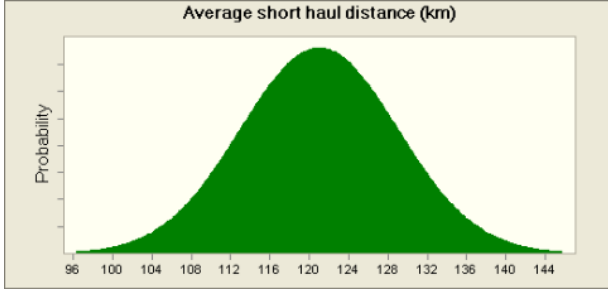
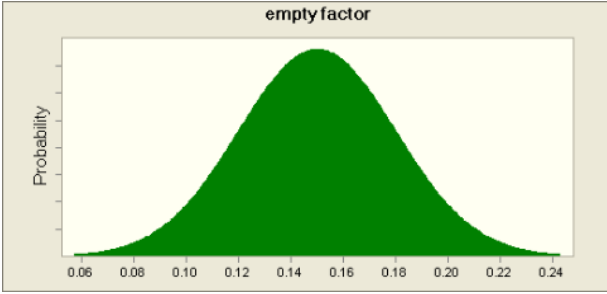
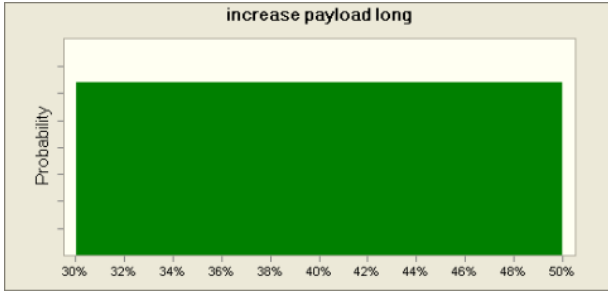
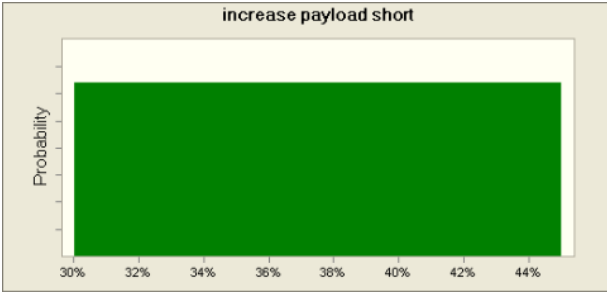
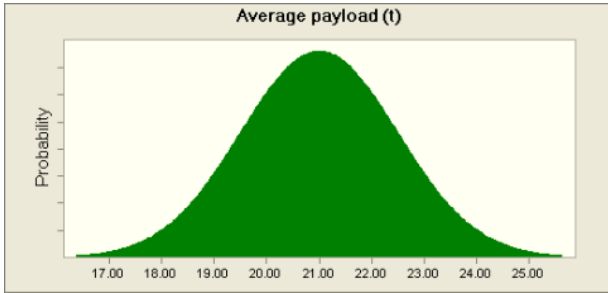
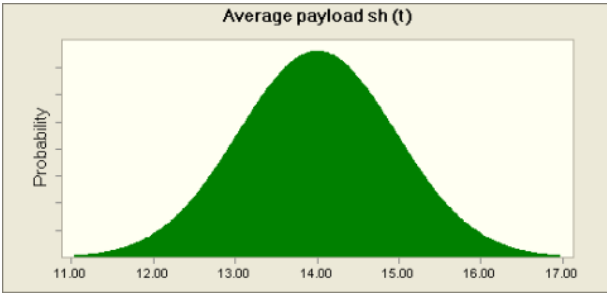
LHVs would bring important efficiency improvements but their extent is limited by the inefficiency of the structure and profile of the freight market. Since the actual loading capacity of conventional trucks is under-utilised, LHVs would currently have an impact on specific market segments of high value goods, large shipment sizes and long trip distances. Combining their introduction with measures to improve overall transport and logistics efficiency would lead to additional positive results.

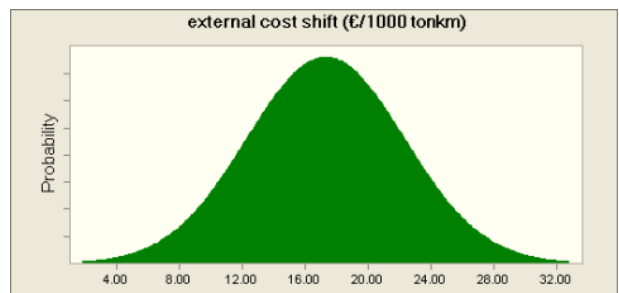
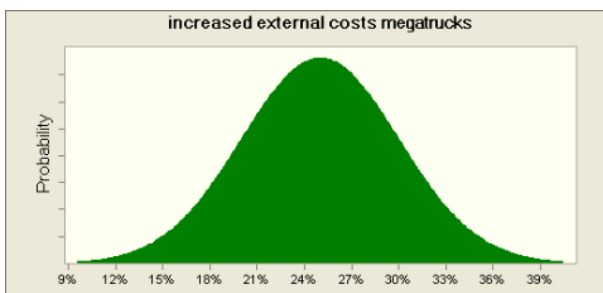
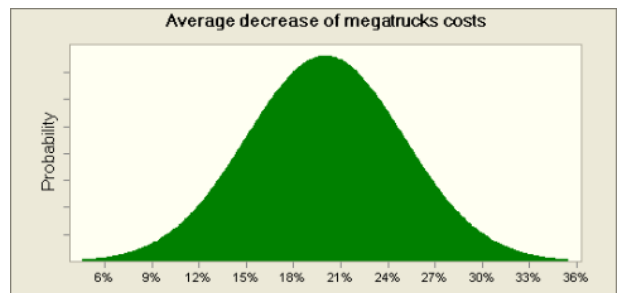
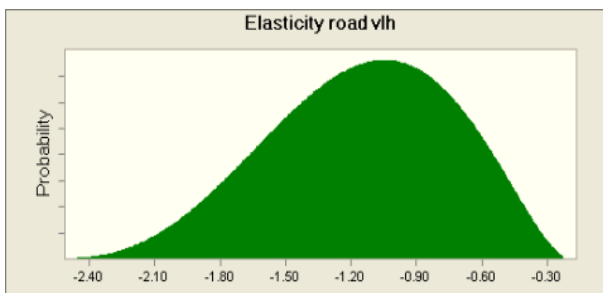
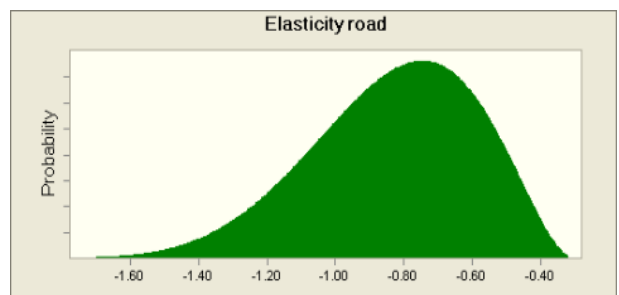
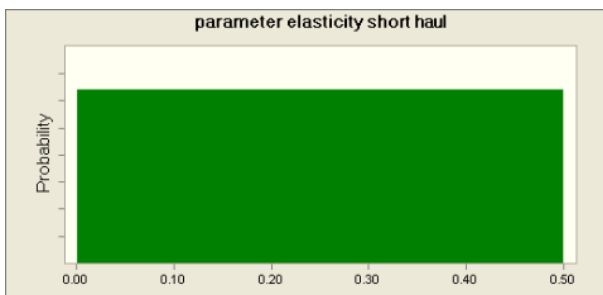
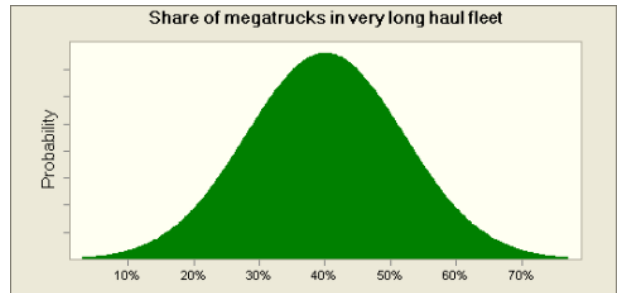
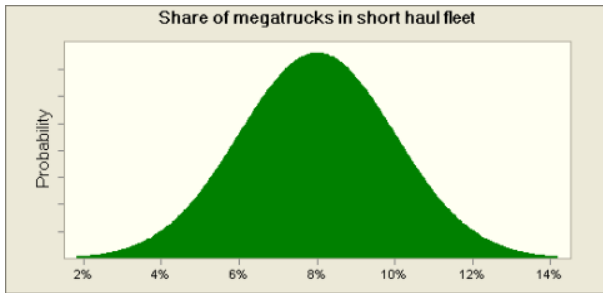
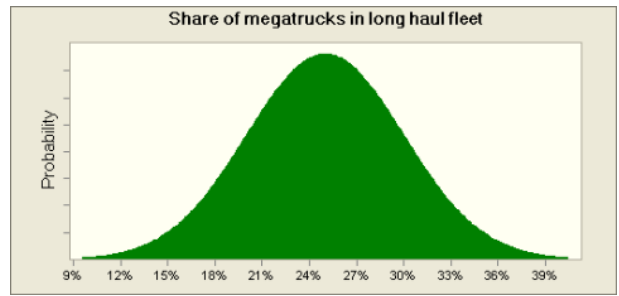
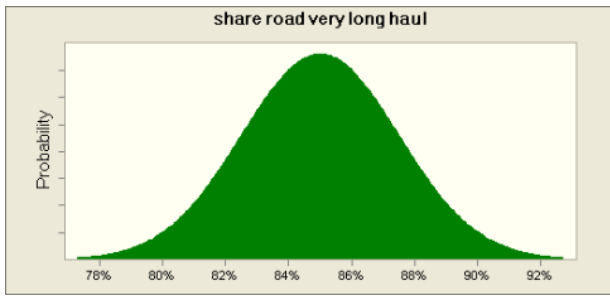
Improving the efficiency of the road sector would obviously worsen the competitive position of other modes, especially rail transport. Since LHVs –as road transport in general- does not compare favourably with rail, a shift from rail to road would result in an increase of the external cost of the part of the transport activity that would be shifted. As long as LHVs replace a sufficient number of conventional trucks though, the overall impact in both economic and environmental terms would still be positive.

The positive impact of LHVs can be increased through measures that maximise efficiency gains and minimise the external costs:

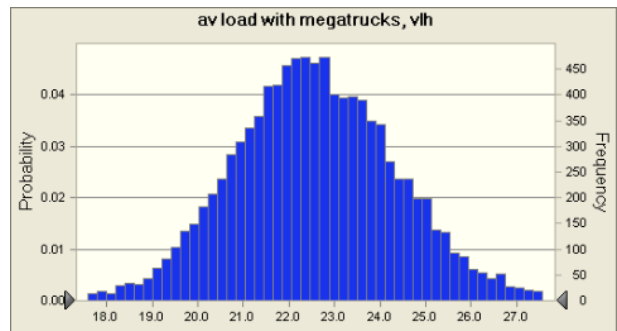
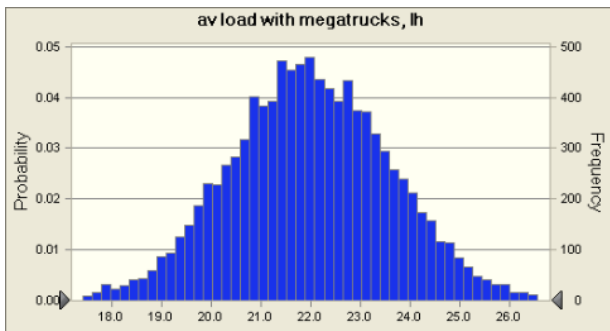
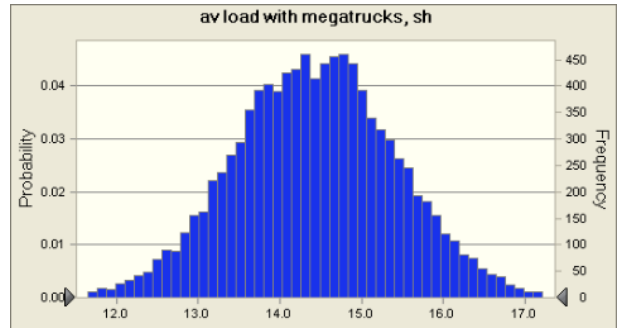
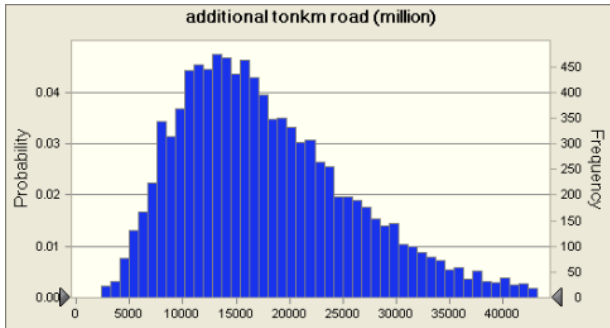
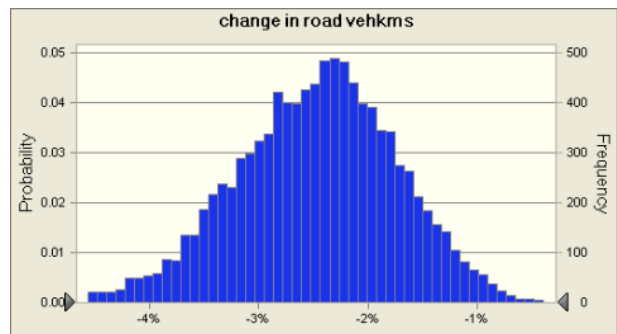
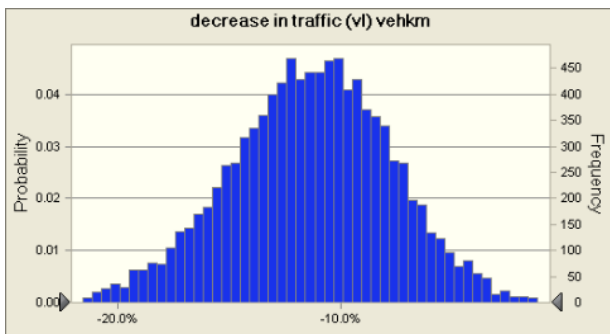
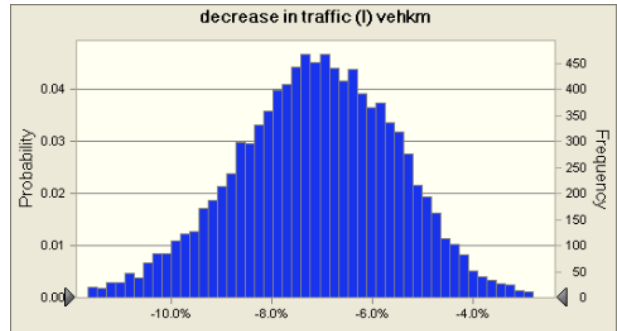
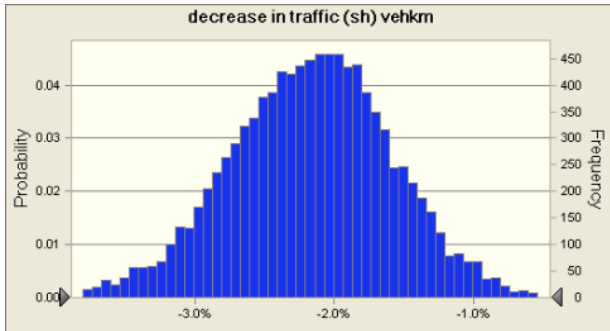
- Improvements in vehicle design to reduce fuel consumption, environmental damage and accident risks.
- Enforcement of minimum load limits and/or maximum percentage of empty trips.
- Standardisation of vehicle sizes and loading units.
- Suitable charging systems to internalise external costs and minimize the impact on other modes.
- Common infrastructure design specifications for Trans-European Transport Networks.

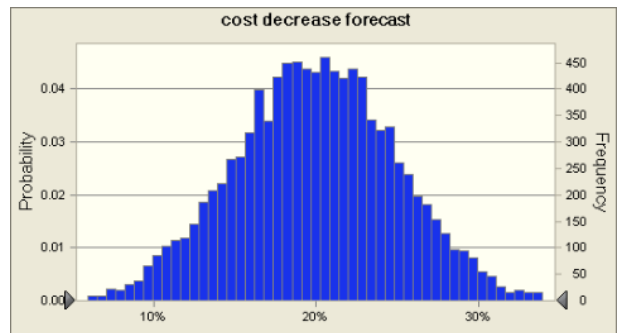
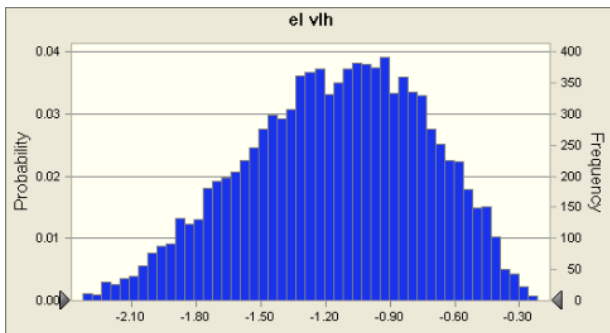
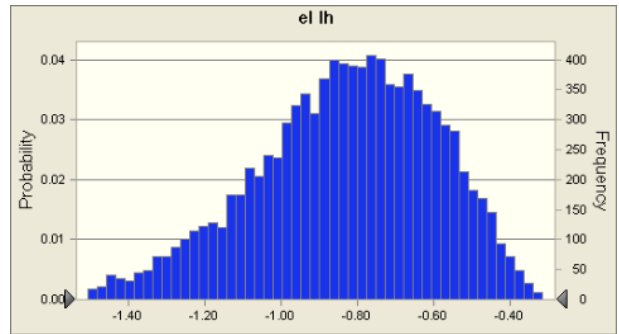
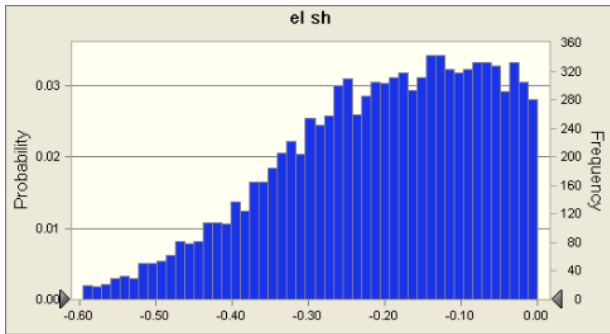
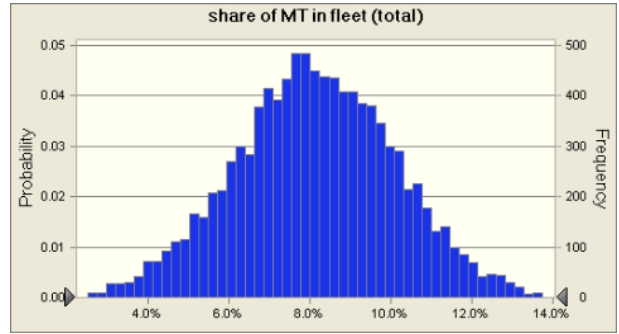
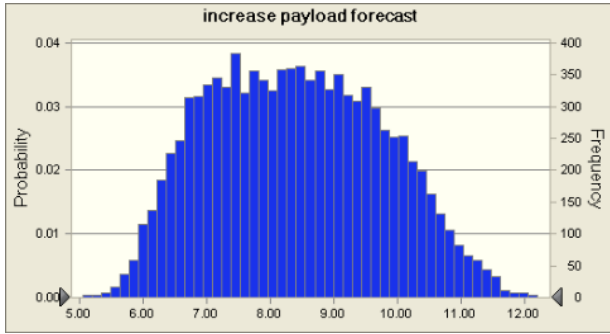
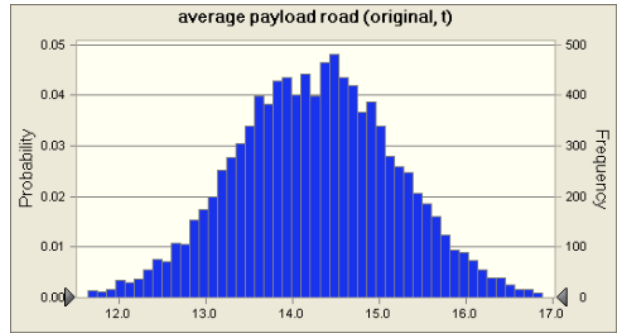
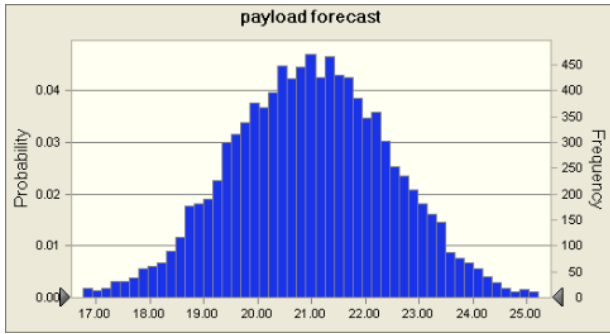
ANNEX I - Probability distributions of input variables

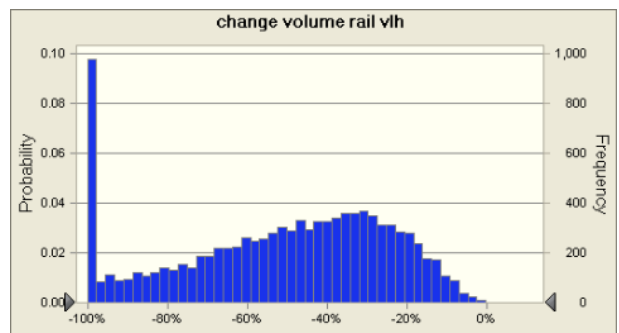
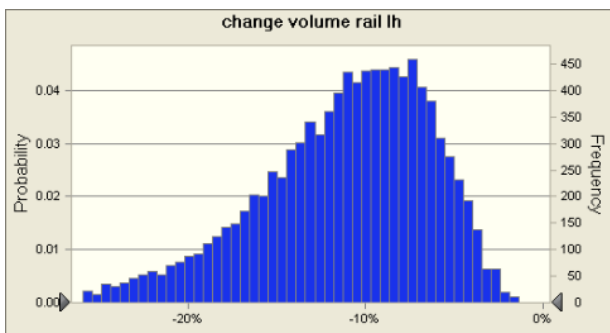
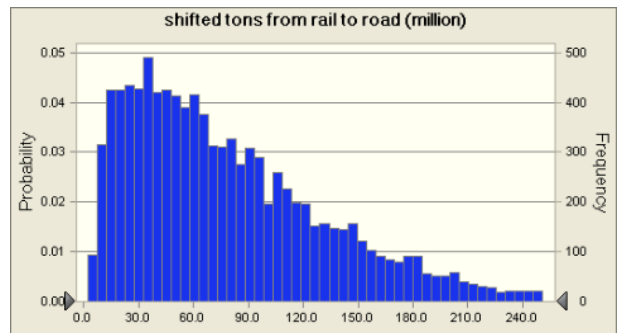
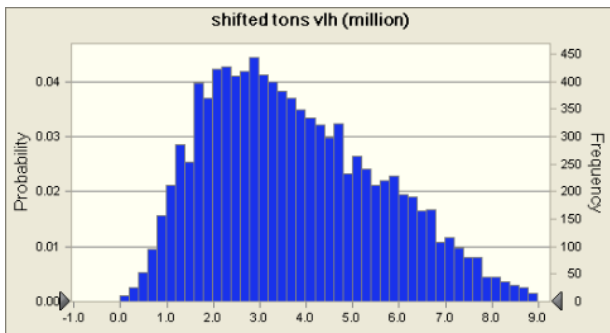
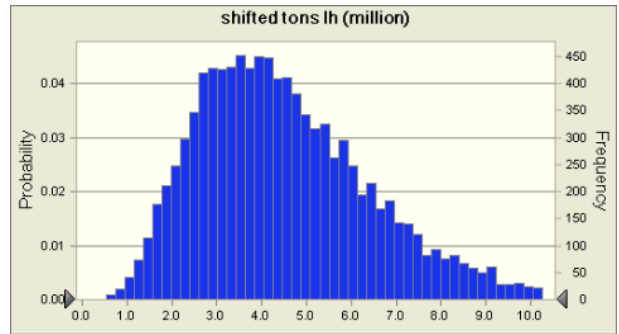
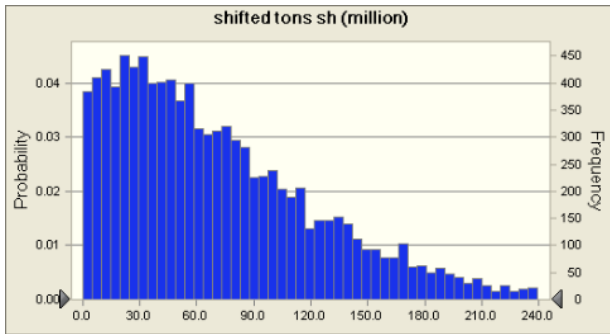
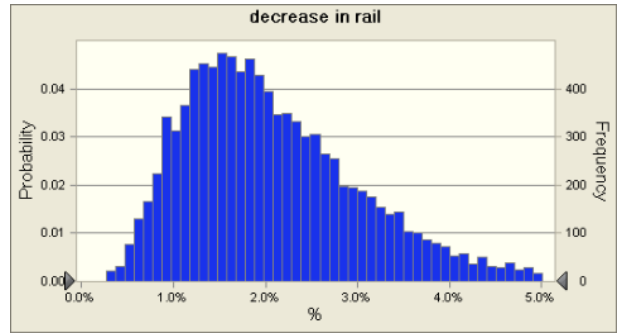
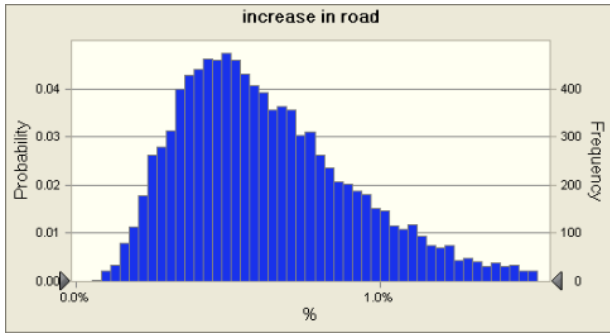


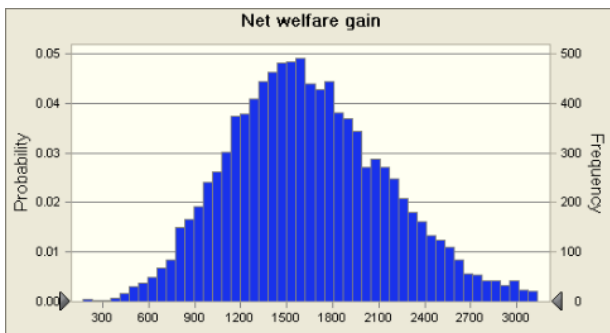
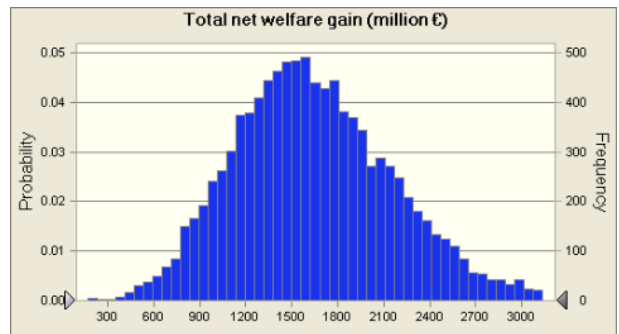
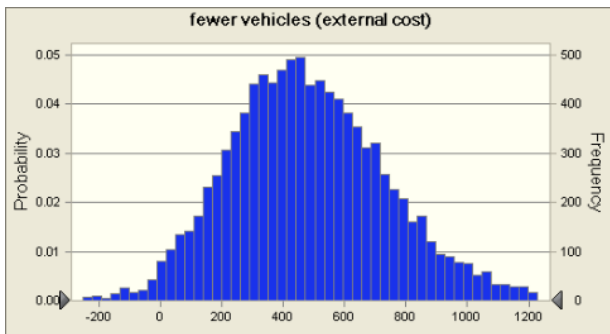
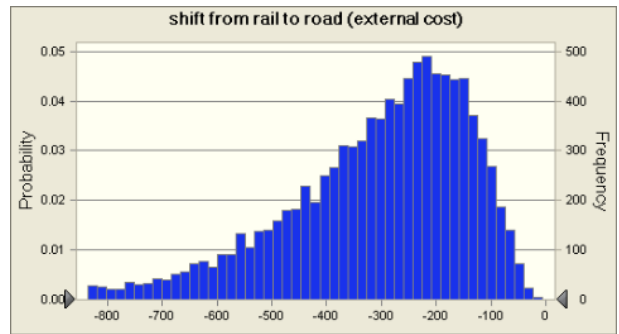
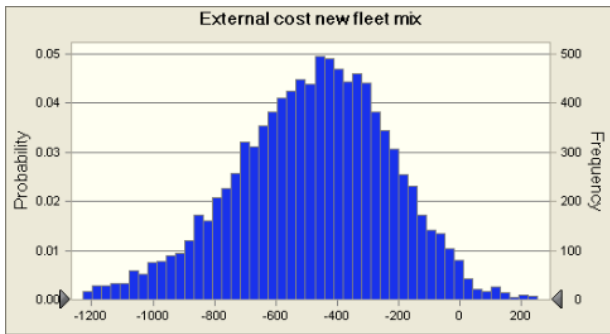
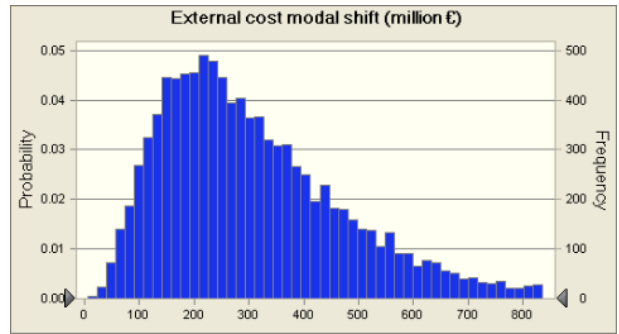
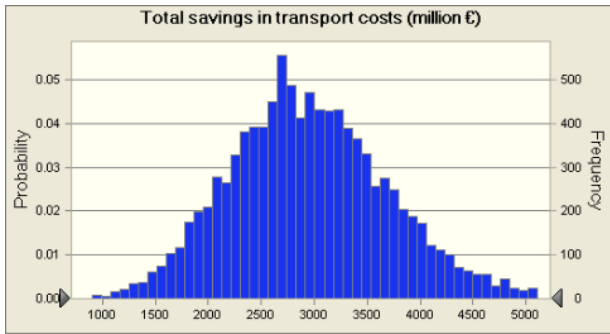
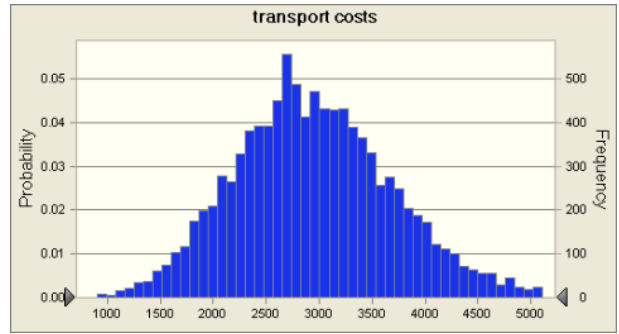
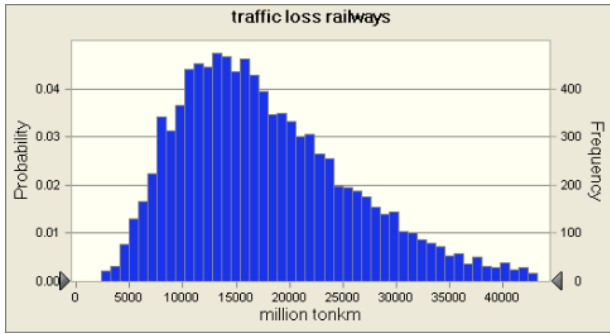


ANNEX II – Probability distributions of forecast variables (results)

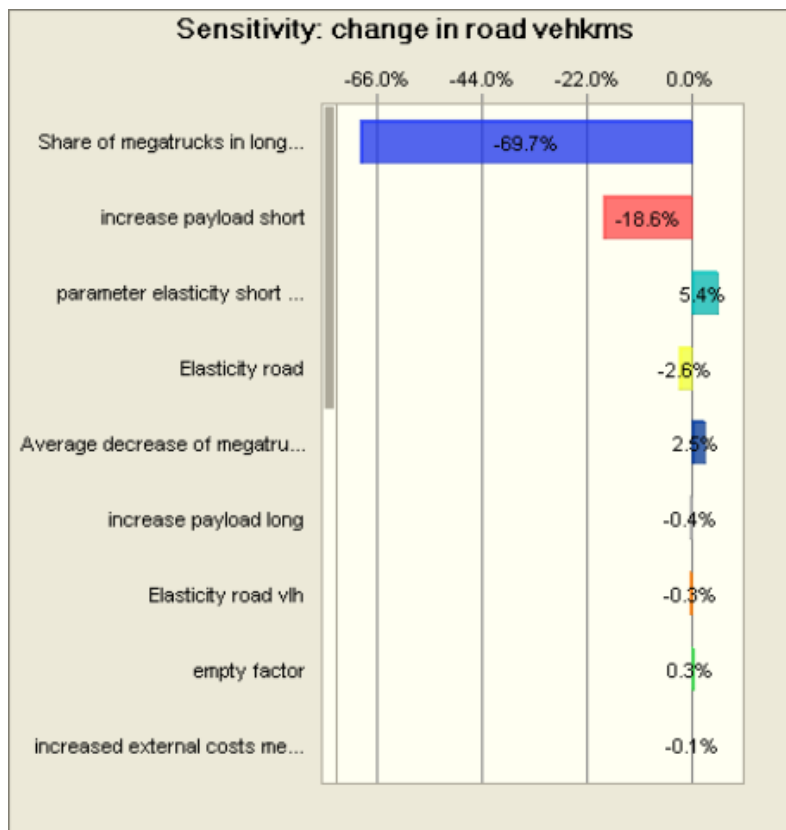
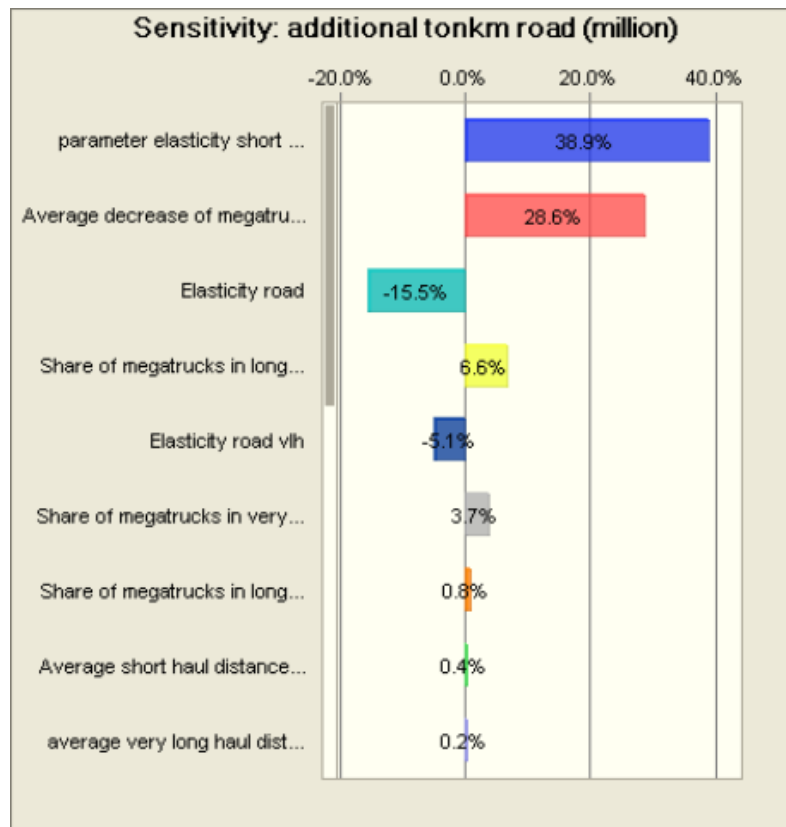


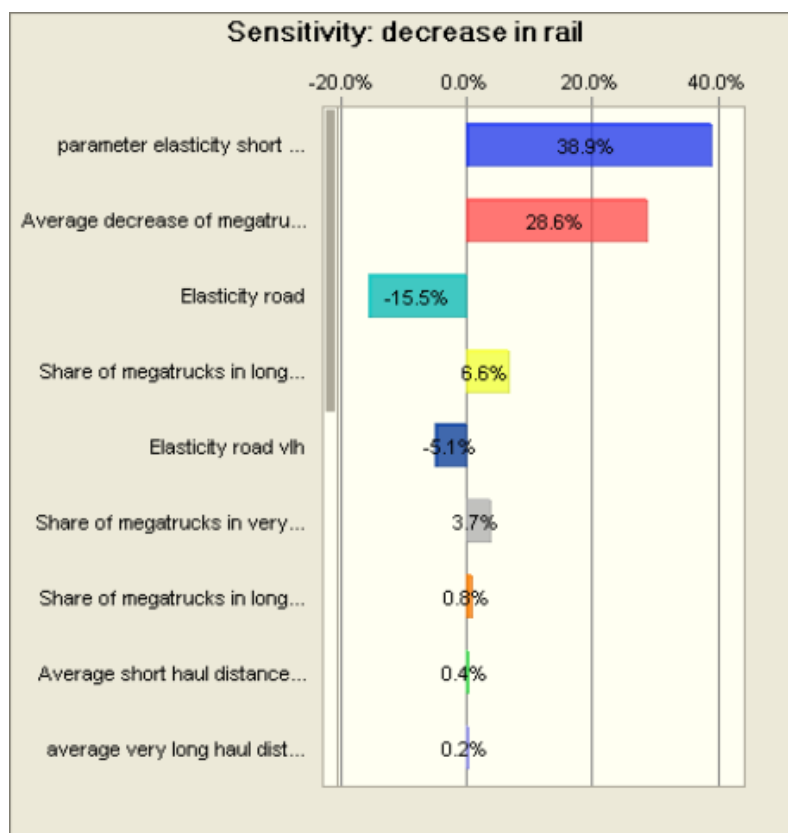
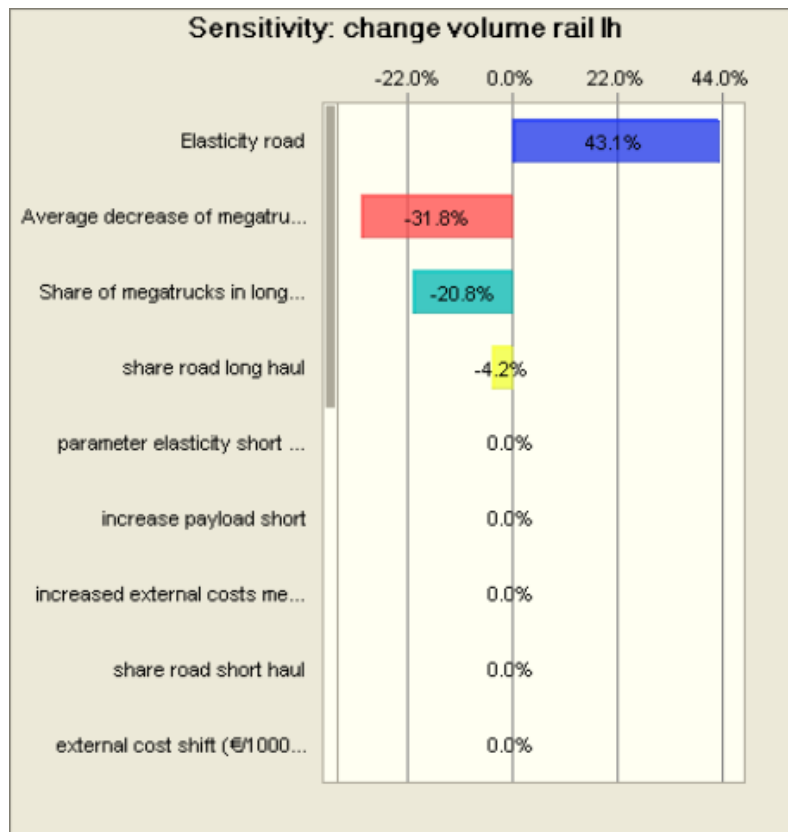


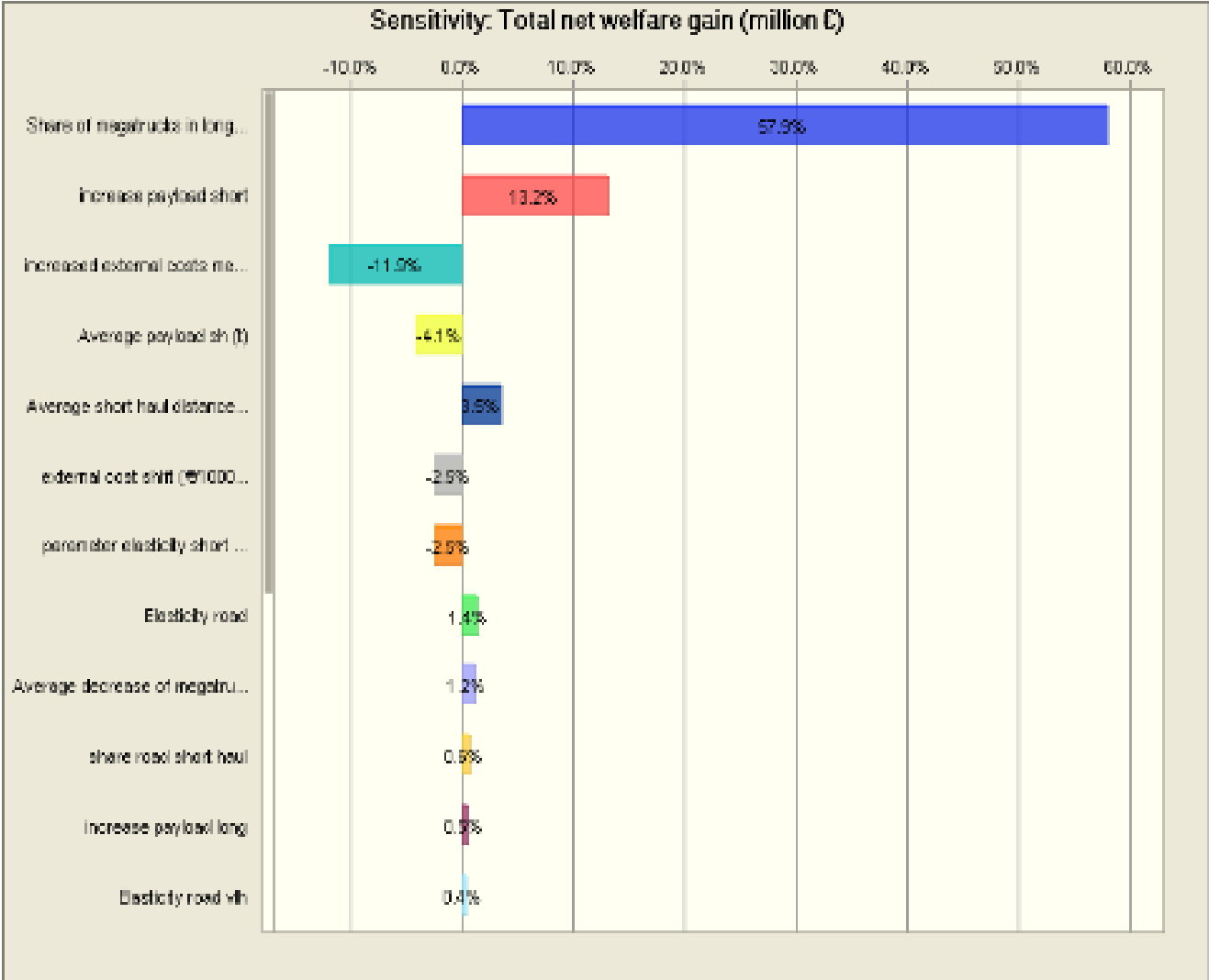




ANNEX III – Sensitivity tests for main forecasts







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Abstract

The European Commission is considering the implications of allowing the use of LHVs, vehicles measuring up to 25.25 m and weighing up to 60 tons, for the whole of the European Union transport system. The introduction of such trucks on the European road network will generate environmental impacts, safety and infrastructure costs.

The present study aims at carrying out an uncertainty analysis of the technical and economic aspects of LHVs based on assumptions and results ranges taken from recent literature. The results suggest that the potential impacts of the introduction of LHVs at EU level can be positive –under certain conditions- in both economic and environmental terms. The increased payloads per vehicle are expected to reduce transport costs and lead to significant savings for operators, industry and consumers. Since fewer trucks would be required to transport the same volume of trade, the environmental and other external costs of freight transport would also be lower, even though an individual LHV consumes and pollutes more than a conventional truck. An analysis of the potential benefits to the economy and the society as a whole has been carried out.

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