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Internalisation of External Costs of Transport: Impact on Rail

Study for the Community of European Railway and Infrastructure Companies (CER)

Final Report

Karlsruhe and Paris, July 2009

Internalisation of External Costs of Transport: Impact on Rail

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Executive Summary

The purpose of this study is to assess the likely impact in 2020 of the internalisation of external costs for heavy goods vehicles on modal shift and the environment. The analysis has been made for inter-regional traffic, both for the whole network and for two corridors. It was based on studies carried out by INFRAS/IWW (2004; 2005) and various studies for the Commission for which the main results are summarised in the IMPACT Study (CE Delft et al., 2008) for the Commission. Transport modelling was done by combining the NESTEAR freight transport model with its detailed logistic features and the IWW road transport model which provides a detailed simulation of congestion on roads and its environmental impacts.

Different scopes and levels of internalisation of external costs have been analysed. These range from the narrow scope (air pollution, noise and congestion) and capped values in the Commission's 2008 proposed revision to the Eurovignette directive to the wider scope (inclusion of CO_2 and accidents) and uncapped values from the IMPACT Handbook. In our analysis we first assumed that rail productivity would grow – according to the expected productivity growth in other industrial sectors - at the industrial average of 1.8% per year:

Impact of different scenarios on inter-regional traffic and CO_2 emissions 2020

Scenario	Modal share of rail in % of ton km	% shift to rail compared to base scenario	Reduction in carbon emissions (millions of tonnes in 2020)
Base: no internalisation of cost, 1.8% p.a. increase in rail productivity	19.2	-	-
Capped: as Base with capped charges for external cost of air pollution, noise and congestion – Commission's July 2008 proposal	19.9	0.7%	0.6
Capped +: as Capped plus CO_2 and accidents charged at median values in Handbook	21.4	2.2%	1.7
Upper limits: as Capped + plus all externalities in Handbook at upper limits in Handbook	24.1	4.9%	4.9
Upper limits plus 0.9% p.a. higher rail productivity	30.5	11.3%	11.7

This table shows that the effect of the Commission's July 2008 proposal would be relatively limited, both in terms of modal shift and CO_2 emissions. However, including all external costs and setting all values at more realistic levels would increase the proportion of inter-regional traffic carried by rail from 19% to 24% for the inter-regional transport markets (distance >300 km). Additional investment by governments and railways, which could be supported by ear-marked revenue from charging, could easily bring a further 0.9% p.a. increase in rail productivity, and this would further increase the proportion of this traffic carried by rail to 31% of market share for inter-regional transport.

Most of this is longer distance traffic for which rail is most competitive. For example, 59% of all land-borne traffic over distances exceeding 700 km and 68% for distances exceeding 900 km would be carried by rail. Much of this is combined transport for which the feeder part of the trip would be by road. This demonstrates the increasingly complementary relationship between rail and road transport, i.e. rail using its obvious strengths on long distances and road freight playing its critical role for regional feeders and distribution.

These changes would represent a major turnaround in the transport sector. They would substantially improve transport efficiency and make a major contribution to achieving the objectives of the White Paper on Common Transport Policy (European Commission, 2001). There would also be significant savings in CO_2 emissions amounting to about 7% of the EU's CO_2 reductions target as set out in the "Bali Roadmap". These changes would represent a first and major concrete step to achieving these targets and make a serious and important move towards sustainability in the transport sector.

The analysis of two key corridors (Rotterdam-Genoa and Antwerp-Warsaw) shows that the modal shift would be even greater on these corridors than for the network as a whole. Rail traffic would concentrate along these corridors with an increasing modal share. The share of rail transport carried along the Rotterdam-Genoa corridor would go up from 11 to 13% and on the Zeebrügge/Antwerp-Warsaw corridor from 5 to 7%. The impact of internalisation would be particularly marked for the Antwerp-Warsaw corridor for which the rail offer is currently less well developed.

This analysis underlines the importance of internalisation of external costs in achieving the EU's modal shift and emissions reduction targets and in bringing the EU in line with its own commitments for an efficient and sustainable transport policy.

1 Background and Objectives of the Study

1.1 Background

The external costs of transport are significant. The INFRAS/IWW report (2000) estimates the overall external costs of transport to be 7.8% of GDP for EU15. 92% are caused by road traffic, 30% by road freight. External costs of railways are 2% of their total; the share of rail freight is less than 1%. Also the average and marginal cost figures give a clear indication that rail transport has considerable advantages with respect to external costs.[1] Studies like FACORA (2005) demonstrate that full internalisation of all external costs would remove market distortion and substantially improve on the market position of environmentally friendly transport modes. Studies launched by the EU Commission, as for instance UNITE (2005) or GRACE (2007), come to lower values in particular for accidents and climate change, but these have to be reconsidered against the background of the dedicated targets of the EU with regard to safety and climate change.

Therefore there is a broad consensus that external costs matter and have to be considered in the directives for infrastructure pricing. Directive 2001/14 includes the possibility to include external costs into rail track charging in Article 7 (5), subject to the condition that such charging is applied at a comparable level to competing modes of transport. Directive 2006/38 includes an obligation for the Commission to present, no later than 10 June 2008, a general applicable, transparent and comprehensive model for the assessment of all external costs on all modes to serve as the basis for future calculations of infrastructure charges. This model should be accompanied by a strategy for a stepwise implementation of the model for all modes of transport.

The European Commission published a ʻHandbook on Internalisation of External Costs of Transportʻ in February 2008. It summarises the results of several EU studies on external costs of transport and gives plausible intervals for their evaluation. On this basis the Commission has prepared a proposal for the internalisation of three types of externalities: congestion, air pollution and noise. The proposal includes cap values which shall not be exceeded. The member states can decide whether to make use of the charging option and what magnitude of

[1] The type of external costs and the average figures can be seen in Figure 3.

mark-ups to make for external costs – providing they do not exceed the cap values – is chosen.

1.2 Objectives of the Study

The intention of the internalisation strategy is to reduce external costs of transport by better technology, higher efficiency and traffic diversion to safer and more environmentally friendly transport modes. Therefore the **first objective** of the study is to analyse the impact of the internalisation strategy of the Commission on modal split. As the intended change of Directive 2006/38 concerns road freight transport only, also this study will be limited to the impacts on the freight transport market.

An internalisation of external costs would increase the transport costs of road haulage. This may induce a diversion from road to rail. However, when the "push" effect of higher road transport, prices is combined with a "pull effect" through better logistics quality of rail transport the total effect can be synergetic and substantially greater. Once there is a better integration of rail transport into the logistics chains of shippers and forwarders, the railway transport along the main corridors can become a preferred alternative to direct transport operations by road on longer distances.

This leads to the **second objective** of the study which is to analyse the combined effect of external cost internalisation and improved logistics quality of the railways. To make the impact analysis concrete and transparent, the study will focus on two corridors which will be analysed in detail: A North-South corridor from Rotterdam to Genoa and an East-West corridor from Zeebrügge/Antwerp to Warsaw. These detailed results will be enriched by more aggregate scenario figures for the relevant railway network.

The **final results** of the study will consist of comparisons for the modal split and the environmental impacts – in particular with respect to CO_2 emissions – in Europe. These results will be shown for the relevant railway network including all trans-European links and demonstrated in a detailed way for the two selected corridors.

2 Scenario Definition

2.1 The Rationale Behind Scenarios

As usual in scenario making the reference situations for “today“ and “tomorrow“ have to be defined. Based on the data environment of the year 2005 and their development under business as usual conditions, a Base Scenario 2020 has been derived which includes all developments which are expected to come in the near future except for the changes induced by the special assumptions on internalisation of externalities and increase of rail productivity.

2.1.1 Internalisation Strategies

A key question to be answered is to which extent the Commission’s strategy of internalisation might influence competition in the freight transport market. This question has a medium and a long-term dimension, because, following the task defined for the Commission in Directive 2006/38, a stepwise approach to internalisation is foreseen. The vision which underlies this study suggests that finally the internalisation of externalities will become consistent with the long-term strategies of the Commission for safety, climate change and emissions. This means that the internalisation charges will correspond to the target values set for externalities on the European level to achieve a desired level of safety and environmental quality.

Following this general idea a *Scenario Capped* will be analysed which includes the internalisation concept of the Commission’s proposal. A *Scenario Capped+* will analyse the impacts of internalising all external costs (the full list according to Figure 3) under the assumption that medium figures of externality values are transposed into a charging scheme. Finally a *Scenario Upper Limits* will explore the boundary of the range of internalisation. In some cases a valuation of externalities of this order of magnitude will be necessary to be consistent with the long-term EU target values (e.g.: climate change; NO_x and $PM_{10}/_{2.5}$ concentrations). Therefore this scenario is not a purely theoretical exercise, rather a realistic perspective if the targets set by the EU and the member countries, particularly on climate change, are seriously followed by active policy making.

2.1.2 Productivity Change in Rail Freight Transport

There is a host of possibilities for the industry to react to higher infrastructure charges on roads. One of these is to change the transport mode and divert to environmentally more friendly modes. The point of departure of this study is that such a diversion of freight transport consignments to the railway sector will be fostered if the railways can offer competitive service quality. This means that the logistics quality of railway service has to be increased so that the railways are able to compete on markets with high logistics quality requirements (e.g.: just-in-sequence transport with guaranteed delivery schedules, mixed cargo, full and partial load transports).

Several European and national projects have studied in detail which improvements are possible for the railway sector with respect to capacity gains, better operation control systems, better organisation and logistics performance to improve on the position in the core business segments of the railways and open the chance for railways to become competitive in service provision on supply and distribution chains in modern production and logistics systems.[2] We will refer to these projects not because we think that every technical or organisational instrument assumed is optimally designed. The reason for using on this research is that it tries to exploit the potential of the railways in future market development. Our analysis is based on the overall productivity results and not on the single assumptions for technical and organisational changes of each study. In the following we will form a consistent scenario for high technology and commercial organisation in an environment free of political, technological and organisational barriers in Europe, which is called the *Rail Productivity* Scenario. This indicates that we assume that the railway sector will achieve a competitive edge compared with the road haulage industry also on markets with high logistics requirements.

The *Rail Productivity Scenario* will be combined with the *Upper Limit Scenario* to explore the potential of the railways in a future environment, in which the idea of the Commission to revitalise the railways, as it has been formulated in the White Paper 2001, is transposed into a set of concrete supply side changes.

Following this logic of scenario building the scenarios are depicted in section 2.2.

[2] For instance: New Opera (EU); Correct (German-French DEUFRACO programme); Logistics Action Plan (EU); LOGOTAKT (German Ministry of Economic Affairs)

2.2 Definition of Scenarios

The scenarios comprise a base case 2020 and four internalisation scenarios 2020.

(1) *Base Scenario 2020*: The base scenario will include all expected changes which are not related to the internalisation of external costs (e.g. increase of energy prices) until the year 2020. Improved rail productivity beyond an average productivity growth of all industrial sectors (1.8 % p.a.) is not included in this scenario. On the federal road network we assume an infrastructure charging system based on full cost recovery.

(2) *Scenario Capped*: The externalities will be defined and evaluated on the basis of the proposal of the Commission. The externalities will comprise congestion (discussed later), noise and air pollution. The values will be defined at the caps suggested by the Commission. Reference year is 2020.

(3) *Scenario Capped+*: This Scenario extends Scenario Capped insofar as further externalities defined in the Handbook are internalised at medium values while the externalities included in (2) remain capped.

(4) *Scenario Upper Limits*: This Scenario sets all externality values of the Handbook at the upper limits.

(5) *Scenario Upper Limits and Rail Productivity*: Scenario Upper Limits is combined with the railways' productivity assumptions. [3]

[3] Rail Productivity is a consistent combination of scenario assumptions of different studies for a significant increase of rail freight productivity.

3 Corridor Definition

The corridors to be examined in detail are:

(1) Rotterdam-Genoa

(2) Zeebrügge/Antwerp-Warsaw

These corridors are illustrated in Figure 1 and Figure 2.

Figure 1: North-South Corridor

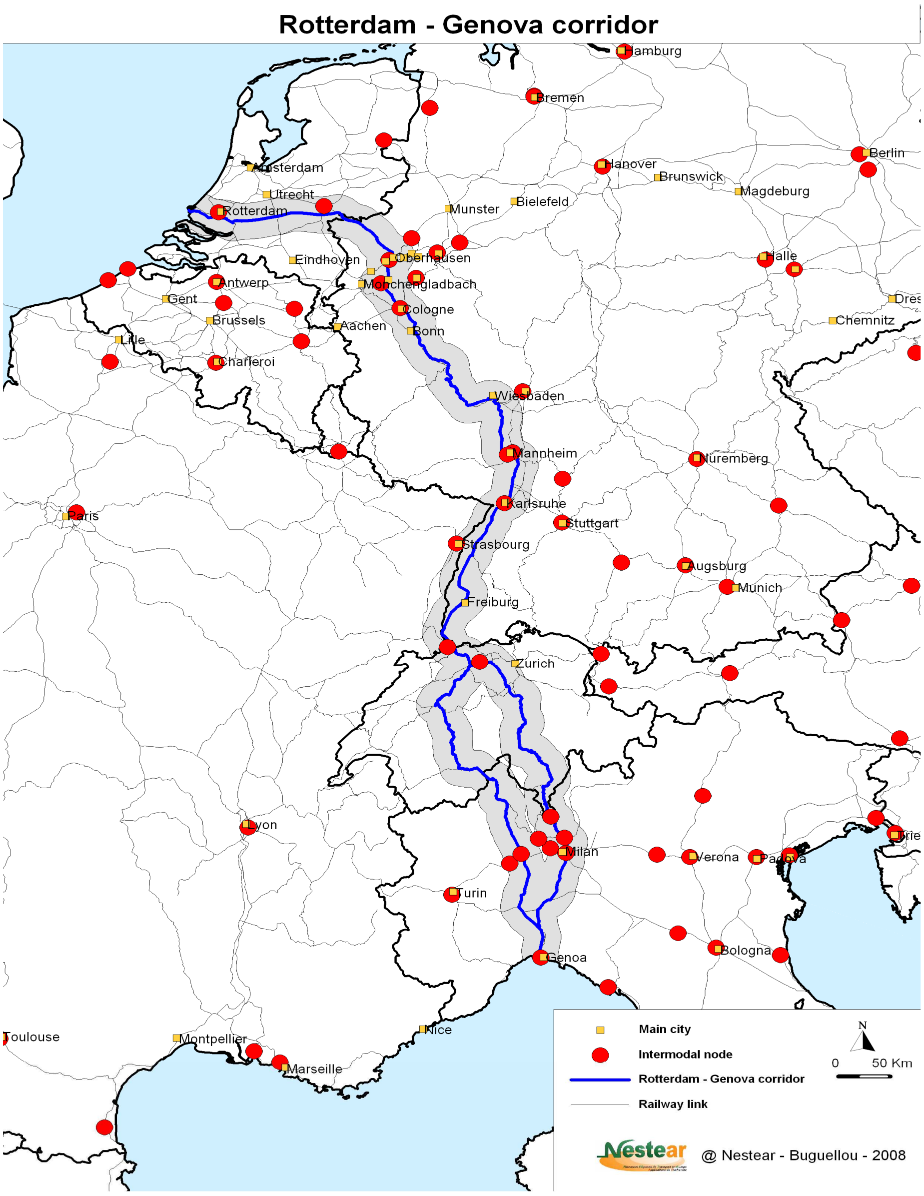
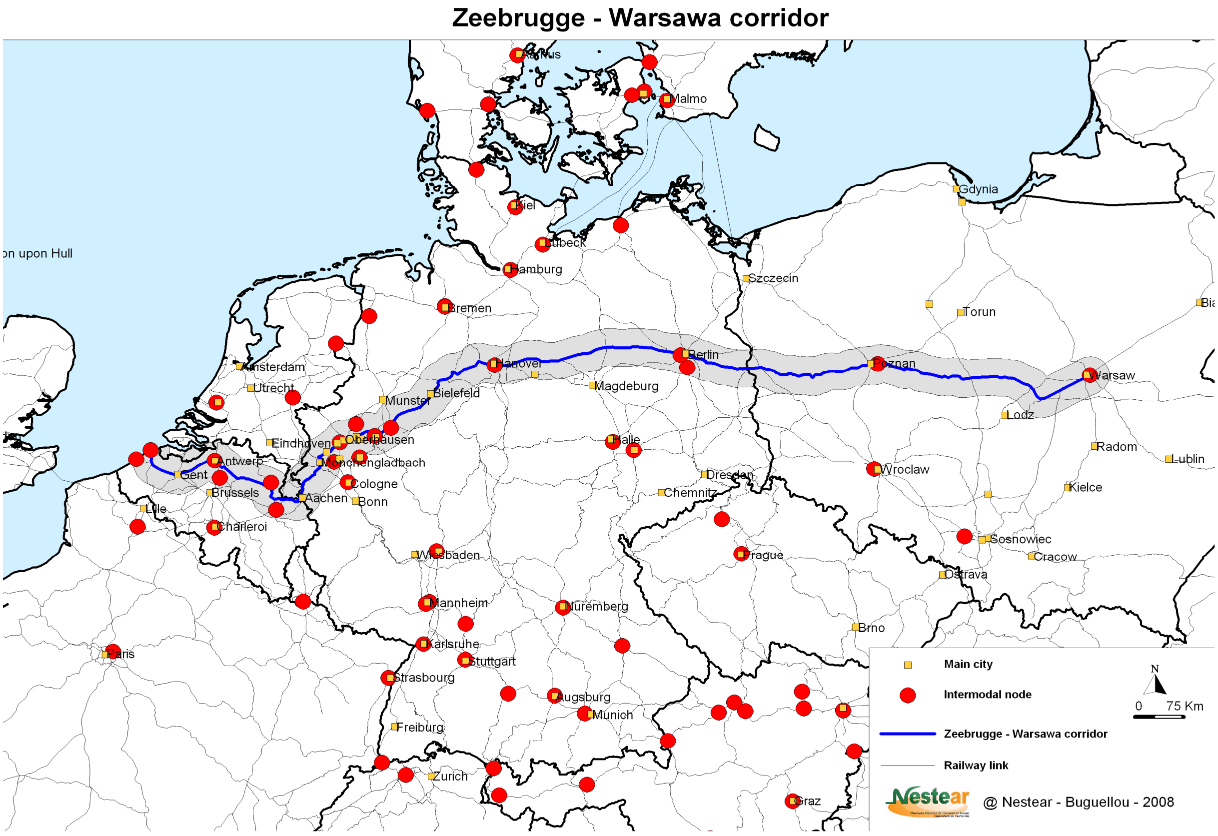


Figure 2: East-West Corridor Zeebrügge/Antwerp-Warsaw



As can be seen from Figures 1 and 2 it is not easy to clearly define a corridor. For the present study we define the corridors by originating and destining regions, major cities and agglomerations linked together, the existence of major road and rail infrastructure and the regions touching a distance band of 50 km alongside the main infrastructure links. From this the two corridors are defined as follows:

North-South:

Rotterdam – Arnheim – Emmerich – Duisburg – Cologne – Mainz – Mannheim – Karlsruhe – Basel – Lötschberg/Gotthard – Turin/Milan – Genoa

West-East:

Zeebrügge/Antwerp – Dortmund – Hannover – Berlin – Frankfurt/Oder – Poznan – Warsaw

4 Cost Values in Scenarios

4.1 Preliminaries

Before discussing the input cost values of this study, it is important to refer to the state of the art of measurement and valuation of external costs of transport. There are two scientific streams to be mentioned which have generated different classifications and estimations of magnitudes of external costs of transport. The first is the studies of INFRAS/IWW for the UIC (2000; 2004). The second stream consists of a number of studies launched by the Commission to calculate the marginal costs of externalities in transport (e.g. CAPRI (2001), UNITE (2005), GRACE (2007)).

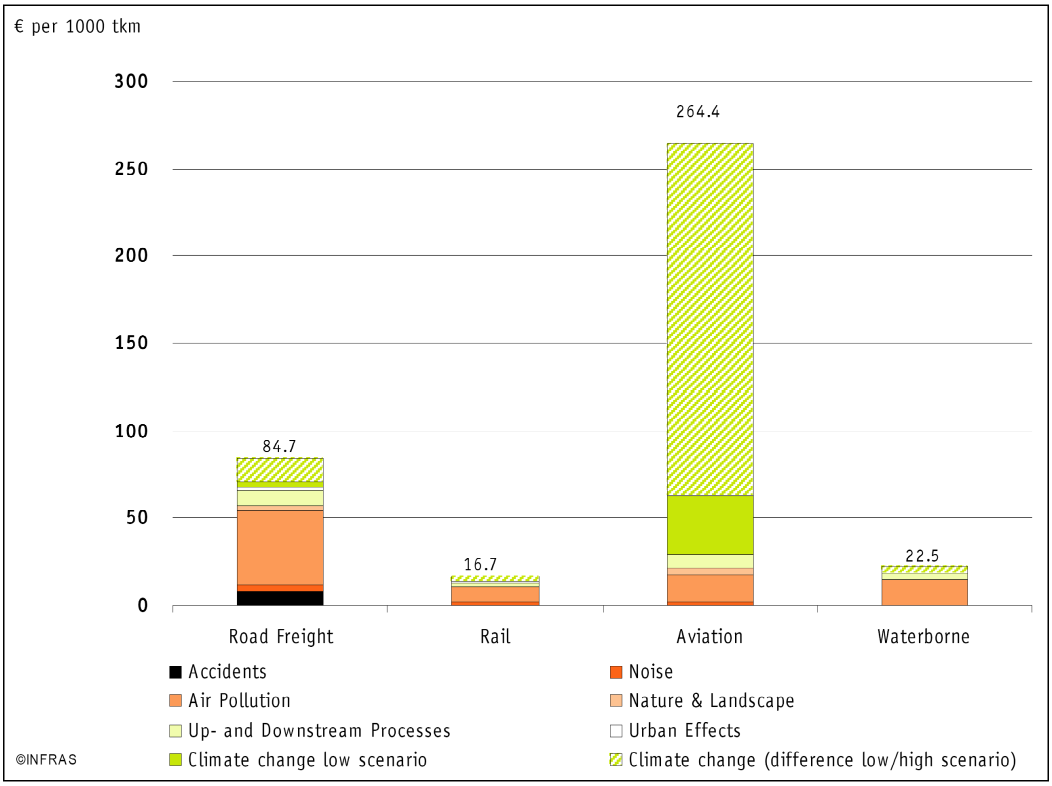
The first stream gives a full classification of external costs of transport which can be seen in Figure 3. It includes air pollution, noise, uncovered costs of accidents, climate change, up-stream/down-stream effects, nature and landscape (biodiversity) and urban separation effects. Congestion externalities are not included in the picture because they are externalities of a different type. Congestion is caused and congestion effects are mainly absorbed by road users and in this sense "club internal" to the community of road users. As they result from involuntary interactions among users, who don not take into consideration the impacts of their route/modal choice decisions on other users, they are "individually external" such that the situation of the road users can be improved by internalisation of congestion externalities. Stream 1 gives figures for total and average costs as well as of the marginal costs of externalities. Internalisation of these externalities can be achieved by employing a variety of instruments, such as taxes, charges, emission certificate trading, insurance or regulation.

The congestion externality is in the heart of the second stream, because the latter stresses short-term optimal pricing strategies based on the neoclassical Pigou-pricing scheme. This leads to social marginal cost pricing which includes congestion cost and a subset of the externalities of stream 1. Typically stream 2 includes only externalities which are directly related to traffic activity while stream 1 in addition to the traffic effects also considers externalities linked to the provision of the infrastructure, vehicles and energy. Internalisation in stream 2 is assumed to be achieved by setting charges equal to the sum of marginal costs for infrastructure provision and traffic-dependent marginal external costs.

The Handbook on external costs of transport, which was launched by the Commission in early 2008, seeks to summarise both approaches. The Commission's proposal, however, is based on the second stream, only, and is restricted to a small subset of the overall externality list. Only congestion, air pollution and noise are left in the internalisation scheme suggested. The Commission has fixed cap values for these externalities which should not be exceeded. The Member states will be free to add mark-ups for the above externalities below the cap values. It follows from this that only a small part of the overall externalities is considered; very important impacts such as climate effects, safety or infrastructure related impacts are neglected. The Commission argues that the neglected externalities may be internalised using different instruments as for instance fuel taxation or insurances. However, the references to potential actions to be taken (e.g. increase of lower limits of diesel taxes) are very vague.

Furthermore, the Commission intends to prevent the Member states from using costs values which are in the upper range of the Handbook values. This is done by capping the cost values which might be charged to moderate magnitudes, which lie in the middle of the possible ranges for congestion, air pollution and noise. This will be the starting point of our impact analysis.

Figure 3: External Costs of Transport in EU 15, Base 2000



Source: INFRAS/IWW, 2005. Average Cost Values. Climate Change: min 20 EUR/ton CO_2; max 140 EUR/ton CO_2

4.2 Cost Values for Operating and External Costs

The values for operating costs have been derived from several studies from France, Germany, and Italy. The 2005 values have been projected on the basis of trend developments to the year 2010 in real terms (no rate of inflation considered). It is foreseen to allow for mark-ups for external costs after an appropriate revision of Directive 2006/38. The external cost elements considered are congestion, air pollution and noise. In the analysis, external congestion costs are differentiated according to the level of congestion in the raster cells of the defined corridors. (see the raster cell resolution in Figures 20 and 21)

4.2.1 Cost Values for Climate Change

The cost values for the externalities considered in the Commission's proposal are taken from the Handbook (CE et al., 2008). Upper values for climate change (140 Euro/t of carbon) were derived from INFRAS/ IWW (2005) because this corresponds better to the medium and long-term CO_2-reduction target of the EU.

4.2.2 External Congestion Cost

External congestion costs have been calculated after identifying congested parts of the road network using the VACLAV model of IWW and the TEN-STAC/WorldNet data base (see the traffic assignment figures 22-26). As congestion cost cannot simply be added to total infrastructure costs because they are of a different nature, the infrastructure costs have been subtracted from congestion costs according to the Handbook proposal. In the Capped and Capped+ scenarios up to 10% of congestion costs are regarded as external and added to the other external costs. In the Upper Limits scenario, congestion costs have been calculated in line with the Commission's proposal (see Table 1) by applying a detailed analysis of the time-dependent traffic flows on the two corridors.

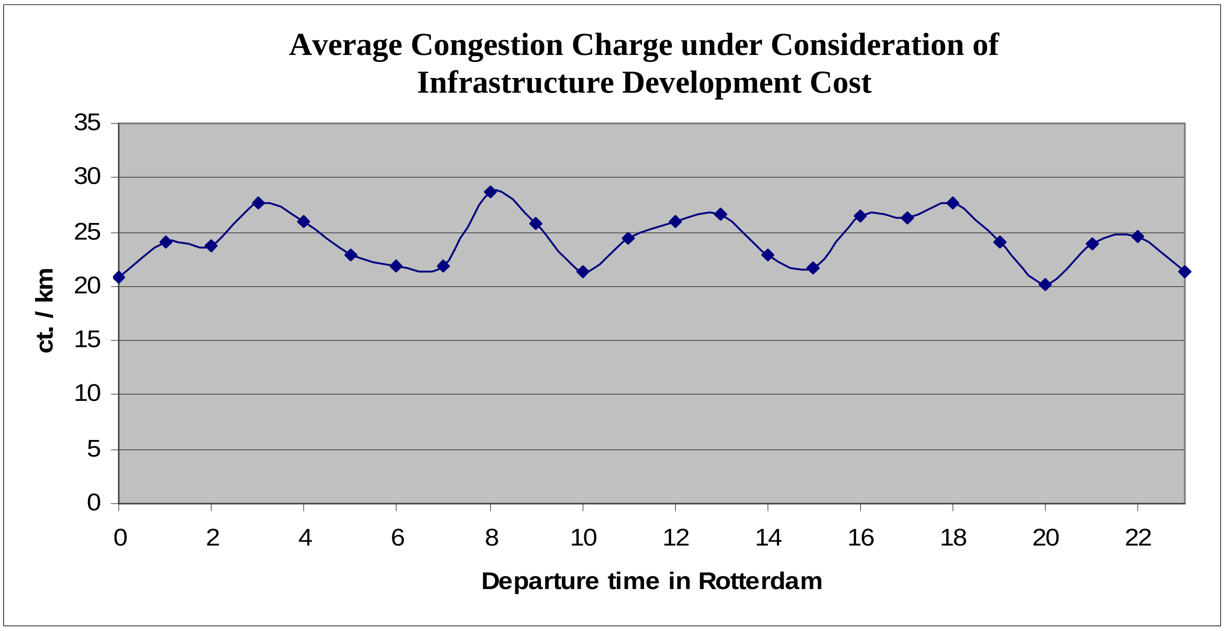
Table 1: Chargeable congestion cost

Euro cent/ vehicle-km	**Time period A**	**Time period B**	**Time period C**
Suburban roads	0	20	65
Other interurban roads	0	2	7

Period A. nearly free-flow traffic
Period B: near capacity limit
Period C: traffic flow collapsed

In the calculations it has been assumed, in line with the Commission's proposal, that the users pay at least a charge for the allocated infrastructure cost. In cases with considerable congestion (traffic flow near the capacity limit or already a collapsed traffic situation), the values of the Handbook (Table 1) have been applied. For this reason, the road segments in corridors have been classified into suburban and rural segments. Assuming typical time distributions of the traffic flows and driver rest cycles congestion cost in function of departure time and departure location have been derived.

Figure 4: Congestion cost under consideration of infrastructure development cost of corridor 1



Under certain conditions concerning the driving-cycles, the average congestion plus infrastructure cost reaches 29 ct/km. This is the case, when the trucks pass through the high density agglomerations in the Netherlands, the Ruhr and the Milan areas during rush-hour.

The other external costs from the Handbook have been aggregated using typical average driving cycles. A distinction has been made between day and night and between inter-urban and suburban. Urban sections have not been considered because the unit cost values from the Handbook seem to refer to typical city roads and not to motorways through the suburban areas of the agglomerations.

4.2.3 Air Pollution

The values for air pollution from the Eurovignette revision proposal are compiled in the following Table 2.

Table 2: Cost values for air pollution

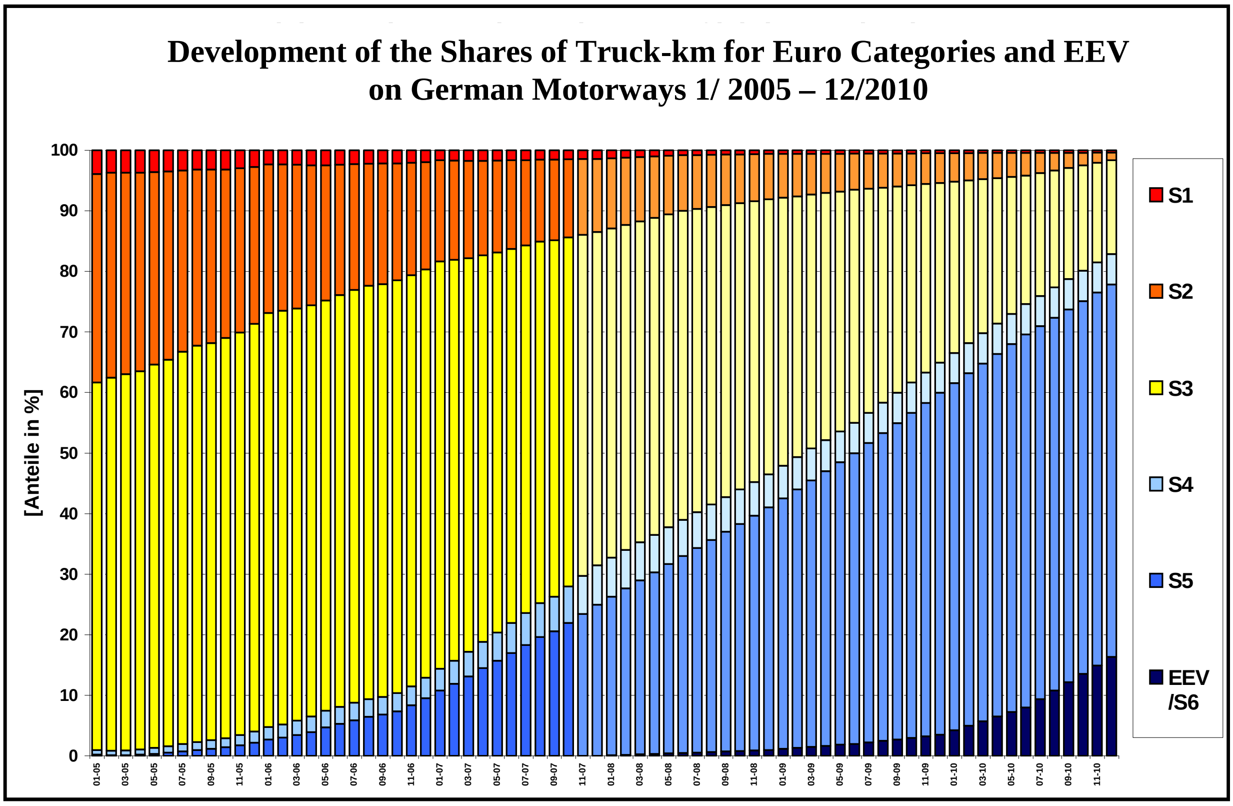
Air pollution, ct/km	Suburban roads	Other interurban roads
EURO 0	16	13
EURO I	11	8
EURO II	9	8
EURO III	7	6
EURO IV	4	4
EURO V and less polluting	3	2

Starting with the treatment of air pollution we set the reference emission category to Euro 5. This means that in the year 2020 the environmental standard will be Euro 5 on the average. This clearly contrasts the values elaborated in the Handbook, where Euro 2 and Euro 4-based values have been assumed.

Figure 5 shows that the share of trucks which are categorised Euro 5 and better will increase rapidly, if the km charges on motorways are differentiated on the basis of Directive 2006/38. In Germany it is expected that that share of Euro 5 or better will be more than 70% in the year 2010. Similar shares are expected in Switzerland and Austria. As soon as further countries differentiate road user charges according to Euro categories the diffusion of low air pollution technology will be accelerated significantly.

This means: In the year 2020 we reasonably can assume that the shares of Euro 2 and Euro 3 vehicles on the charged road network will be close to zero. The share of Euro 4 will be low (it can be followed from Figure 5 that the road haulage companies already presently move to Euro 5 or even better – the regulation of emissions of particulate matter and NO_x which is planned for the forthcoming Euro 6 category is used already in the German TollCollect charging system starting in 2009). Therefore the average environmental category in the year 2020 will be at least Euro 5. This is reflected in much lower charges for air pollution compared with the Handbook, as exhibited in the scenarios. As the member countries will be allowed to fix the environmental charges themselves and the cap values of the Commission represent the upper limits, there is high probability that Euro 5 conforming cost values will be applied in the year 2020 in all countries in which Euro 5 vehicles have reached a high share. In other countries the possibilities to add external costs or to differentiate charges according to Euro categories have not been used so far and we assume that this policy will not change after 2020. To take into account some residual EURO 3 and EURO 4 vehicles, we assume an average cost of 4 ct/km instead of 3 ct/km (cf. Handbook, Table 15).

Figure 5: Development of the Truck Fleet Structure with Respect to Environmental Categories; Source: Progtrans/IWW, 2007



4.2.4 Noise

The relevant values for noise are indicated in Table 22 of the Handbook (Table 3).

Table 3: Cost values for noise (ct/km)

Noise	Urban	Suburban	Rural
Day	7.01 (7.01 – 17.00)	1.1 (0.39 – 1.10)	0.13 (0.06 – 0.13)
Night	12.78 (12.78-30.98)	2 (0.72 – 2.00)	0.23 (0.11 – 0.23)

With respect to noise emissions on the motorway network (suburban and rural areas only) the values of the Handbook are relatively low (0.13- 2 ct/km). It should be noted that long-distance trucks generally do not cross city centres on the secondary road network. Therefore the high noise costs mainly affect distribution activities which are not in competition with railway transport. Considering the driving cycles (there are much more rural areas passed through in daytime than suburban sections by night) we deduce a weighted average of 0.4 ct.

4.2.5 Compilation

The cost values of the scenarios are summarised in Table 4.

Table 4: Cost values in the scenarios

EUR/km

Components of transport cost			2000 in 2000 values	2005 in 2005 values	Base Szenario	Scenario Capped	Capped+ Scenario	Upper Limits Scenario
Wages of the drivers			0,27	0,31	0,39	0,39	0,39	0,39
Social charges			0,07	0,08	0,08	0,08	0,10	0,10
Fuel			0,23	0,27	0,38	0,38	0,38	0,38
Distance dependent depreciation			0,05	0,06	0,06	0,06	0,06	0,06
Time dependent depreciation			0,05	0,06	0,06	0,06	0,06	0,06
Repair			0,08	0,09	0,09	0,09	0,09	0,09
Administration			0,15	0,18	0,18	0,18	0,18	0,18
Other			0,19	0,21	0,21	0,21	0,21	0,21
Sum			1,09	1,25	1,44	1,45	1,47	1,47
External + infrastruct.cost	2000 Values	2005 Values						
Infrastructure charges	0,180	0,200		0,050	0,200	0,200	0,200	0,200
Climate change handbook	0,022	0,024					0,024	
Climate change 140 EUR	0,110	0,122						0,122
Noise	0,004	0,004				0,004	0,004	0,004
Congestion	0,025	0,028				0,028	0,028	0,090
Accidents	0,050	0,055					0,028	0,055
Pollution EURO 5	0,040	0,044				0,022	0,022	0,044
Other	0,070	0,078					0,039	0,078
Sum			1,09	1,30	1,64	1,70	1,82	2,06

Wages drivers: 1 % p.a. increase due to scarcity of drivery, 1% pa. Increase due to better law inforcement + regulation
Infrastructure charges: In 2005 only in some countries km-dependent charges, change of system assumed until 2020
Climate change: 140 EUR/tonne assumed.
Noise: Only urban/suburban road sections assumed, directive already relates to the upper limit values.
Congestion: External components of congestion cost
Pollution: Dominance of EURO 5 vehicle assumed, additional vehicle cost for EURO 5 is already includes in vehicle cost calculation
Other: Up- and downstream process/nature/landscape/water and soil pollution
Congestion: Base and Capped as a lump-sum; Upper-limits according formula of directive

The upper part of Table 4 includes the private operating costs of trucking. These costs have considerably increased in the past years to a level of 1.25 Euro (2005). Rising energy prices and higher wages will lead to a further increase to 1.44 Euro (2020 in real terms). Furthermore, we assume that the costs of social requirements will increase substantially, in the first instance because of a stricter enforcement of social regulations and the penetrating of electronic logistics boxes in the truck fleet such that control becomes easier and better harmonised in the EU member states.

The lower part comprises the charges which are added by the state or by state monitored organisations. They include infrastructure charges and charges for externalities. First of all, infrastructure charges are assumed to the levied on the highway and motorway network in the EU in 2020. The average charge is set to 0.2 Euro/truck-km for heavy goods vehicles (gross weight 3.5 tons or more). This average can be differentiated according to axle load, number of axles, congestion and Euro emission category (Euro 1 to Euro 5 plus EEV[4]).

As can be seen from the lowest line of Table 4 (taking the differences compared with the Base Scenario), the externality costs amount to 6 ct/km in the Scenario Capped, 18 ct/km in the Scenario Capped+, and 42 ct/km in the Scenario Upper Limits, which corresponds to percentages cost increases of 3.7, 11.0 and 25.6%, compared with the Base Scenario.

In the Scenario Upper Limits it is assumed that also the rail mode is charged its external costs. Figure 3 shows an overall ratio of 5:1 for the external costs of road: rail, without taking into account congestion. From this it follows that the average charge for rail freight would be about 8 ct/wagon-km.

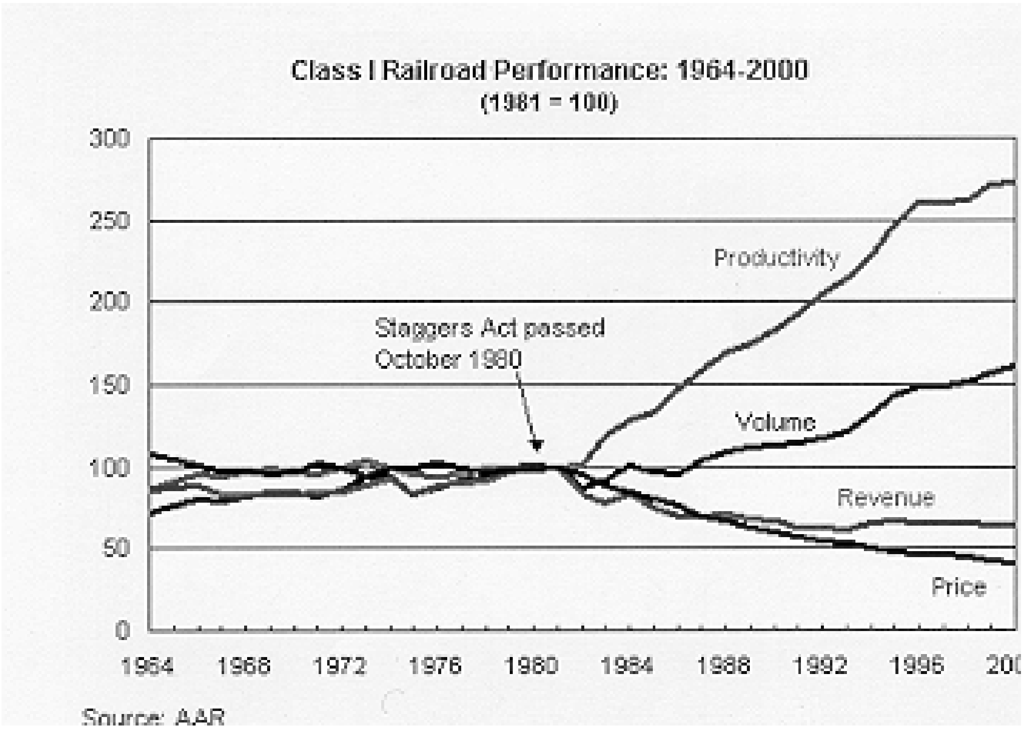
[4] Environmentally Enhanced Vehicles

5 Productivity Change

5.1 Examples for Substantial Productivity Improvements

US experience has shown that a tremendous increase of productivity (170% over 20 years) was possible after the companies were freed from obligated services and prices, and could act commercially following Staggers Act in 1980. This development cannot be taken as a reference profile for the European railways because of the totally different conditions in the supply and demand side of the US freight transport market. Nevertheless the picture of Figure 6 is a useful demonstrator for the effects of a fundamental change of regulatory conditions.

Figure 6: Development of Performance Criteria Following the Deregulation of US-Railways



For the European case the changes also appear fundamental, which result from free network access, interoperability of network use and commercial management including new types of alliances or mergers, paired with infrastructure investments to make freight train operations widely independent from passenger service. Therefore a jump of productivity can be expected, although not be as radical as occurred in the US.

5.2 Assumptions of the *Rail Productivity Scenario*

Already under business as usual conditions the productivity of the railways is expected to grow according to the industrial average of about 1.8% per year. This productivity increase assumed in the Base Scenario relates to those cost elements which can be influenced by the railways under business as usual conditions. For the 15 years between the reference year and the Base year this results in an overall productivity increase of about 30%. The main drivers for this productivity change are:

- Rehabilitation of the network
- Modernisation of rolling stock
- Improved organisation, in particular of international transport.
- Intensive usage of information and communication technologies.

In addition to this, the Rail Productivity Scenario summarises the concepts of several studies for future railway activity on the freight market and introduces a number of innovations concerning

- infrastructure: capacity extensions for bottleneck sections, in particular for sea-port-hinterland transport and freight dedicated bypasses of agglomerations.
- rolling stock (higher axle loads),
- operating system (ERTMS level 2),
- new commercial organisation for integrated European services,
- installation of equipment on infrastructure and rolling stock to reduce environmental impacts (in particular noise),

such that

- capacity bottlenecks will be removed,
- new types of operations will become feasible (border crossing with the same engines and crews),
- new types of services will become economically viable (scheduled services with single wagon technology),
- interoperability is guaranteed on the European networks,

- new dimensions of reliability and resilience become possible for just-in-sequence services in intermodal transport,
- cost reductions per unit of consignment become possible because of better capacity use,
- new forms of market organisation according to the cooperation principle become possible,
- and acceptability of the exposed population is achieved.

All in all these technical and organisational changes are not dramatic. In particular we have not assumed dedicated freight tracks over long distances, very long trains, double stock wagons, ERTMS level 3 and other advanced railway technologies which might come in a long-term future. The overall result of these technical and organisational measures is an increase of productivity compared with the Base Scenario of the order of 15% (or 45% compared with the year 2005). Given the assumed improvements, one could expect more than 15% of extra productivity gains from the assumed changes. But it has to be considered that not all improvements induced by the above measures will result in lower costs. This is due to the fact that commercially organised railway companies will have to make payments to shareholders, and due to the fact that the states which have to contribute massively to the investments for capacity extensions, might insist on a higher infrastructure cost recovery through increasing rail track charges. We have assumed 100% cost recovery for the busy freight railway corridors. Therefore, the further productivity gain of 15% is the part of the rail improvements which can be given to the customers in the form of reduced transport tariffs and improvements of services.

Flexibility and reliability are key service parameters for non-bulk cargo. Therefore, a productivity gain of this order of magnitude, eventually accompanied by an increase of costs for road traffic, can help the railways to achieve a competitive edge in important market segments of long distance transport. Some examples should demonstrate the compatibilities of freight railways in logistics demanding non-bulk transport as part of the assumptions of the productivity scenario:

a) *Reorganisation of single wagon load systems*. Today, the average ramp-to-ramp transport time of railways is heavily influenced by waiting times in marshalling yards. A wagon from Lyon to Vienna, for instance, is routed via Metz, Mannheim, Nuremberg and possibly Linz. Today, at each marshalling yard, a waiting time of between 6 and 18 hours is quite typical. At the same time we can observe some positive examples of direct freight trains on long corridors on the one hand and new operational schemes with higher frequencies and thus, shorter waiting time on the other hand. All these measures decrease the unit capital cost of the cargo and of the wagons. Especially in agglomerations freight trains often have to wait for a long time in order to let passenger trains pass by. With the implementation of new high-speed lines and a concentration of freight trains on long-distance freight-dedicated corridors there is a further potential to decrease capital cost and the labour cost of engine drivers.

b) *Reduction of bottlenecks*: Having removed capacity bottlenecks, the utilisation of railway lines can be considerably increased and average infrastructure cost can be decreased.

c) *New forms of business-business collaboration*: Railways could outsource transport services of branch lines to local operators operating efficiently and with another cost structure.

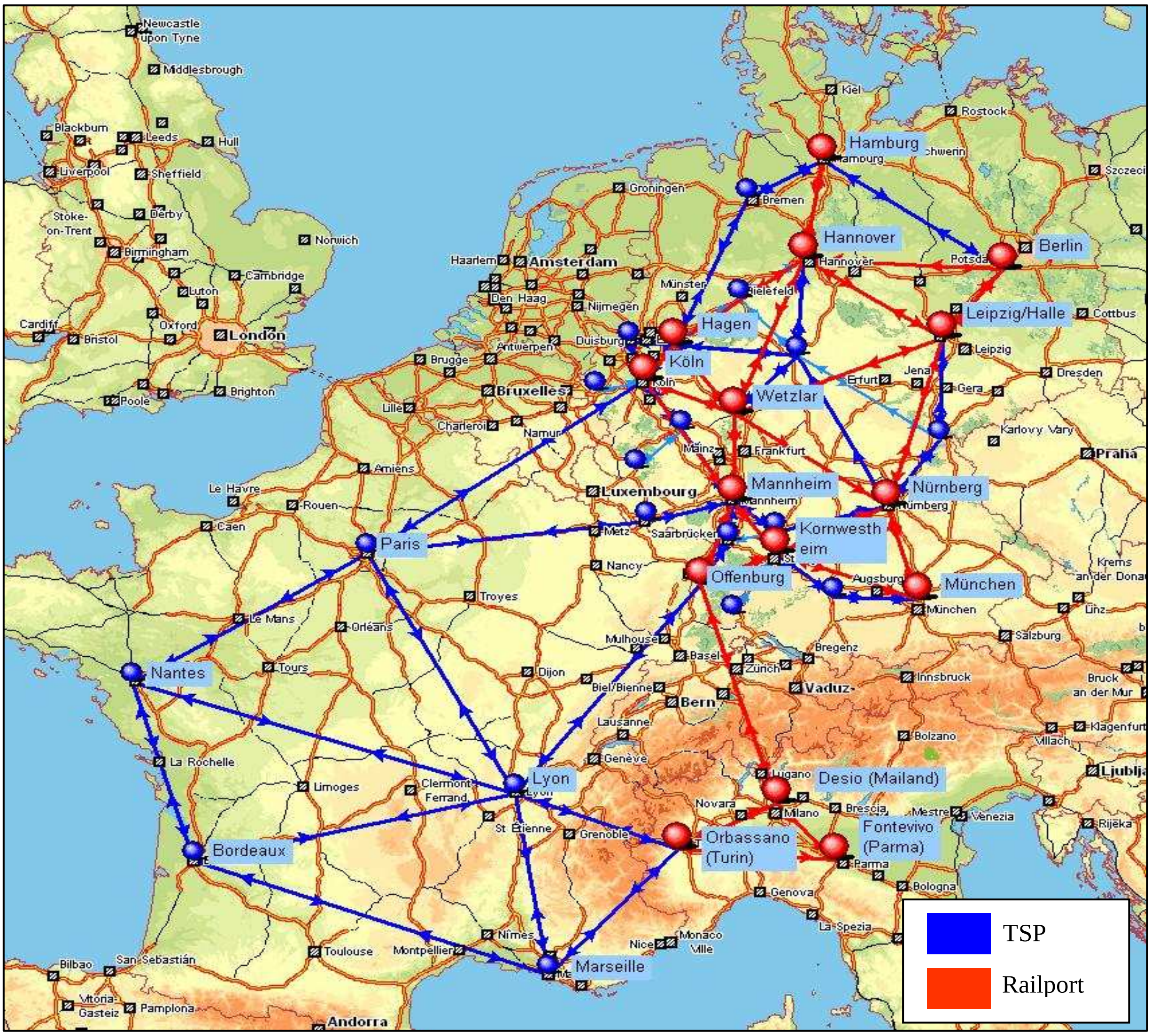
d) *Fixed cost degression:* Infrastructure cost mainly consists of fixed cost. With the exception of agglomeration areas and some core South-North corridors, major parts of the European long-distance railway network are not reaching capacity limits. It is possible to increase railway traffic without significant impacts on infrastructure cost.

e) *Long-distance freight trains:* In the past couple of years, direct trains have been introduced passing through several countries (Turkey-Germany, China-Germany). Such transports are very cost efficient and highly competitive.

f) *Micro-logistic research* in the project LOGOTAKT, launched by the German Ministry of Economic Affairs, underlines that new logistics organisations in form of open networks or broad alliances of shippers and forwarders, and innovative scheduled supply operations for milk-runs and main runs become economically viable. If the railways meet basic requirements they can *participate* in this scheduled system on long-distance main runs and attract new type of demand in the form of consignments down to pallet size. The LOGOTAKT concept takes up the idea of developing a Europewide network of railports which predominantly are located at marshalling yards and offer a full logistics service for long-distance transport (see Figure 7).

As a result one can conclude that the *Rail Productivity* Scenario will lead to a productivity increase of the railways of 15% compared with the Base Scenario in connection with a significant improvement of service parameters. If we compare this with the US example it even appears to be rather conservative.

Figure 7: Example for a Railport Concept



6 Network and Matrix Definitions

The European network models of NESTEAR and IWW are similar such that the results can be easily transferred. NESTEAR uses a NUTS 2[5] classification for the regions and additionally about 2000 entry points. IWW uses a NUTS 3 classification with about 1500 regions. NUTS 2 matrices from NESTEAR are broken down by regional indicators to the NUTS 3 level and can then be processed by the VACLAV transport modelling system of IWW.

Background data for freight movements are taken from the ongoing WORLDNET study (2008) for the Commission. The impedance functions on road links are non-linear and thus, congestion can be modelled endogenously. The road network model of IWW had been calibrated on the bais of most recent UN traffic counts such that it gives a realistic picture of the network loads of the year 2005. As congestion is modelled by links it will not be necessary to cluster links as has been done in the Handbook (urban, non-urban). This means that IWW/NESTEAR are able to model congestion in a much more differentiated way compared with the Impact Handbook[6]. The classifications urban/suburban and non-urban will only be used for the graphical presentations, to make the results comparable to others which are derived on a cluster basis.

[5] NUTS stands for: Nomenclature of Territorial Units of Statistics, defined by Eurostat.

[6] The scenario computations for the Impact Handbook have been performed using the Trans-Tools model, which is not yet mature, and Tremove, which is a cluster-based environmental evaluation model. It uses constant elasticities and does not consider the manifold reactions of transport agents in a multi-modal network. In particular these model tools are not yet adjusted to the specificities of the market for freight and logistics which are characterised by nonlinear and asymmetric behaviour of agents such that an integration of microscopic modelling is necessary to predict the break-even points for logistic changes (here: change from road to rail).

7 Estimations of Transport Impact

In this section, the results of our analysis will be presented. The aggregate results provide an overall picture; the disaggregate results relate to the two example corridors.

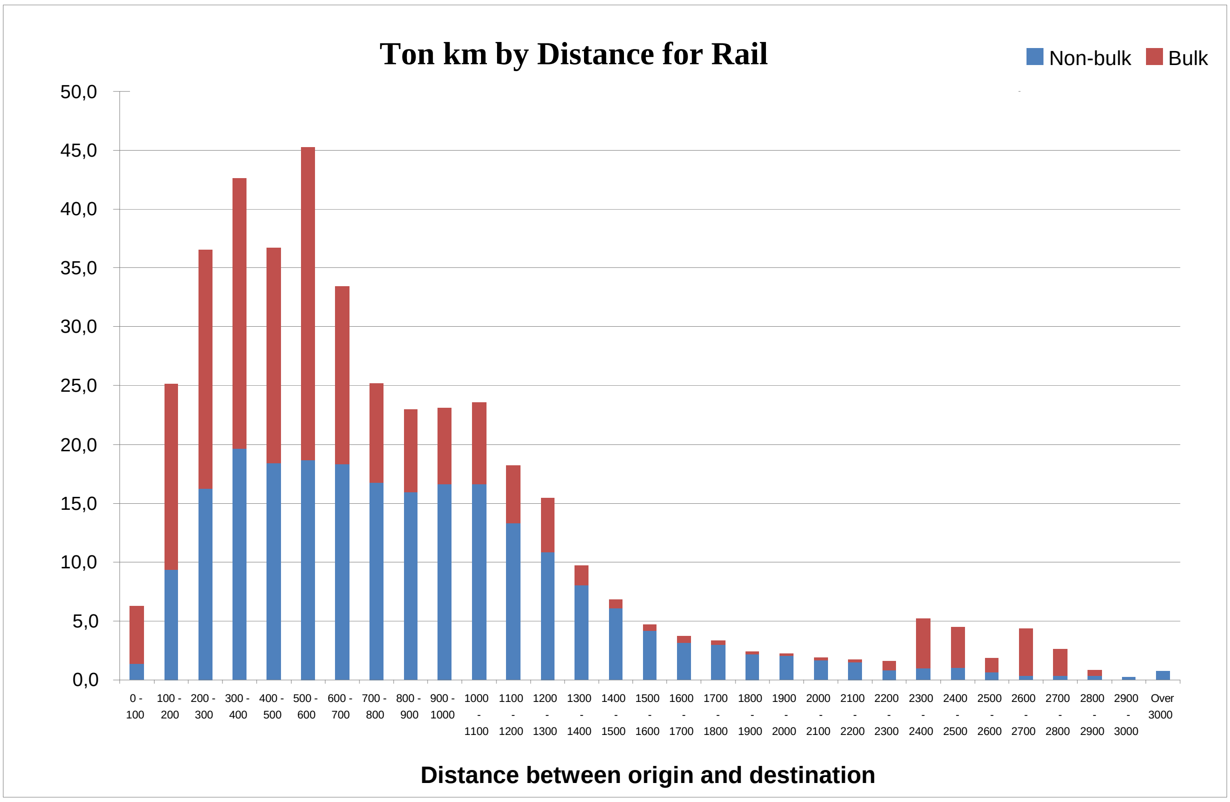
7.1 Aggregate Analysis

This section will estimate the expected aggregate impacts on inter-regional traffic (using regions as described in Chapter 6) of the different scenarios on the European scale. The transport segments which are expected to be sensitive to modal change are non-bulk cargo shipments over a distance of more than 300 km. Non-bulk in this context includes unitised cargo, container transport, single wagon or less than car load transport.

7.1.1 Base Scenario

Figure 8 and Figure 9 show the ton km by mode and distance in the Base Scenario. As it can seen, freight transport is subdivided into bulk and non-bulk. In the non-bulk segment the railways can achieve significant market shares on distances of 300 km and more. Therefore we will only analyse distances of more than 300 km for the possibility of modal shift from road to rail. For bulk cargo we assume that no modal shift is possible.

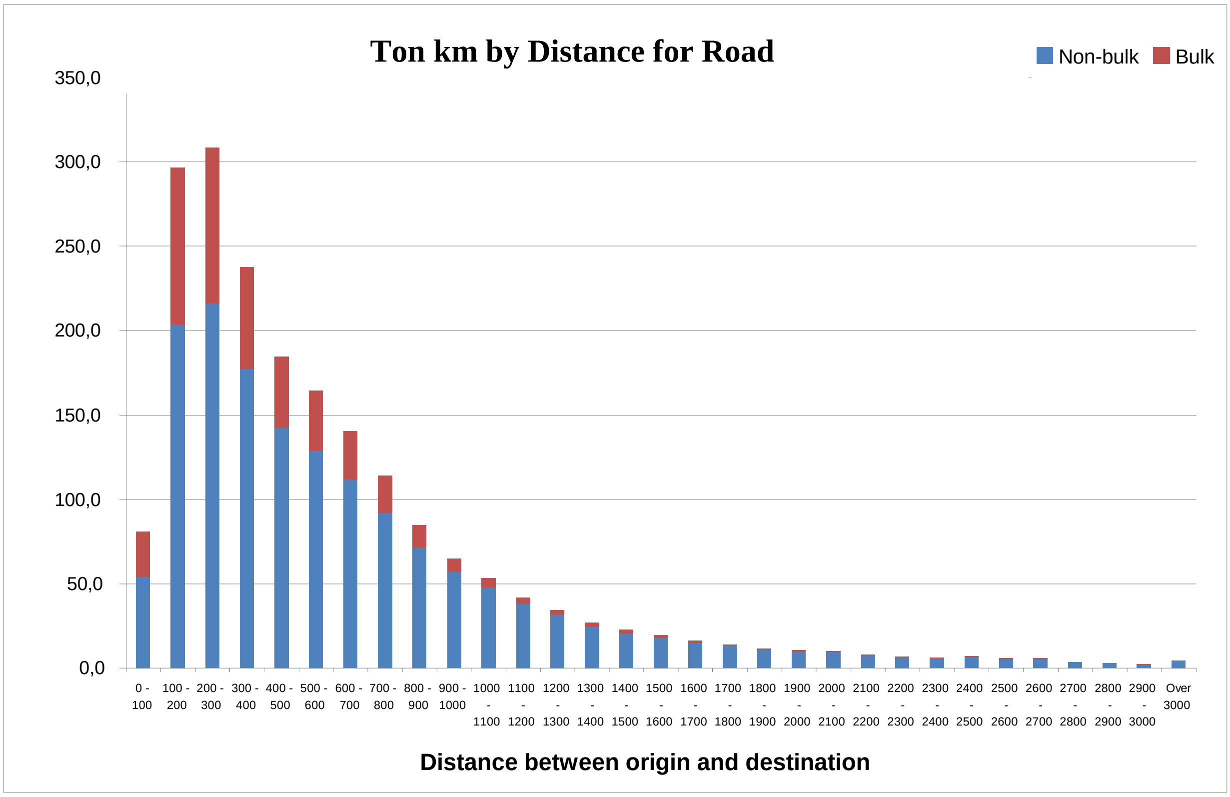
Figure 8: Ton km by distance for rail in the Base Scenario



In road transportation (Figure 9) there are not such clearly defined market clusters. For the markets which are potentially interesting for the railways – transports of at least 300 km – there is an enormous unexplored market potential for the railways. This market mainly consists of non-bulk transport. In our analysis we will refer to this segment as "long-distance non-bulk transport".

It can be assumed that under certain conditions, railways are able to enter into this segment. This shift may become possible through new policy measures (internalisation of externalities, investment activity) and improved organisation of the railway companies, in particular for international services. This will be analysed further in the next subsection.

Figure 9: Ton km by distance for road in the Base Scenario



7.1.2 Impacts on Modal Share

To interpret the results it is important to understand the philosophy of the NESTEAR model approach. The categories of long-distance freight transport can roughly be clustered into bulk cargo, wagon load operations and combined transport. It can be assumed that there is little competition between rail and road with respect to bulk cargo. Bulk cargo is a low-cost business and can only marginally be influenced by the additional logistics capability of railways. Eventually the option of long train formation on rail track dedicated for freight could change this picture, but this seems to be a highly theoretical idea from the present point of view and has not been considered.

Both single wagon load transport and intermodal container transports are parts of complex systems and are in direct competition with road transport. Therefore NESTEAR has included wagon load transport in the 2000/2005 statistics and made the projections for 2020 together for wagon load and combined transport. This means that the "combined transport" rail service of the model forecasts for 2020 includes also wagon load. In the following sections we will refer to this segment as "non-bulk cargo".

Figure 10: Ton km by distance class and mode (only non-bulk cargo); Capped Scenario

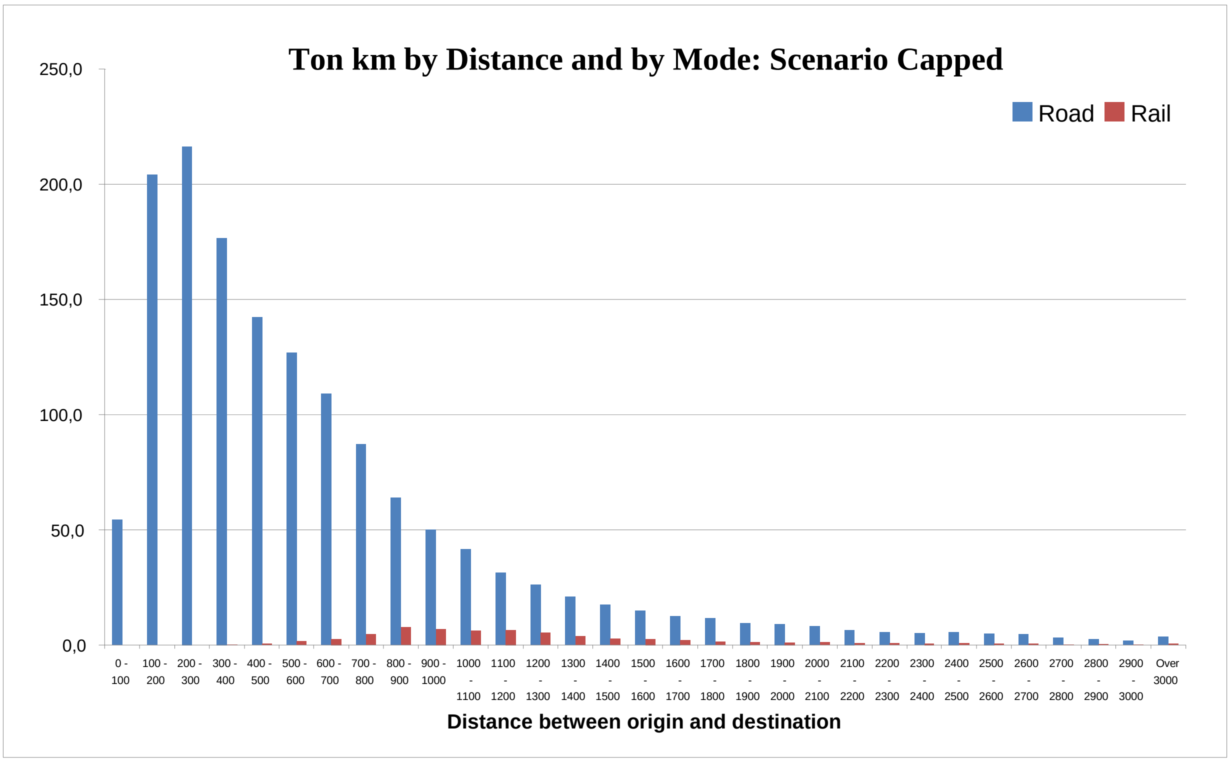
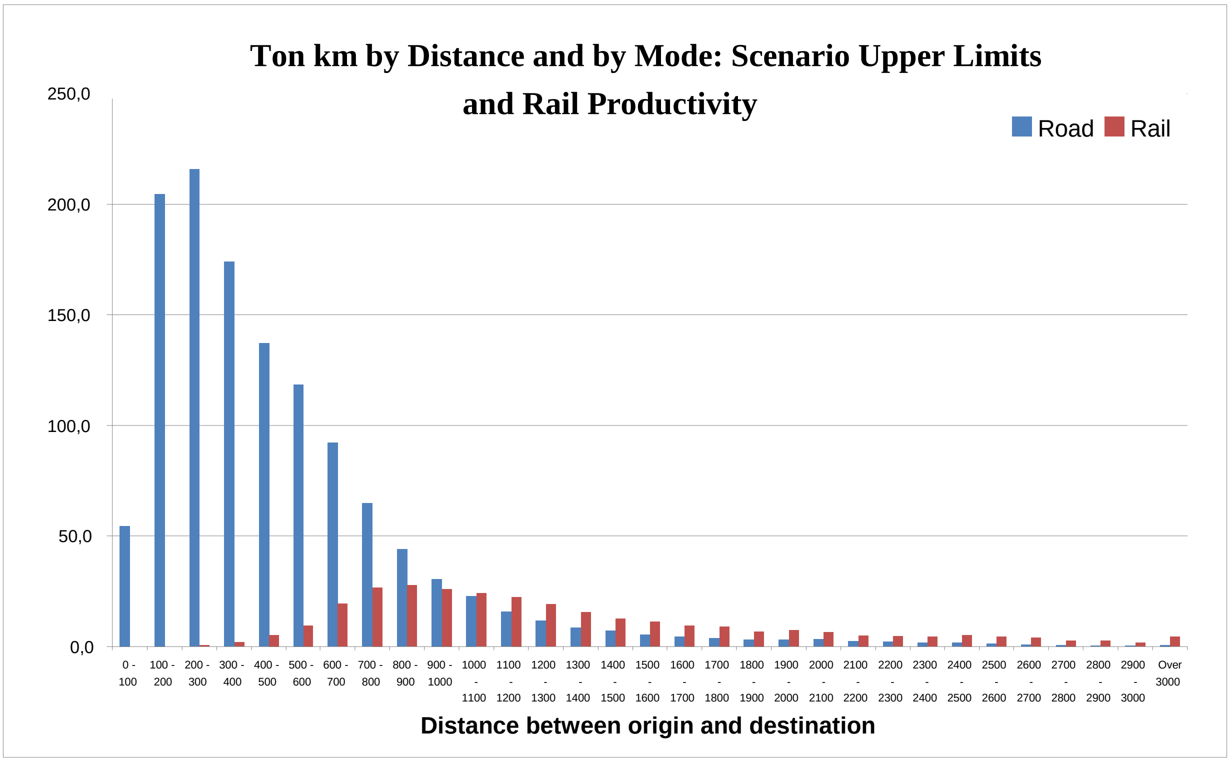


Figure 11: Ton km by distance class and mode (only non-bulk cargo); Scenario Upper Limits/Rail Productivity



Figures 10 and 11 show that the modal shift can only be expected on the long distance relations. No market reaction is expected on distances below 300 km. Between 300 and 500 km the reactions are significant but of modest magnitude. There is a significant difference between the Scenario Capped and the Upper Limits Scenario including Railway Productivity assumptions. In the Capped Scenario, railways can increase their market share mainly in the distance class of around 1000 km and above. In the maximum scenario, however, the railways can become the dominant market player on distances longer than 1000 km. While the shorter distances < 500 km are mainly domestic transport, which will show a modest growth in the future, the longer distances include originating and destining international transport and transit, which will continue to grow dynamically in the future. Therefore one can conclude that the combined “Upper Limits/Rail Productivity” policy would give the railways the chance to fully participate in the growth of the markets and take over a major share of the future transport tasks. Furthermore, the market segments exploited by improved railway service include high value transport services and are the most interesting ones from the commercial point of view.

The aggregate results are summarised in Table 5.

Table 5: Inter-regional ton km by Scenario

Billion ton km	**Road reference bulk**	**Rail reference bulk**	**Road non-bulk**	**Rail transfer simulation non-bulk**	**Total road**	**Total rail**	**Total ton km**	**Modal share of rail in %**
Scenario Base	446	413	1.496	49	1.942	463	2.404	**19.2**
Scenario Capped	446	413	1.477	66	1.924	479	2.403	**19.9**
Scenario Capped +	446	413	1.441	100	1.887	513	2.400	**21.4**
Scenario upper limits	446	413	1.372	164	1.818	577	2.395	**24.1**
Scenario up. lim.+rail prod.	446	413	1.223	320	1.669	734	2.402	**30.5**
Only inter-regional transports.								

The market positions for road and rail on the bulk cargo market, which are not influenced by the changes of road charging and rail productivity, are exhibited in the left two columns of Table 5. The following two columns give the transport figures for the market segments which are sensitive to the changes, in particular non-bulk cargo as for instance container and wagonload transport. Columns 5 and 6 show the total transport performance for road and rail. Column 7 gives the sum of total road and total rail and column 8 the modal share of the railway mode.

The *Base Scenario* 2020 shows a small improvement of the railways' position compared with the reference year 2005 (45 billion ton km). This is due to several factors: First, the presumed increase of rail productivity (1.8% per year), secondly the expected increase of energy prices, which affects the energy efficient railways less severely than road transport and thirdly higher wages and stricter control of social requirements for road transport. As to the cost effects of these changes see Table 4.

The *Capped Scenario*, which reflects the proposed internalisation by the Commission including congestion, air pollution and noise, generates some modal shift from road to rail, but it is relatively modest (about 0.7% compared to the base). As the measures constituting this scenario can only be regarded to be first small steps and far from full internalisation of external costs the Capped Scenario can contribute to flanking other political actions assumed in the Base Scenario, which are much more effective (e.g.: control of social requirements).

The *Capped+ Scenario* includes further externalities which have been discussed in the Handbook, as for instance climate change, accidents, up-stream/down-stream or infrastructure related impacts (biodiversity), evaluated at mean values. In this case a significant change of the market position of the railways can be expected. The market share for the relevant market increases from 19.2 to 21.4% which makes a difference of 2.2%.

Going to the *Upper Limits* of the valuation ranges for external costs would increase this effect substantially. The modal share of rail in inter-regional freight transportation is in this case expected to grow significantly by 4.9 from 19.2 to 24.1%. In particular Figure 11 underlines that the railways can become the dominant market player on the long-distance transport market for containerised goods. This underlines that a large impact can only be expected from internalisation if all externalities are internalised and they are valued at sufficiently high rates. The completeness of the internalisation scheme is important for achieving substantial results. This does not mean that all externalities have to be included in the km-based infrastructure charges. For instance, climate effects could be internalised by trading schemes or by carbon taxes, or accident externalities could be internalised by insurance taxation. But it means, indeed, that the overall cost increase for road transport induced by the mix of instruments sums up to the cost mark-ups assumed in this study.

Combining the *productivity* assumptions with the full internalisation of external costs will – according to the simulation results – bring a drastic change of the transport market structure. The railways will become leading players for long distance transport of goods which in principle can be containerised. The effects from productivity improvements are of the same order of magnitude as the effect from a internalisation strategy alone. This underlines that internalisation of externalities and productivity gains of the railways are significantly synergetic. If the railways can offer high quality logistics services (consolidation of consignments, just-in-sequence transport) they will become a generic alternative to road. Forwarders and shippers will take this into account, in particular if the reliability of road transport does not increase in the future because of network congestion.

Figures 12-15 show the modal shares of the railways and their dependency on distance.

Figure 12: Transport shifted from road to rail in different scenarios (bill. ton km)

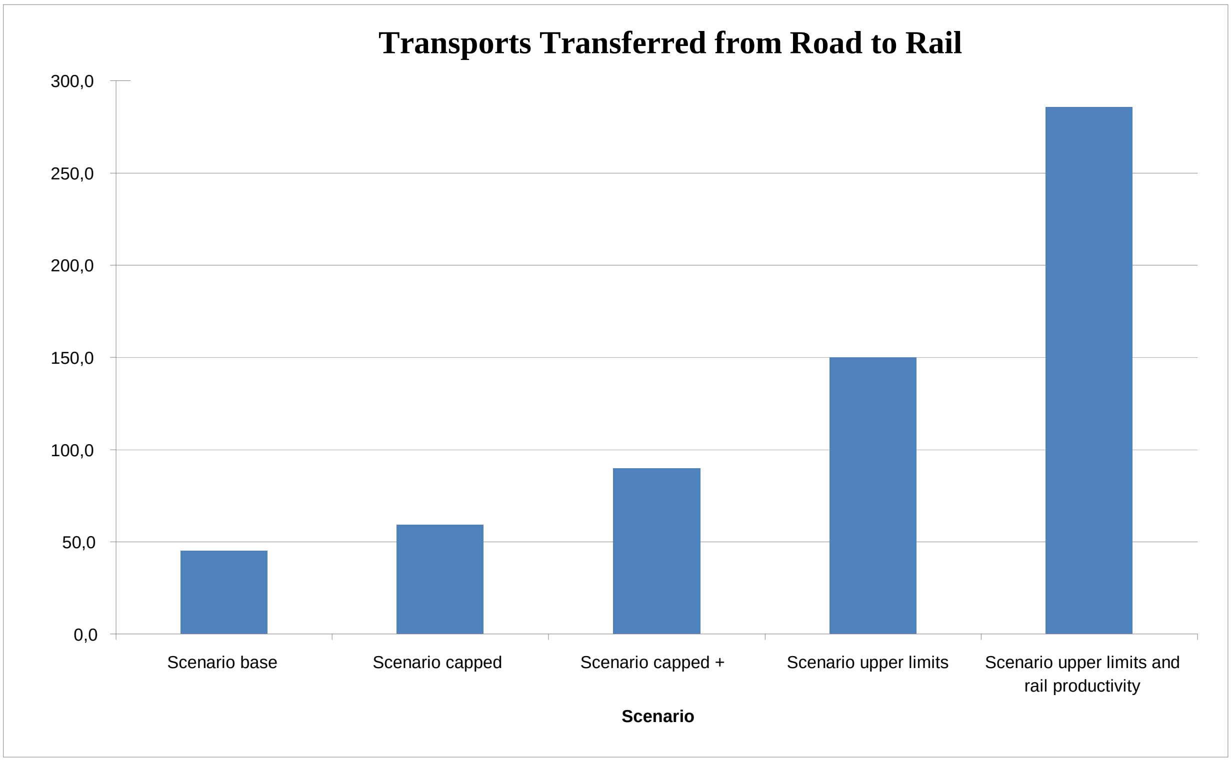


Figure 13: Modal share by distance

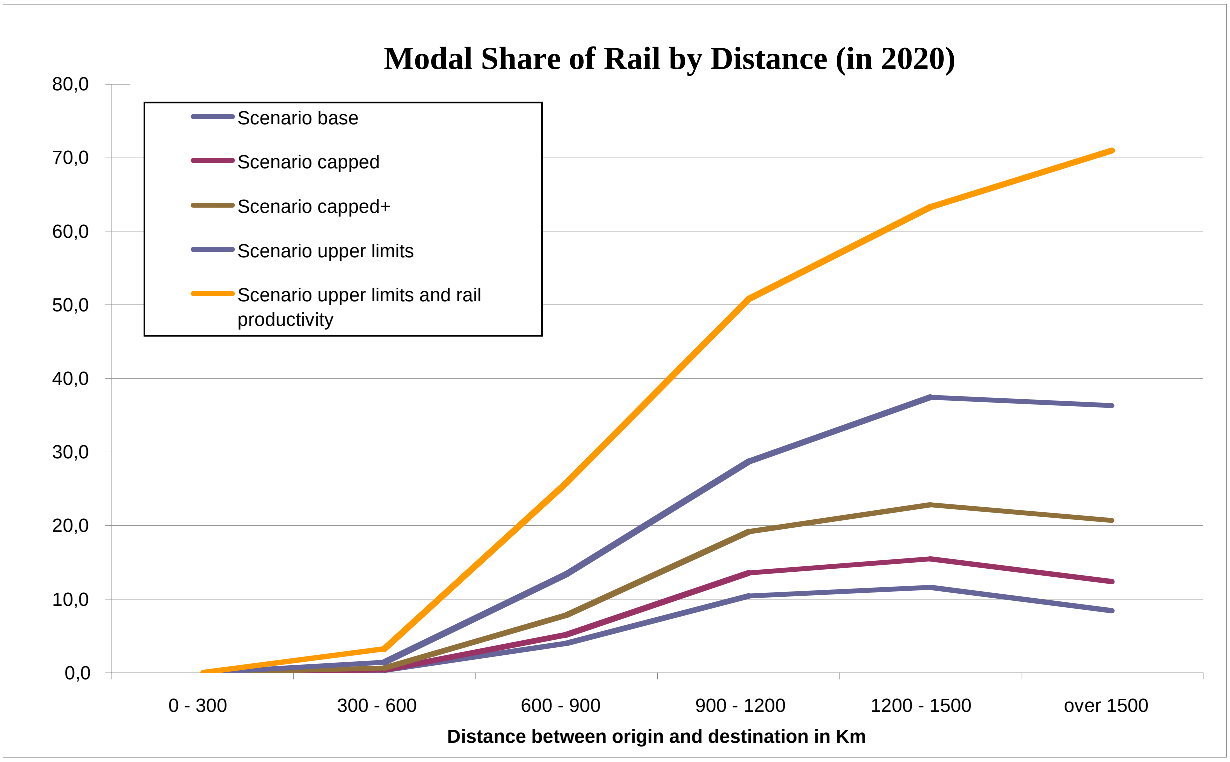


Figure 14: Structure of rail transfer by distance in the Scenario Upper Limits/Rail Productivity

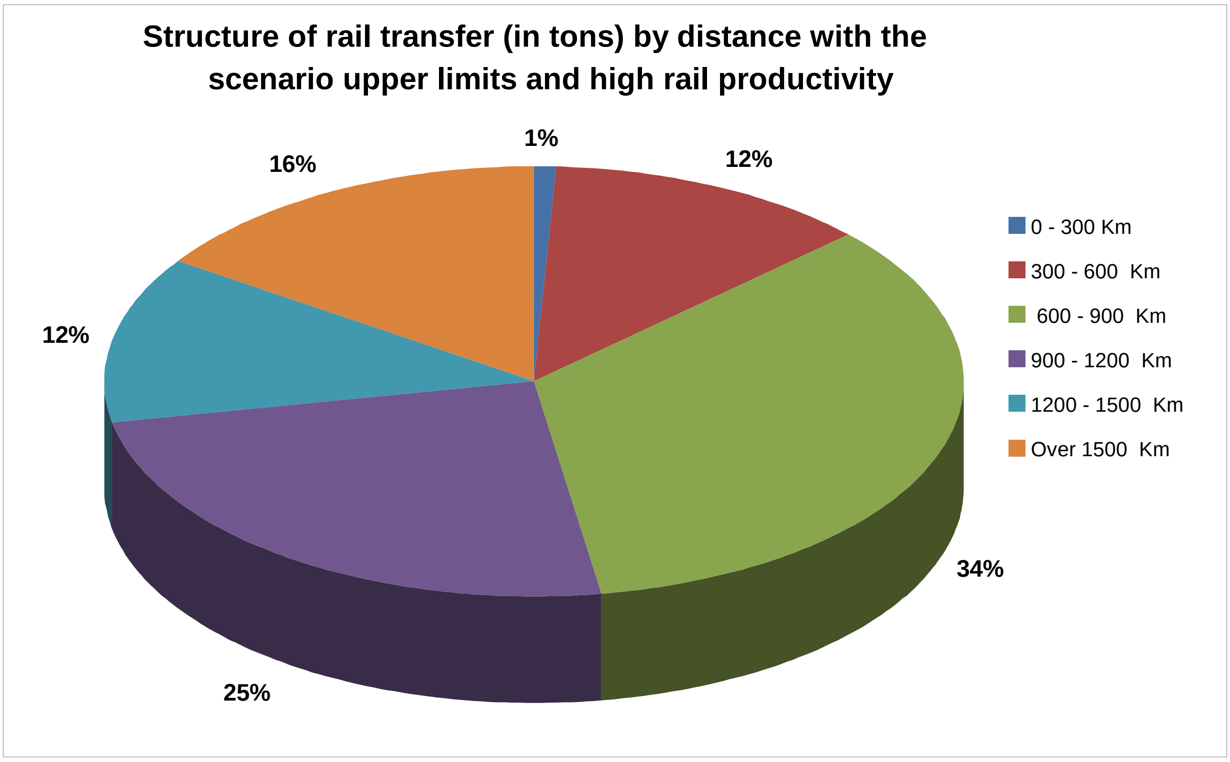


Figure 15: Scenario Upper Limits/Rail Productivity – Modal Shift from Road to Rail

Road Traffic Transferred to Rail with the Scenario Upper Limits

7.2 Corridor Results

Two corridors have been selected for a detailed analysis of modal shift and environmental impacts:

Case Study 1: Rotterdam-Genoa Corridor

Case Study 2: Zeebrügge/Antwerp-Warsaw Corridor.

The definition of a corridor is not a trivial exercise, because on long distances between origins and destinations there may exist a number of routes which partly go parallel to each other. In the present case the corridor definition follows three steps:

Step 1: Definition of a main route, including a limited set of parallel alternative routes. The width of a corridor route has been defined at 50 km.

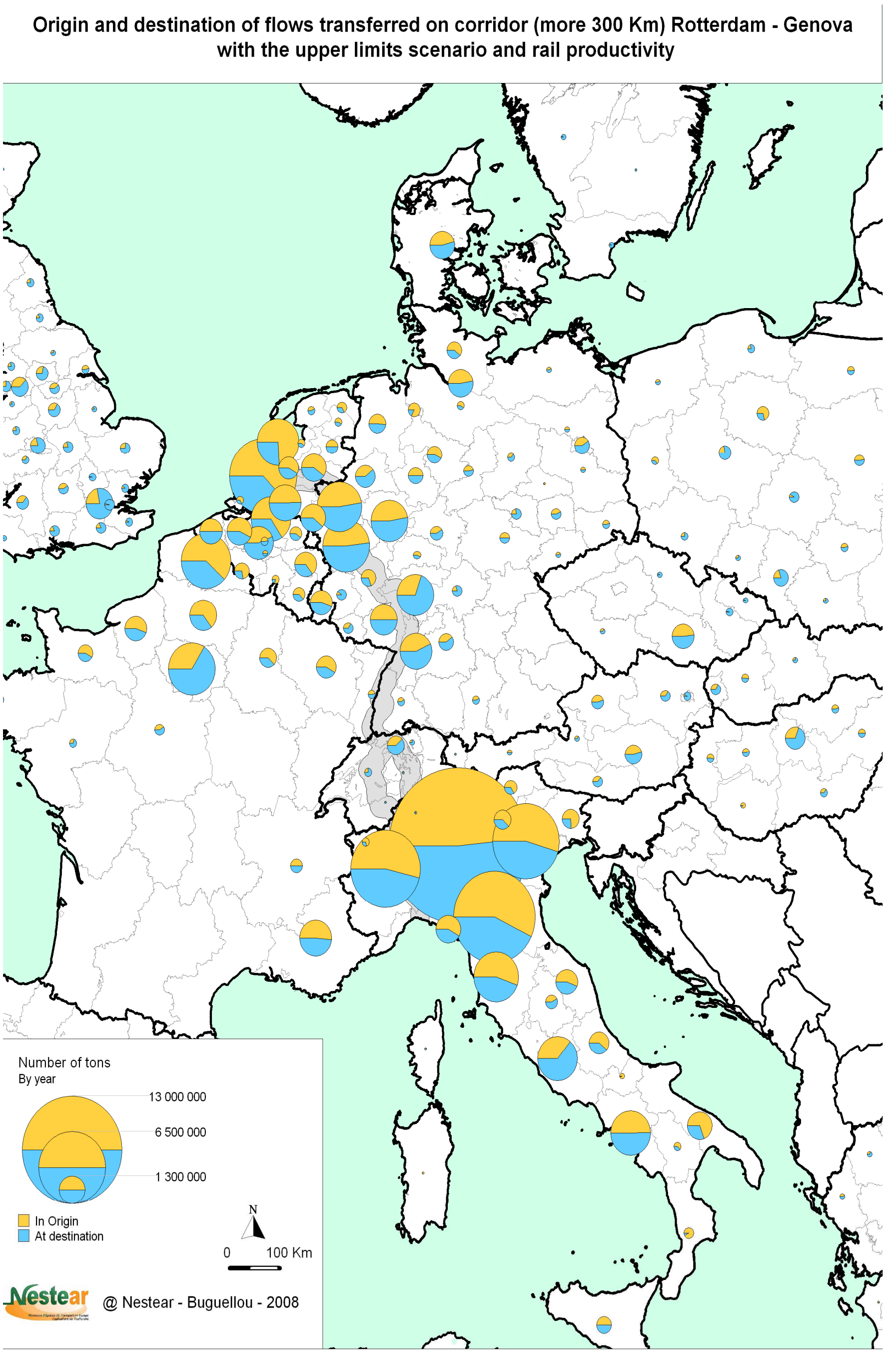
Step 2: Definition of transport activities which are assigned to a corridor. The minimum distance travelled alongside a corridor is used as a criterion and set alternatively to 1 km, 300 km and 500 km. In this summary we will only refer to the 300 km limit.

Step 3: Distinguish traffic which is observed on the defined corridor only, and traffic stemming from origin-destination-pairs which are combined along the corridor by shortest paths. In the latter case also transport activity (tons, ton km) is included which is outside the corridor (access and egress).

7.2.1 Rotterdam-Genoa Corridor

The north-south corridor connects two industrial and trade centres in Europe – The Benelux countries and Northern-Italy. In between a number of agglomeration areas are passed, as for instance Rhine-Ruhr, Rhine-Main and Northern-Switzerland. The transport volumes on this corridor mainly result from the transport relations between these agglomeration zones (Figure 13).

Figure 16: Origins and destinations of flows transferred to rail mode on the Rotterdam-Genoa Corridor



Already today, railway transportation on this corridor is well developed due to a number of factors: important flows of sea-containers, restrictive road transport policy in Switzerland, increasing logistic performance of the railway undertakings and competition between several incumbent companies and new entrants.

Table 6: Ton km shifted to Railway mode on the Rotterdam-Genoa Corridor
Reference: Cost situation of year 2005

Rotterdam-Genoa
For all Origin-Destination and 300 km on the corridor

Bill. Ton km	**Initial Rail**	**Initial Road path**	**Rail trans-ferred**	**Road post and pre shipment**	**Sum ton km rail**	**All rail-way ton km - Europe**	**Share of corridor in total ton km (%)**
Scenario Base	33.1	14.9	16.1	1.2	**49.2**	463	11.3
Scenario Capped	33.1	18.6	19.6	1.5	**52.8**	479	11.0
Scenario Capped +	33.1	24.7	25.6	2.2	**58.7**	513	11.4
Scenario Upper Limits	33,1	33.9	34.3	3.4	**67.4**	577	11.7
Scenario Up. Lim.+Rail Prod.	33.1	46.7	62.5	6.0	**95.6**	734	13.0

Table 6 exhibits the transport volumes shifted from road to rail on the North-South corridor from Rotterdam to Genoa. The first column contains the initial rail bulk cargo transport, which is assumed to be independent of the cost and productivity changes in the scenarios. The second column gives the ton km on road alongside the defined corridor, which is shifted from road to rail in the scenarios. Column 3 shows the total additional rail transport on the corridor, which results from shifting road transport from origins and destinations which used other corridors before the cost/productivity changes. The fourth column gives the additional ton km which have to be transported on road for pre- and post shipment. It underlines that shifting additional transport to rail will also imply additional shipments between origins/destinations and transhipment centres. The fifth column sums up the bulk and container/unitised cargo. From this we can derive the differentials between the Base Scenario and the External Cost/Rail Productivity Scenarios. Columns 6 and 7 give the total figures for rail transport in Europe and the shares of the total which is allocated to the North-South corridor. The latter will increase with rising competitiveness of the railways on the major corridors.

The Base Scenario shows considerable shifts of transport compared with the reference cost situation which is given by the 2005 cost values. As Table 1 shows, very substantial changes have to be expected between 2005 and 2020 which do not relate to the External Cost/Rail Productivity Scenarios and therefore are included a priori in the Base and all other Scenarios.

The results for corridor Rotterdam-Genoa perfectly support the general picture sketched above. The Capped Scenario, based on the proposals of the Commission for internalising congestion, air pollution and noise externalities, generates low impacts, but at least it tends to the desired direction. The integration of all Handbook externalities at medium values (Capped+) more than doubles this effect such that it becomes substantial. Scenario Upper Limits takes the high values of the Handbook and results in a doubling of the Capped+ modal shifts.

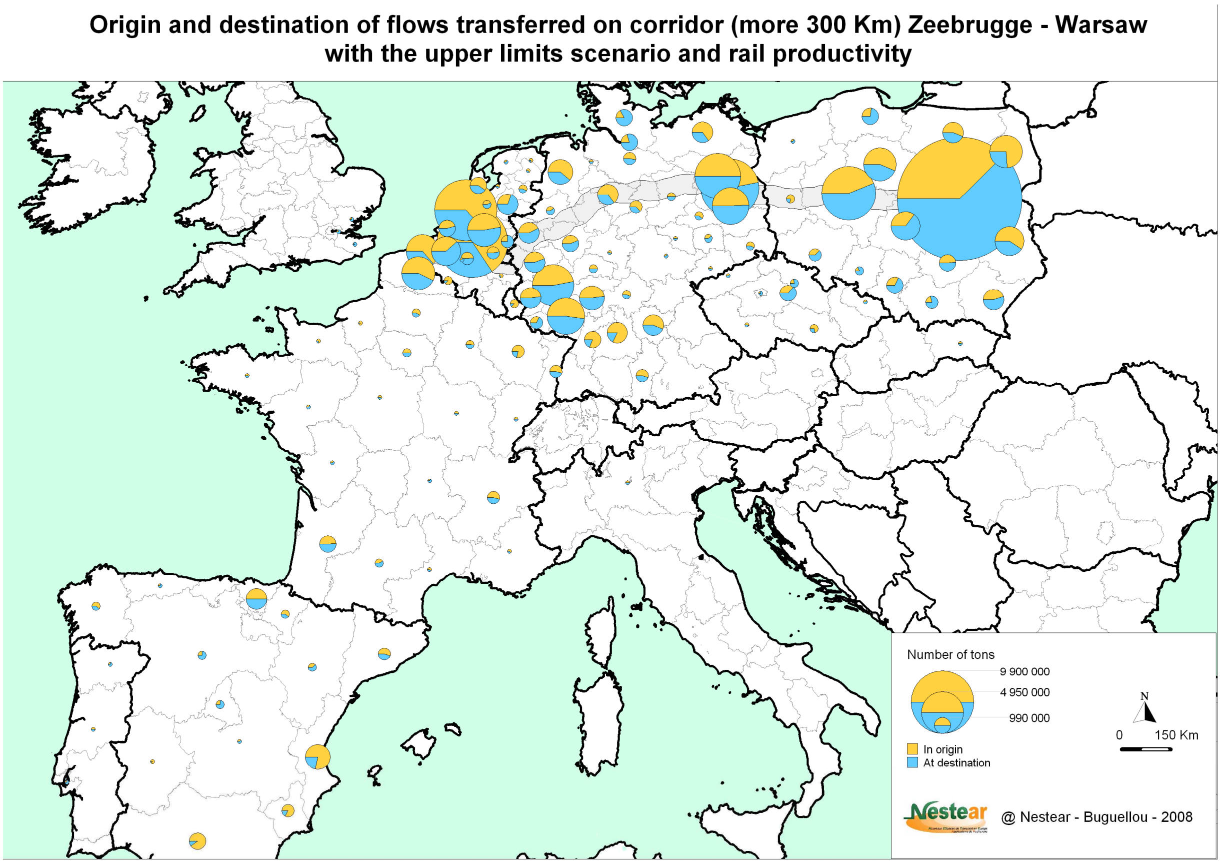
Increased rail productivity according to the high productivity assumptions achieves a similar modal shift like the Upper Limits Scenario. Combining Upper Limit and Rail Productivity boosts the modal share of railways insofar as 46.4 Bill. ton km are shifted from road to rail compared with the Base Scenario. This demonstrates that a significant synergy effect can be expected from a combined policy of fair pricing and developing railway productivity.

Figure 17: Road Transport Shifted from Road to Rail in the Upper Limit/Rail Productivity Scenario on the Corridor Rotterdam-Genoa

7.2.2 Zeebrügge/Antwerp-Warsaw Corridor

The East West corridor mainly connects the industrial centres in the Benelux countries and the Ruhr area with the Warsaw area. Berlin and Poznan are important centres along the corridor.

Figure 18: Origins and destinations of flows transferred to the Zeebrügge/Antwerp-Warsaw Corridor



This East-West corridor is developing rapidly, however, the bases for tonnage and ton km are much lower compared with the busy North-South corridor between Rotterdam and Genoa[7]. As there are a number of transport corridors in Europe which show similar characteristics, i.e. modest volumes today and rapid increase of transport performance, Antwerp-Warsaw is a good prototype.

The results of our calculation show indeed that the relative effect of internalisation strategies is bigger for this type of corridor than for already developed ones – railways increase their

[7] Note that the transport volumes depicted by the pie-diagram in Figure 18 look very big for the Warsaw region. This is partly caused by the regional classification (NUTS 2).

market performance by the factor 2.5 (Table 7). For the North-South corridor this factor is 2.0.

Table 7: Transportation performance shifted to the Zeebrügge/Antwerp-Warsaw Corridor
Reference: Cost situation of year 2005

Zeebrügge/Antwerp-Warsaw
For all Origin-Destination and 300 km on the corridor

Bill. ton km	**Initial Rail**	**Initial Road path**	**Rail trans-ferred**	**Road post and pre ship-ment**	**Sum ton km rail**	**All rail-way ton km in Europe**	**Share of corridor in total ton km (%)**
Scenario Base	15.5	4.2	5.6	0.2	**21.1**	436	4.8
Scenario Capped	15.5	6.2	8.0	0.4	**23.5**	479	4.9
Scenario Capped +	15.5	10.3	12.6	0.8	**28.1**	513	5.5
Scenario Upper Limits	15.5	16.9	20.0	1.5	**35.5**	577	6.1
Scenario Up. Lim.+Rail Prod.	15.5	29.7	36.1	3.1	**51.6**	734	7.0

Table 7 shows the transport volumes shifted from road to rail on the West-East corridor from Zeebrügge/Antwerp to Warsaw. The first column contains the initial rail bulk cargo transport, which is assumed to be independent of the cost and productivity changes in the scenarios. The second column gives the ton km on road alongside the defined corridor, which is shifted from road to rail in the scenarios. Column 3 shows the total additional rail transport on the corridor, which results from shifting road transport from origins and destinations which used other corridors before the cost/productivity changes. The fourth column gives the additional ton km which have to be transported on road for pre- and post shipment. It underlines that shifting additional transport to rail will also imply additional shipments between origins/destinations and transhipment centres. The fifth column sums up the bulk and container/unitised cargo. From this we can derive the differentials between the Base Scenario and the External Cost/Rail Productivity Scenarios. Columns 6 and 7 give the total figures for rail transport in Europe and the shares for the North-South corridor, which will increase with rising competitiveness of the railways.

On this corridor there are less congested areas compared with the Rotterdam-Genoa corridor. Accordingly, the low congestion charges (on the average) on this corridor reduce the relevance of congestion fees. As the remaining two externalities, air pollution and noise, are valued low in the Capped Scenario, the impact on transport is negligible. The transport shifts increase by the factor 3 as soon as the full range of externalities is internalised (at medium values). In this case the reaction of transport demand is significant. This effect can be doubled again, if the upper values of the full range of externalities are internalised.

Combining the Upper Limits Scenario with increased Rail Productivity results in a drastic upturn of the railway share through a shift of 30.5 bn ton km in the year 2020, compared with the Base Scenario. This result is remarkable insofar as the percent change of impacts of External Cost/Rail Productivity policies is greater on the West-East compared with the North-South corridor although the congestion level on the North-South corridor is much bigger. This underlines the effectiveness of a combined policy with the clear objective to improve on the market position of the railways by concerted policy actions.

The results also underline that the potential of modal change on the freight transport market are much bigger than assumed in the Mid-term Review of the Commission White Paper (2006), based on the ASSESS-Scenario results. ASSESS estimates an increase of rail freight transport until the year 2020 of 13%, which would imply a decline of market share of the railways. The corridor results underline the general indication that the railways have a much higher potential and can contribute to the environmental targets of the EU by attracting higher transport shares. The study results support the vision of a re-vitalisation of European railways as developed in the White Paper on Common Transport Policy of 2001 “Time to Decide”. But the comparison with the railway prospects exhibited in the Mid-term review gives rise to question whether the measures considered in the White Paper are strong enough to achieve the targeted result.

Figure 19: Road Transport Diverted to Rail on the Antwerp-Warsaw Corridor, Scenario Upper Limits/Rail Productivity

Road Paths Transferred to Rail with the Scenario Upper Limits and High Productivity of Rail and more than 300 km on the corridor

8 Environmental Impact: Impact on the Emission of Greenhous Gases

8.1 Principles of Measurement

The assumptions made on relative cost changes in the scenarios Base, Capped, Capped+, Upper Limits, and 'Upper Limits + Rail Productivity' have a significant effect on the emission of CO_2 from freight transport. This is due to the fact that

- freight transport is partly shifted from road to the less energy-intensive rail mode,
- road congestion is alleviated because of the expected modal shift.

The corridor Rotterdam-Genoa, and especially the western part of the corridor Antwerp-Warsaw follows densely populated areas, connecting major urban settlements (see Figures 20 and 21). This implies that road transport activities along these corridors cause high levels of environmental damage, and are increasingly inefficient operations due to congestion.

Figure 20: Urban areas along the corridor Rotterdam-Genoa

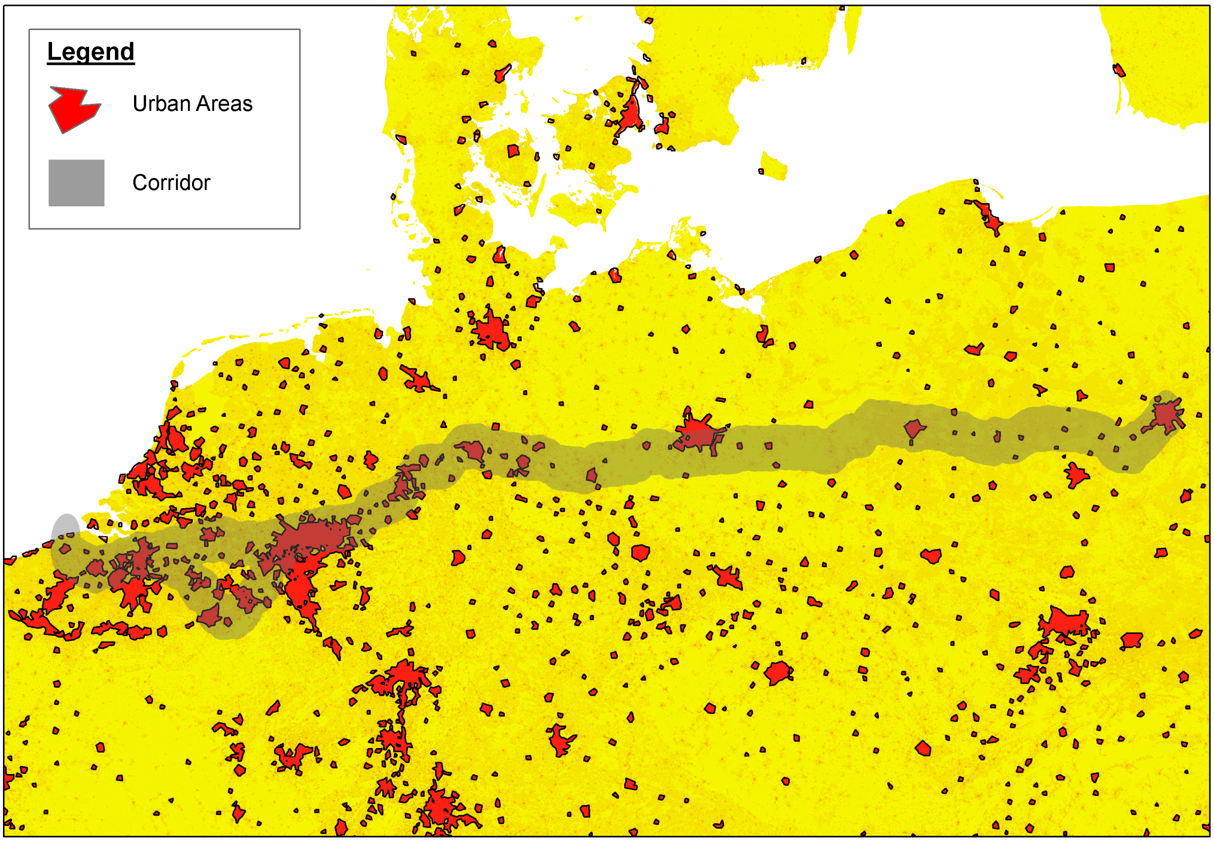
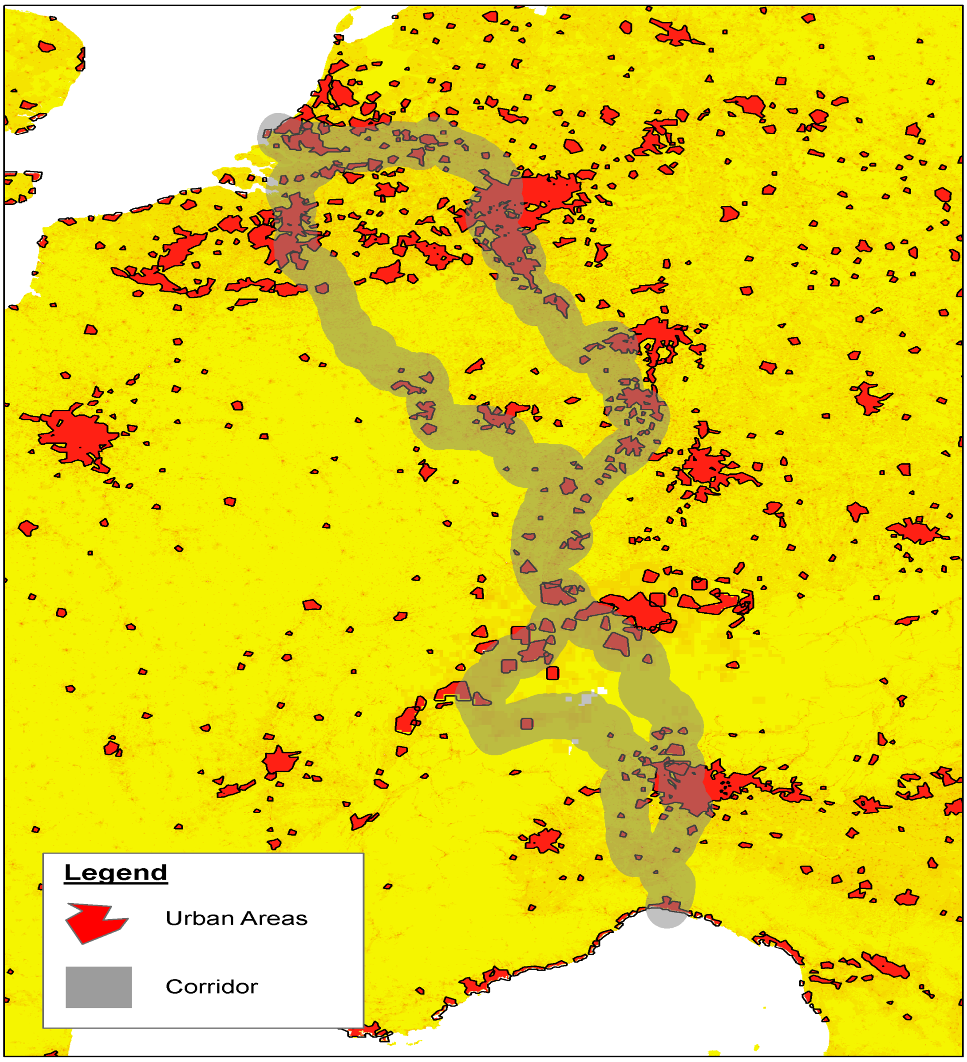


Figure 21: Urban areas along the corridor Rotterdam-Genoa



The measurement of environmental impacts is based on three modelling instruments:

- NESTEAR model for railway assignment and modal split,
- IWW-VACLAV model for road traffic assignment including all user categories,
- IWW-GIS model to identify urban and suburban areas.

The IWW-VACLAV modelling for road traffic assignment starts from the NESTEAR modal split values and the associated freight transport matrices. The freight transport matrices differ according to the scenarios and are added to the other traffic categories (car, LDV, short-distance HGV). As VACLAV is calibrated on the base of observed traffic flows (UN traffic count data base) it produces a realistic picture of the overall traffic loads or the road system. This also holds for agglomerated areas such that the classification prepared in the Handbook for urban, suburban and non-urban areas is not a necessary input. The model generates congestion endogenously and produces a much more detailed pattern of capacity loading and the associated congestion as well as environmental impact figures. It is possible to relate all outcomes of the calculations to raster cells (GIS grid units) or network links (infrastructure units). The higher degree of detail gives more insight into the hot spots of the network and the contribution of HGV charging to reduce the bottleneck problems.

Figures 22-26 depict the road network loading for the Base Scenario 2020 and the reduction of traffic load in the Upper Limits/Rail Productivity Scenario. The base is the network of the Base Scenario 2020 loaded by car, LGV and HGV (Figure 22). The busiest parts of the network can be identified and will be analysed by the further figures with respect to freight transport.

Figure 22: Average daily traffic, passenger cars, LGV and HGV, in the Base Scenario 2020

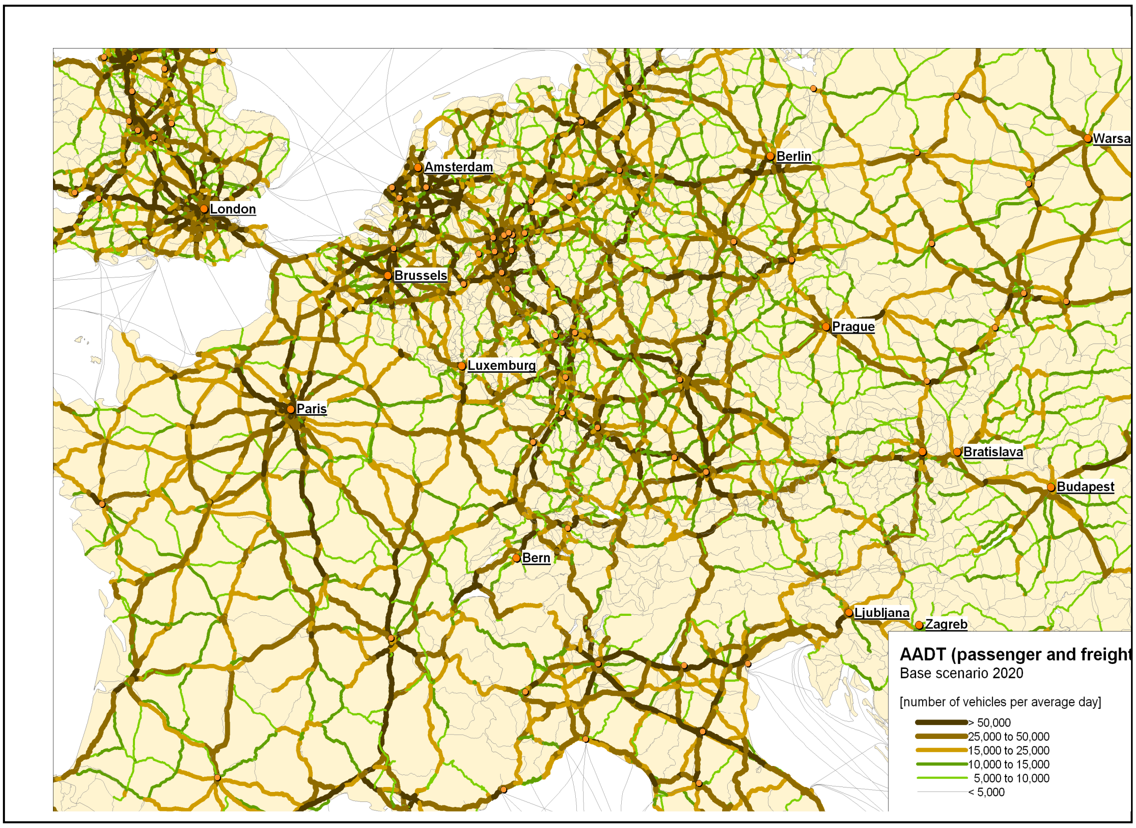


Figure 23: Traffic load with goods vehicles in the Base Scenario 2020

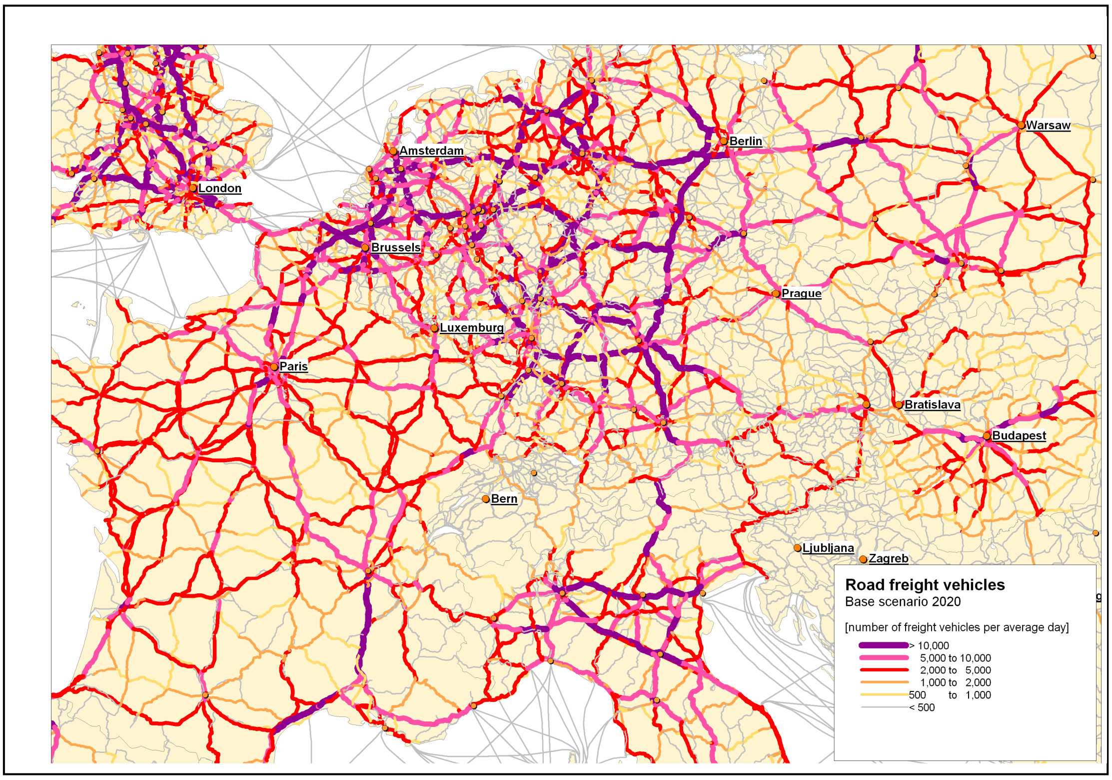


Figure 23 shows the load of the road network in the Base Scenario 2020 with freight vehicles, 3.5 tons and more. The busiest parts are Southern UK, Benelux, Rhine-Ruhr, Rhine-Main regions and Northern Italy. It was assumed that most of North-South transport on long distances passing through Switzerland is transferred to rail shuttle along the Gotthard and Lötschberg tunnels. The reasons are strong assumptions on (1) low tariff for the rail shuttle and (2) the use of the shuttle time for drivers resting. This explains among other reasons why the share of rail transport on the North-South axis is increasing in the Base Scenario 2020 considerably compared with the situation 2005.

All internalisation and productivity scenarios result in a shift from road to rail and eventually in route diversions because of congestion pricing. Scenario Upper Limits/Rail Productivity is the most effective scenario with this respect and contributes to a significant relief of traffic congestion along the busiest corridors. Figure 24 shows that the reduction of HGV on main routes is more than 1,000 vehicles per day and in heavily congested areas even up to 2,000 vehicles per day or more. Taking into account that the average equivalence factor of trucks with respect to the influence on traffic flow is about 2.5, the equivalent reduction of traffic load and assuming an average daily traffic volume of 50,000 car equivalents this would result in a reduction of about 10%. For a road which would be loaded to 100% of its capacity in the

Base Scenario with highly unstable traffic flow this would imply a reduction to 90% of capacity and much more stable flow conditions. From this it follows that also the *road haulage industry would benefit* from the internalisation/productivity policy insofar as the logistic chains served by trucks – almost all short-distance and most of medium distance origin-destination relationships – would enjoy improvements by better reliability and accountability of services.

Figure 24: Difference traffic load goods vehicles Scenario Base versus Upper Limits/Rail Productivity

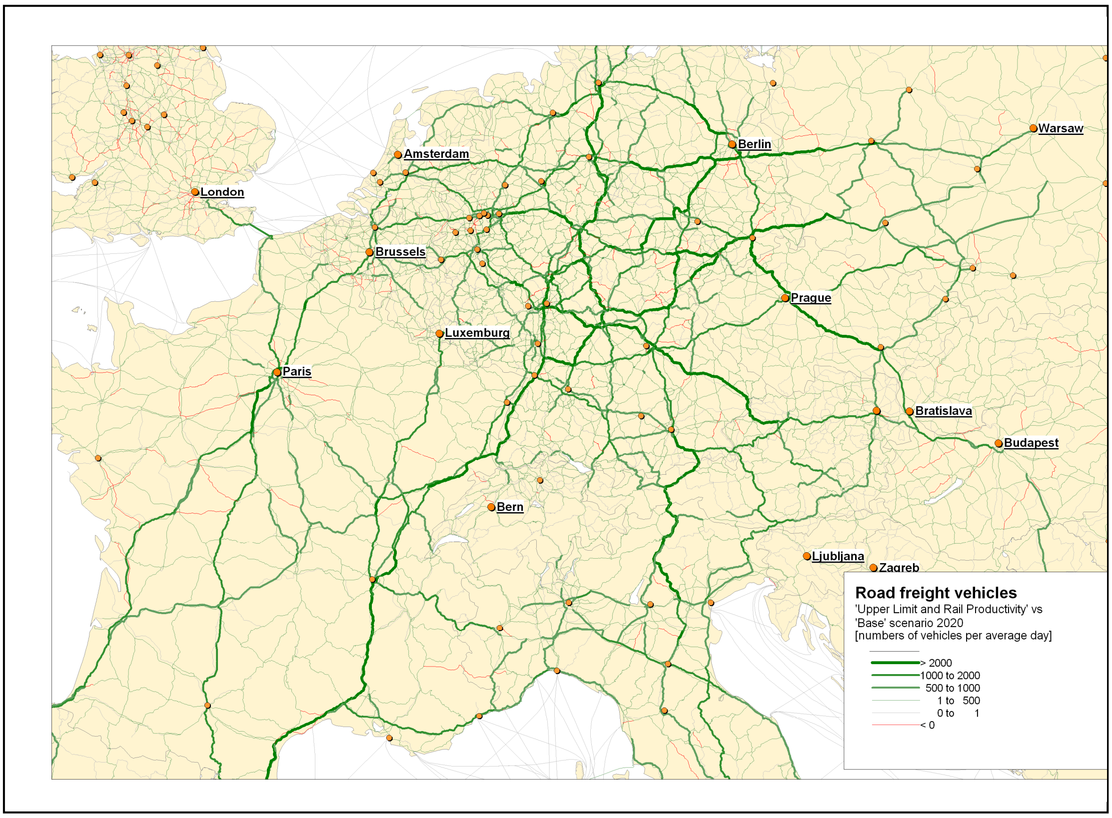


Figure 25 identifies the congested network parts of road freight transport in more detail such that the time losses caused by congestion can be quantified for every movement between origin and destination. Furthermore functional relationships between speeds, the associated driving cycles and fuel consumption (as well as emissions of NO_x or particles) can be applied to calculate CO_2 and other emissions.

Figure 25: Time losses caused by congestion, Base Scenario 2020

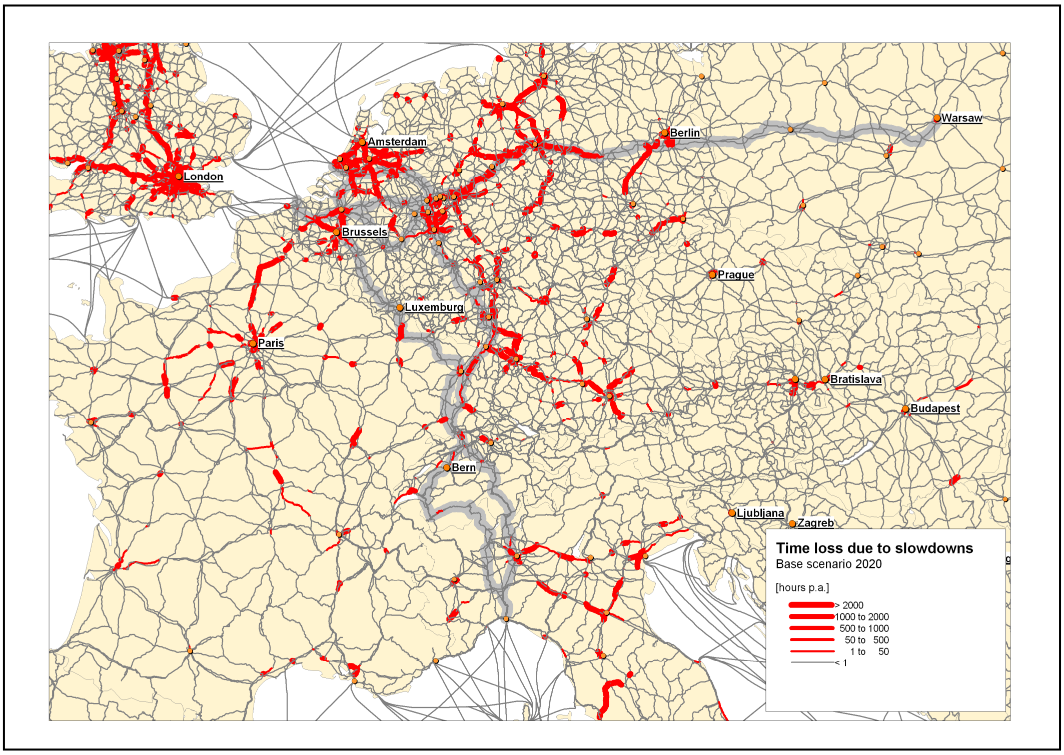


Figure 26: Difference of time losses due to congestion. Base versus Upper Limit/Rail Productivity Scenario

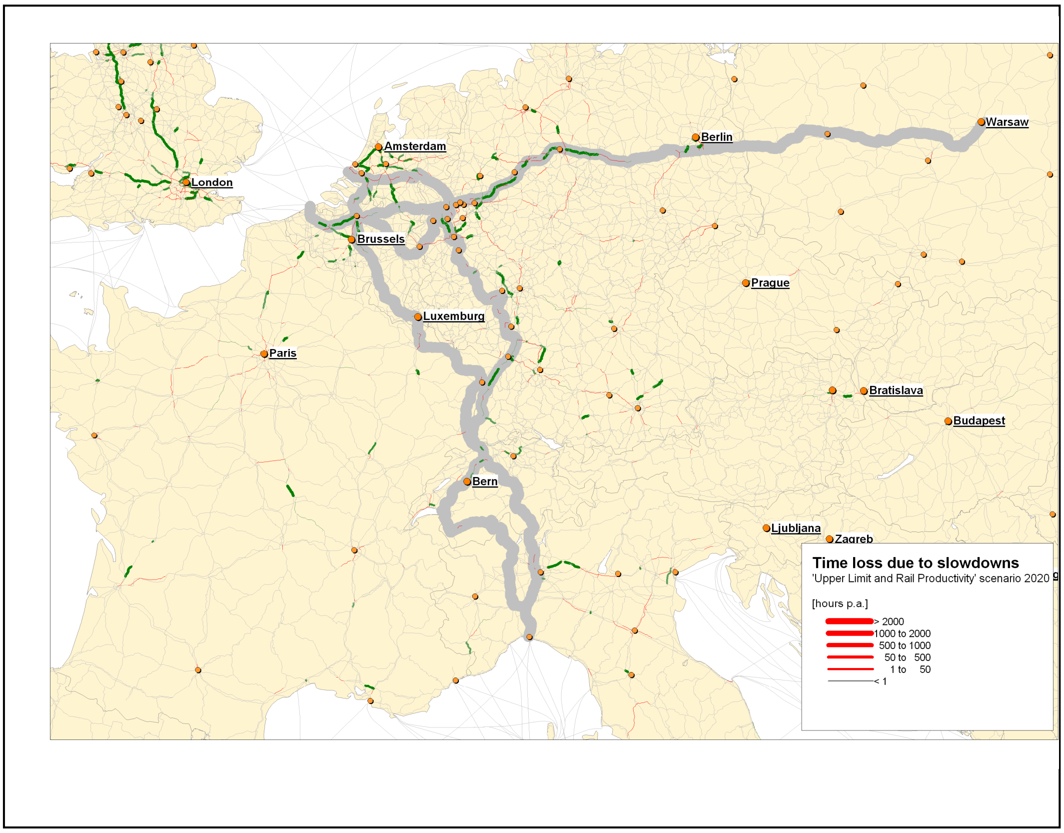


Figure 26 gives the differences of the time losses between the Base and the Upper Limits/Rail Productivity Scenarios for the corridors under comparison. As most of the congested areas on the North-South corridor (Rotterdam-Genoa) are in the Benelux, the Rhine-Ruhr and the Rhein-Main areas the main reductions of congestion are observed in these areas. The optimistic assumptions with respect to the acceptance of the rail shuttle through Switzerland effect that no congestion will occur in this country and also no reduction of congestion due to internalisation of externalities in the EU. Note that Switzerland applies already the most advanced infrastructure and external cost internalisation scheme such that the domestic transport flows are not influenced by EU policy.

Looking at the West-East axis from Zeebrügge/Antwerp to Warsaw the map identifies the major effects in the Benelux and the Rhine-Ruhr area. East of Berlin there will be little congestion because it is assumed that the motorway Berlin-Frankfurt/Oder – Warsaw will exist in 2020. For all network parts which will experience a relief of congestion the associated changes of speed, driving cycles and emissions of CO_2 or other pollutants have been calculated.

As a result, all changes of truck movements and conditions on roads could be translated into savings of CO_2 (and other) emissions for the total network and for the two selected corridors. These savings have to be compared with the additional emissions caused by the increase of rail movements.

Shifting transport from road to rail implies additional production of externalities by the railway mode, which has to be considered in a total balance of impacts. NESTEAR has produced link-related figures for additional freight trains alongside the corridors, which could be used as inputs for the calculation of energy consumption and CO_2 emissions. The additional energy consumption caused by additional transhipment activities at intermodal freight centres and railports have been considered as well as the increase of road shuttle for intermodal transport activities.

This model approach would in principle allow for a detailed estimation of air pollution, noise and accident impacts. As this would presuppose, however, further modelling work, based on raster cell and link information, to analyse the concentration of pollution and the exposure of population to air pollution and noise this analysis concentrates on the quantification of CO_2 emissions only.

8.2 Results of CO_2 Impact Calculation

The technical assumptions for the CO_2 impact estimation are summarised in the following Table 7.

Table 7: Assumptions made to estimate rail freight CO_2 emissions

Determinant	Assumption
Average weight of train	1,000 tons gross weight
Average link speed of freight train (without intermediate stops)	80 km/h
Energy efficiency of freight trains	Increase by 10%, due to decrease in container weight, improved loading factor, longer trains
Electricity production	Decrease of proportion of fossil energy sources by 4% (from 48% in 2005 to 44% in 2020, country mix)
Energy efficiency of coal-fired power plants	Improve in energy efficiency by 8% (from 32% in 2005 to 40% in 2020)

Table 8 gives the absolute CO_2 emission values for the relevant network and the relevant transport market.

The relevant market contains all inter-regional non-bulk transport with a forwarding distance >300 km. There are some rationales behind the sketched definition of the relevant market:

- A modal shift of bulk transport has not been considered in the present study.
- A major proportion of non-bulk transport <300 km are caused by distribution activities which are mainly captive to road transportation.
- The cost for transhipment and marshalling operations inhibit a significant modal shift of transports <300 km (see. Figure 8).

Table 8: CO_2 emissions – absolute volumes

Mill. t CO_2	Base	Capped	Capped+	Upper Limits	UpLimits + productivity
Road freight	88.79	87.90	86.14	81.72	71.99
Rail freight	4.84	5.14	5.79	7.00	9.99
Total	93.63	93.04	91.93	88.72	81.98
Reduction		**0.58**	**1.70**	**4.91**	**11.65**
Reduction %		**0.62**	**1.82**	**5.25**	**12.44**

The overall impact of each internalisation scenario is positive in terms of a reduction of emission of greenhouse gases. The emissions can be reduced on the relevant market for inter-regional freight transport (non-bulk cargo, >300 km) from about 94 in the *Base Scenario* to about 82 million tons per year in the *Upper Limits/Rail Productivity Scenario*. There are considerable differences between the scenarios: While the Capped Scenario can be expected to save only about 0.6 million tons per year, the assumptions of the most ambitious Upper Limit/rail productivity scenario are expected to reduce the CO_2 emissions by about 12 million tons per year for the total network.

Table 9 gives a summary of the changes in CO_2 emissions for the relevant network. Table 10 and Table 11 indicate the changes for the corridors.

Table 9: Impact on CO_2 emissions – absolute changes

Mill. t CO_2	Capped	Capped+	Upper Limits	Upper Limits + Productivity
Difference Road freight	-0.88	-2.65	-7.07	-16.80
Difference Rail freight	0.30	0.95	2.16	5.15
Total difference	**-0.58**	**-1.70**	**-4.91**	**-11.65**

Table 10: Impacts on CO_2 emissions on the Corridor Rotterdam-Genoa – absolute changes

Mill. t CO_2	Capped	Capped+	Upper Limits	Upper Limits + Productivity
Difference Road freight	-0.18	-0.49	-1.12	-2.88
Difference Rail freight	0.06	0.18	0.34	0.88
Total difference	**-0.12**	**-0.32**	**-0.78**	**-1.99**

Table 11: Impacts on CO_2 emissions on the Corridor Zeebrügge/Antwerp-Warsaw– absolute changes

Mill. t CO_2	Capped	Capped+	Upper Limits	Upper Limits + Productivity
Difference Road freight	-0.13	-0.36	-0.88	-1.89
Difference Rail freight	0.04	0.13	0.27	0.58
Total difference	**-0.08**	**-0.23**	**-0.61**	**-1.31**

The impact assessment for the two selected corridors with regard to CO_2 emissions clearly indicates that the measures of the *Capped Scenario* are insufficient to reduce the emission of CO_2 to a significant extent. The *Upper Limits Scenario* can be expected to provide a more effective contribution towards the political aim of reducing the amount of emissions of greenhouse gases. The most significant result however, can only be achieved, if a consequent internalisation strategy for road is accompanied by considerable efforts of the states and the railway companies to remove bottlenecks and enhance productivity.

Some remarks are necessary to interpret the magnitude of the overall results. The overall reduction of CO_2 from long-distance, non-bulk freight transport by 12.4 % is remarkable. Nevertheless it is below other estimations in the literature as for instance the FACORA study (2005) or the recent report of the European Environmental Agency (2008), which estimates, for instance, that the CO_2 efficiency of the railway freight is four times higher than that of road haulage.

The lower results in our study stem from the following considerations: It has been considered that the absolute reduction of CO_2 emissions on the road-side is partly compensated by an increase in CO_2 emissions caused by additional rail freight operations. We have also considered in this study that combined transport and single wagon operations are the rail products to compete in the road-competitive market segments. These rail products imply more transhipment processes, handling activities, a share of empty space in wagons, and less tonnage of a full train, compared with bulk transport, which is still the dominating market segment. Furthermore, additional movements on road are necessary for pre- and post-shipment and the number of rail km on the main run may exceed the number of road km.

The outcome from the above calculations for road and rail paths was that the relationship of specific CO_2 emissions rail:road is about 1:2.5. This can be regarded as a lower bound. If one takes into account that also a part of bulk cargo can be transferred from road to rail then more efficient rail technologies could be applied to accommodate this type of transport. Furthermore, we have not considered extra long train formations or double stack container transport which would lead to further remarkable increases of rail productivity.

From this it follows that the contribution of the modal shift from road to rail on inter-regional freight relationships to the reduction of CO_2 can be estimated at about 12 mill. tons per year. It follows that a modal shift would bring a substantial contribution to the "Bali Roadmap" and the EU target set to cut CO_2 emissions of transport. According to EEA (2008) the projected emissions of transport in the EU will be 949 mill. tons in 2010. If emission are to be reduced to 1990 level of 767 mill. tons/year in 2020, this would require a reduction of 182 mill. tons/year. The modal shift from road to rail estimated in this study under the Scenario Upper Limits/Rail Productivity would contribute about 7% to this goal.

In this sense a modal shift policy would reinforce the effects of planned measures for changing fuels, increasing vehicle efficiency and the implementing the energy package.

9 Conclusions

(1) The proposal of the Commission for a revision of Directive 2006/38 to internalise the externalities of congestion, air pollution and noise with capped values for road freight transport will lead to only modest benefits for the railway industry.

Congestion is in the first instance an argument to differentiate charges according to the time of the day or the location. But it will not lead to a substantial global increase of the total cost for using road infrastructure.

The advantages of the railways with respect to *air pollution* will diminish in the future. The Handbook impact calculations for internalisation scenarios are based on Euro 2 and Euro 4 emission classes. We have assumed that Euro classes below Euro 5 will have only small market shares in 2020 and that most trucks operating on highways and motorways will be Euro 5 and better, at least in Western Europe. It has to be expected that this development will be considered by the national governments when they finally decide on the magnitude of the mark-ups for externalities.

With respect to *noise* all transportation modes will have long-term problems. Railways have lower noise costs on average but on busy corridors they have to make big investments in noise reduction to improve the acceptability to the population of increased rail freight traffic. As the suggested mark-ups in the Commission's proposal are comparatively low, their impacts will play little role in intermodal competition.

(2) As a matter of fact all externalities, for which the internalisation would bring a strong and long-term advantage for the railways, are ruled out in the proposal of the Commission. Indeed, only the internalisation of climate, accident and infrastructure related externalities would bring a relative advantage for the railways of an order of magnitude that would affect the decisions of shippers and forwarders. If this relative advantage would be combined with a substantial increase of productivity and level of service of railways, the railways can become the leading player on the land-borne container transport market over long distances.

(3) These arguments have been specified in the analysis of two corridors and based on micro–logistics arguments. The two corridors can serve as demonstrators for the detailed effects, which will stem from substantially improved service quality of the railways combined with a consequent policy towards externalities of road haulage.

(4) The main results with respect to impacts on modal split for inter-regional freight transport on long distances (>300 km) are

- The effects of internalisation according to the *Capped Scenario* (the Commission's proposal) are marginal. They are expected to improve the modal share of the railways by 0.7 %.

- The effects of the *Capped+ Scenario* (medium values for all external cost elements) are higher and a first significant step towards internalisation of external costs. The forecasted change of modal share is 2.2%.

- The *Scenario Upper Limits* analyses the impacts of a full internalisation on the base of high values for the external costs. It leads to high market reactions and a relevant improvement of the market position of the railways. The change of modal share in this scenario is 4.9%.

- A combination *Scenario Upper Limits/Rail Productivity* is constructed under the assumption that the railways can massively invest to remove bottlenecks and improve their logistics service quality significantly. It will exploit the synergy effects between both policies of internalisation and productivity improvement. In this case the railways will become the dominant market player on long distances and attract a share of 30.5% from the road haulage sector in inter-regional transport (bulk and non-bulk) or about 38% (non-bulk). The change of modal share is 10.3%.

(5) The impacts on CO_2 production of transport are favourable in all scenarios, but differ widely between the *Capped Scenario* and the *Scenario Upper Limits/Rail Productivity*. Detailed calculations using present patterns of rail production technology on the freight market give the following lower bounds for the impacts of the Scenarios:

- The reductions of CO_2 emissions on the Rotterdam-Genoa Corridor vary between 0.1 mill. tons/year (*Capped Scenario*) and 1.0 mill. tons/year (*Scenario Upper Limits/Rail Productivity*).
- The reductions of CO_2 on the Antwerp-Warsaw Corridor vary between 0.08 mill. tons (*Capped Scenario*) and 1.31 mill. tons (*Scenario Upper Limits/Rail Productivity*).

(6) Assuming more optimistic prospects for the future railway technologies, which are consistent with the *Rail Productivity Scenario*, gives the following result for the relevant network and inter-regional transport without bulk: The reduction of CO_2 production could reach a level of 12 mill. tons/year. This would correspond to 12 % reduction of CO_2 emissions of the inter-regional freight transport >300 km without bulk cargo. The contribution to the Bali Roadmap and the target of the EU to reduce the CO_2 emissions of transport until the year 2020 by at least 182 mill. tons/year could be supported at a significant magnitude (7% of the reduction target).

(7) The Commission has anticipated that the proposed scheme of – voluntary - internalisation of a limited number of externalities at cap values might not achieve desired targets. The Commission has announced that a re-evaluation of the internalisation scheme shall be considered for 2013. This shall concern the treatment of externalities which are excluded now from the scheme, the magnitude and capping of cost values and the voluntary nature of the implementation within the member countries. As the proposal of the Commission can be regarded as a first step towards effective internalisation, the railway companies should be interested in a more concrete and binding roadmap for the further development of internalisation.

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