EXTERNAL COSTS OF TRANSPORT

UPDATE STUDY

Summary

Zurich/Karlsruhe, October 2004

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Final Report, Zurich/Karlsruhe, October 2004

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SUMMARY

AIM AND METHODOLOGY

This study is an update of a former UIC study on external effects (INFRAS/IWW 2000). It aims at improving the empirical basis of external costs of transport based on the actual state of the art of cost estimation methodologies reflecting also recent studies on external costs of transport on a European level (especially UNITE).

The following dimensions are considered:

› Cost categories: Accidents, noise, air pollution (health, material damages and biosphere), climate change risks, costs for nature and landscape, additional costs in urban areas, up- and downstream processes and congestion.
› Countries: EU 17 (EU member states, Switzerland, Norway).
› Base year: Detailed results for 2000.
› Differentiation by means of transport:
  › Road transport: Private car, motorcycles, bus, light goods vehicles, heavy goods vehicles,
  › Rail transport: Passenger and freight,
  › Air transport: Passenger and freight,
  › Waterborne transport: Inland water transport (freight).

Two study outputs can be distinguished:

  › Total and average costs for EU17 differentiated by means of transport,
  › Marginal costs per means of transport and traffic situation reflect the additional costs per additional unit of transport. They represent a European average which could be used as basis for the dimensioning of pricing instruments according to the approach of Social Marginal Cost Pricing.

The following table summarises the approach with respect to INFRAS/IWW (2000)

SUMMARY OF METHODOLOGY FOR EACH COST COMPONENT			
Cost component (% of total costs)	**Approach**	**Data basis**	**Differences to the past study**
Accident costs (24%)	Same approach as in INFRAS/IWW 2000	IRTAD, UIC, EUROSTAT statistics	Estimations based on the monitoring/victims principle
Noise costs (7%)	Same approach as in INFRAS/IWW 2000, improved database and methodology for Germany as reference country	ECMT, OECD, STAIRRS (railway noise), UBA Germany	New values for valuation of mortality impacts of transport noise
Air pollution (27%)	Same approach as in INFRAS/IWW 2000	Updated TRENDS data for emissions and traffic volumes, improved emission factors	Improved data basis for emissions, latest results for non exhaust emissions of PM10
Climate change (30%, high scenario)	Same approach as in INFRAS/IWW 2000 (avoidance costs)	TRENDS data for emissions, new shadow prices, two Scenarios: € 20 (low) and € 140 (high) per tonne CO2	New data on avoidance costs and related shadow prices
Costs for nature and landscape (3%)	Same approach as in INFRAS/IWW 2000 (unsealing, restoration and renaturation costs)	EUROSTAT, New Swiss study on costs of nature and landscape (methodology)	Very small differences (mainly changes of transport infrastructure network).
Additional costs in urban areas (2%)	Same approach as in INFRAS/IWW 2000	Up-to-date population data for cities and urban areas	Up-to-date population figures for cities and urban areas, adaptation of cost indicators according to GDP per capita
Up- and downstream processes (7%)	Same approach as in INFRAS/IWW 2000	Ecoinvent, Ecoinventory for the transport sector	Up-to-date life cycle assessment data based on Ecoinvent 2003.
Congestion costs (separate cost category)	Same approach as in INFRAS/IWW 2000	European Transport Model VACLAV	Use of a new traffic data base which is consistent for all countries

Table 1 Remark: The percentages reflect the share of total costs excluding congestion costs.

As shown in Table 1 we use a similar methodological approach to the past study INFRAS/IWW (2000) for this update study. The main reason for this updating procedure is to allow comparability between both studies. The methodology will be applied on significantly improved and updated data sets of most input parameters (e.g. traffic volumes, emission data, dose-response functions, etc.).

Throughout the whole report, congestion costs are treated as a separate issue, since their relevance and measurement are quite different from the ones of other costs categories, especially in regard to total costs. While all other cost categories considered in this study reflect the external costs imposed by transport on the whole of society, including inhabitants not participating in transport, congestion is a phenomenon within the transport sector. Therefore, congestion costs must not be added up with classical externalities.

Three different measures are presented; they provide different results from 0.7% of GDP (decrease of deadweight loss as the potential welfare increase when congestion is internalised) to 8.4% of GDP (sum of charges to be raised to internalise congestion costs) as they address entirely different aspects of the congestion problem. The deadweight loss is taken as the economic measure of external congestion costs in this study.

TOTAL AND AVERAGE COSTS

Accident and environmental costs 2000

The following figures present the results for total and average costs for 2000. **Total external costs** (excluding congestion costs, with climate change high scenario) amount to 650 billion € for 2000, being 7.3% of the total GDP in EU 17. Climate change is the most important cost category with 30% of total cost, if high shadow prices are used. Air pollution and accident costs amount to 27% and 24% respectively. The costs for noise and up- and downstream processes each account for 7% of total costs. The costs for nature and landscape and additional urban effects are of minor importance (5%). The most important mode is road transport, causing 83.7% of total cost, followed by air transport, causing 14% of total external costs. Railways (1.9%) and waterways (0.4%) are of minor importance. Two thirds of the costs are caused by passenger transport and one third by freight transport.

TOTAL COSTS IN 2000 BY COST CATEGORY & TRANSPORT MODE														
[million Euro/year]			**Road**							**Rail**		**Aviation**		**Water-borne**
	Total	%	Car	Bus	MC	LDV	HDV	Pass. total	Freight total	Pass.	Freight	Pass.	Freight	Freight
Accidents	156'439	24	114'191	965	21'238	8'229	10'964	136'394	19'194	262	0	590	0	0
Noise	45'644	7	19'220	510	1'804	7'613	11'264	21'533	18'877	1'354	782	2'903	195	0
Air Pollution	174'617	27	46'721	8'290	433	20'431	88'407	55'444	108'838	2'351	2'096	3'875	360	1'652
Climate Change High	195'714	30	64'812	3'341	1'319	13'493	29'418	69'472	42'911	2'094	800	74'493	5'438	506
Climate Change Low [1)]	*(27'959)*	*(4)*	*(9'259)*	*(477)*	*(188)*	*(1'928)*	*(4203)*	*(9'925)*	*(6'130)*	*(299)*	*(114)*	*(10'642)*	*(777)*	*(72)*
Nature & Landscape	20'014	3	10'596	276	233	2'562	4'692	11'105	7'254	202	64	1'211	87	91
Up-/Down-stream [2)]	47'376	7	19'319	1'585	335	5'276	16'967	21'240	22'243	1'140	608	1'592	170	383
Urban Effects	10'472	2	5'782	147	127	1'220	2'634	6'112	3'797	426	137	0	0	0
Total EU17 [3)]	650'275	100	280'640	15'114	25'491	58'824	164'346	321'301	223'114	7'828	4'487	84'664	6'250	2'632

Table 2 Total external costs of transport in the EU17 countries.
Remarks:
1) Climate change costs for the climate change low scenario with a shadow value of 20€/ t CO_2 (for information only, values not used to calculate total costs).
2) Climate change costs of up- and downstream processes are calculated with the shadow value of the climate change high scenario (140€/t CO_2).
3) Total costs calculated with the climate change high scenario.

TOTAL EXTERNAL COSTS 2000 (EXCLUDING CONGESTION)

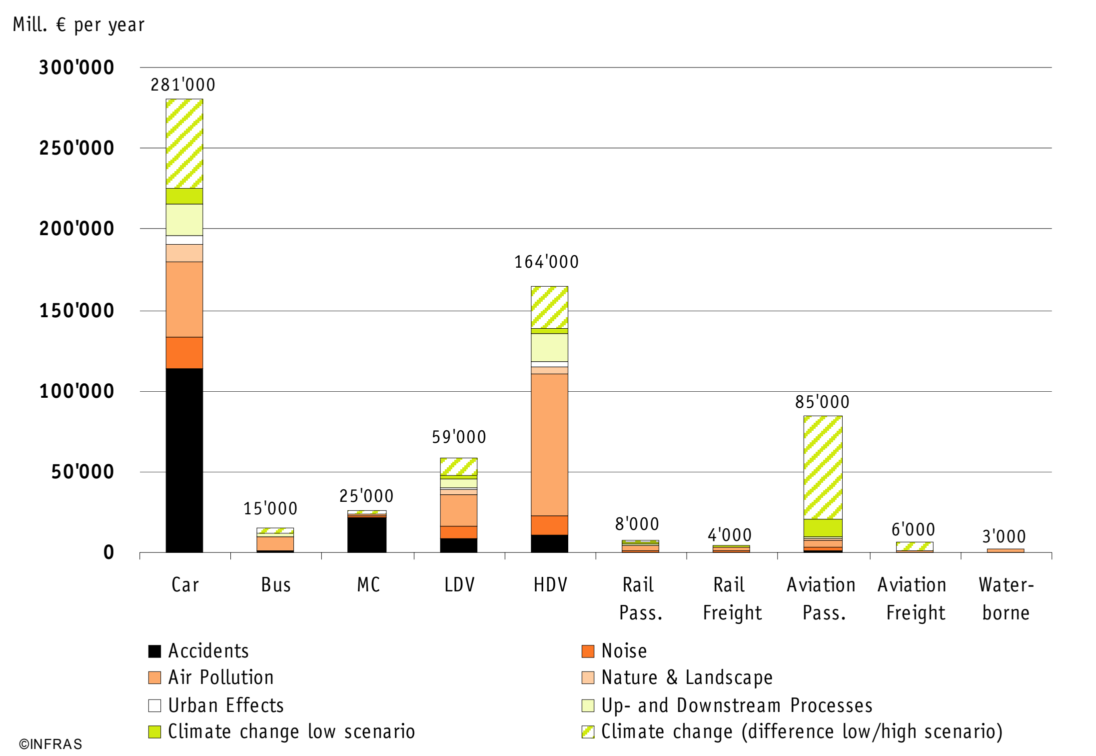

Figure 1 Total external costs 2000 (EU 17) by means of transport and cost category. Road transport is responsible for 84% of total external costs.

Average costs are expressed in Euro per 1'000 pkm and tkm. Within the passenger transportation sector, passenger cars reach 76 Euro (high scenario). Railway costs amount to 22.9 Euro, which is 3.3 times lower than costs for the road sector. Most important for the railway sector are the effects on air pollution, climate change and noise. For the aviation sector, the predominant cost category is climate change.

In the freight sector, the average costs of air transport are significantly higher than the costs of all other means of transport. This is especially due to the fact that freight load (in tonnes) differs from mode to mode. Aeroplanes for example transport high quality freight of low specific weight. The costs for HDV (heavy duty vehicles) amount to 71.2 Euro per 1'000 tkm, which is 4 times higher than the cost for railways (Climate change high scenario).

AVERAGE COSTS IN 2000 BY COST CATEGORY & TRANSPORT MODE														
	Average Cost Passenger							Average Cost Freight						
	Road				Rail	Avia-tion	Over-all	Road			Rail	Avia-tion	Water-borne	Over-all
	Car	Bus	MC	Pass. total				LDV	HDV	Total				
	[Euro / 1000 pkm]							[Euro / 1000 tkm]						
Accidents	30.9	2.4	188.6	32.4	0.8	0.4	22.3	35.0	4.8	7.6	0.0	0.0	0.0	6.5
Noise [1)]	5.2	1.3	16.0	5.1	3.9	1.8	4.2	32.4	4.9	7.4	3.2[5)]	8.9	0.0	7.1
Air Pollution	12.7	20.7	3.8	13.2	6.9	2.4	10.0	86.9	38.3	42.8	8.3	15.6	14.1	38.5
Climate Change High	17.6	8.3	11.7	16.5	6.2	46.2	23.7	57.4	12.8	16.9	3.2	235.7	4.3	16.9
Climate Change Low[2)]	*(2.5)*	*(1.2)*	*(1.7)*	*(2.4)*	*(0.9)*	*(6.6)*	*(3.4)*	*(8.2)*	*(1.8)*	*(2.4)*	*(0.5)*	*(33.7)*	*(0.6)*	*(2.4)*
Nature & Landscape	2.9	0.7	2.1	2.6	0.6	0.8	2.0	10.9	2.0	2.9	0.3	3.8	0.8	2.6
Up-/Down-stream [3)]	5.2	3.9	3.0	5.0	3.4	1.0	3.9	22.4	7.4	8.8	2.4	7.4	3.3	8.0
Urban Effects	1.6	0.4	1.1	1.5	1.3	0.0	1.1	5.2	1.1	1.5	0.5	0.0	0.0	1.3
Total EU 17[4)]	76.0	37.7	226.3	76.4	22.9	52.5	67.2	250.2	71.2	87.8	17.9	271.3	22.5	80.9

Table 3 Average external costs of transport in the EU17 countries
Remarks:
1) The modal differences in noise costs are directly related to the national noise exposure databases used and thus might be subject to different ways of noise exposure measurement.
2) Average climate change costs for the low scenario (for information only, values not used to calculate total costs))
3) Climate change costs of up- and downstream processes are calculated with the shadow value of the 'Climate Change High Scenario'
4) Total average costs calculated with the climate change high scenario.
5) Noise costs for freight trains might be under-estimated as the simplified traffic allocation procedure applied did allocate most freight trains to daytime traffic.

AVERAGE EXTERNAL COSTS: PASSENGER 2000 (EXCLUDING CONGESTION)

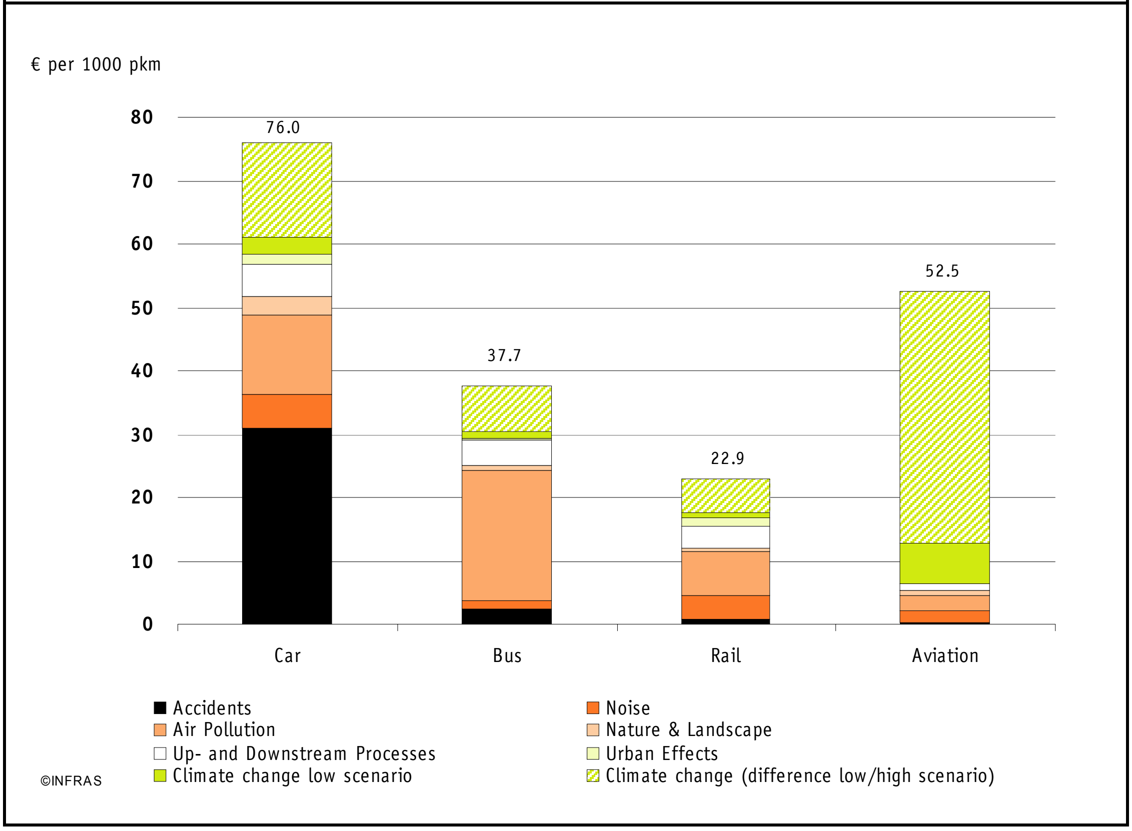

Figure 2 Average external costs 2000 (EU 17) by means of transport and cost category: Passenger transport. The high value of climate change costs in aviation is due to the higher global warming effect of aviation's CO_2 emissions at high altitude during flight (factor 2.5 used compared to the impacts of CO_2 emissions on the earth surface, based on IPCC 1999).

AVERAGE EXTERNAL COSTS: FREIGHT 2000 (EXCLUDING CONGESTION)

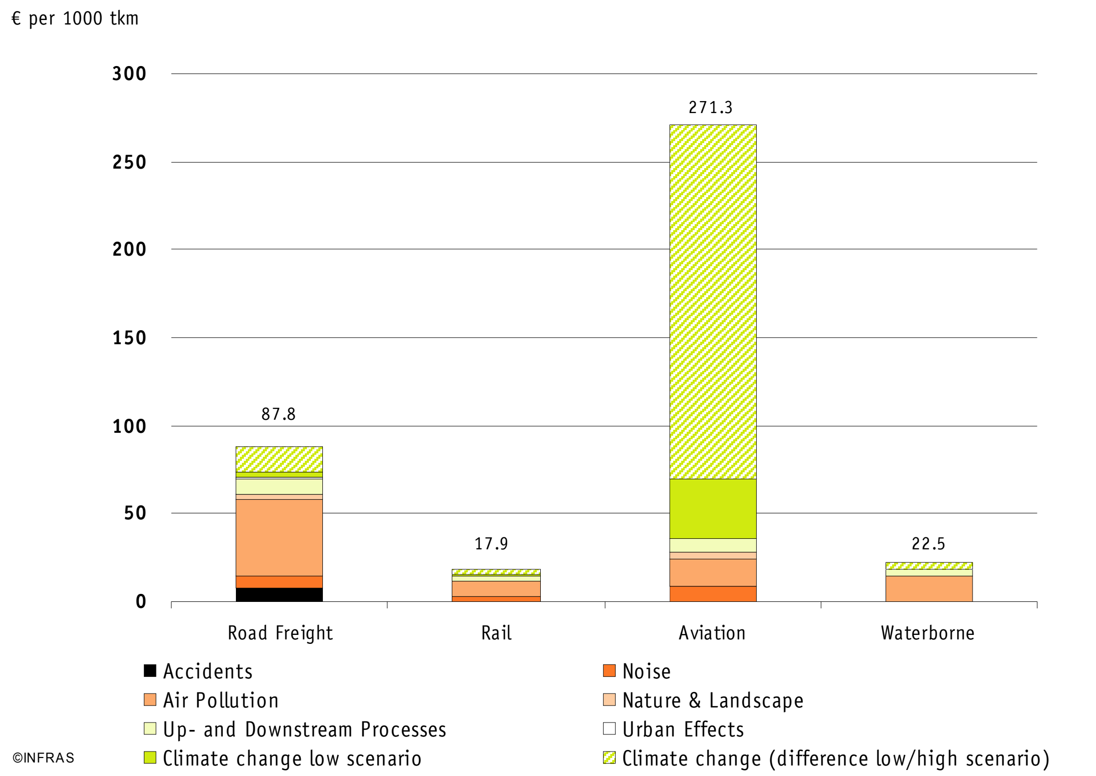

Figure 3 Average external costs 2000 (EU 17) by transport means and cost category: Freight transport. The high value of climate change costs in aviation are due to the higher global warming effect of aviation's CO_2 emissions at high altitude during flight (factor 2.5 used compared to the impacts of CO_2 emissions on the earth surface, based on IPCC 1999).

Development 1995–2000

Total costs increase in the period 1995–2000 by 12.1% (1995 values adjusted to 2000 prices). The main reason for this development are increasing traffic volumes which lead to higher green house gas emissions and thus to increasing climate change risks (especially in road passenger transport and air passenger transport). Another cost category which shows increasing costs are air pollution costs especially for road freight transport. Although PM10 exhaust emissions decrease significantly due to improved engine technologies and particle filters, non exhaust emissions increase more or less in line with traffic volumes.

COMPARISON: TOTAL EXTERNAL COSTS 1995 AND 2000 (EXCLUDING CONGESTION)

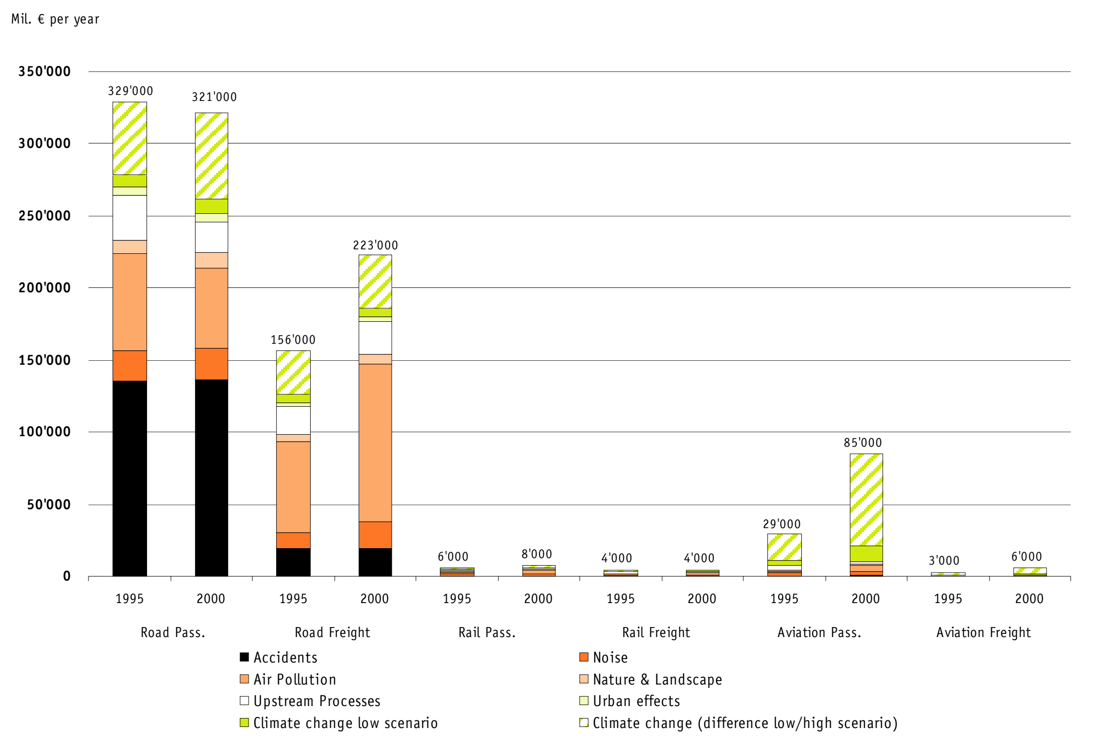

Figure 4 Comparison with the total external costs between the years 1995 and 2000 by transport means and cost category (1995 values at 1995 prices, 2000 values at 2000 prices).

MARGINAL COSTS

The following table shows the values (the ranges respectively) for all cost categories. The ranges are quite significant, since different vehicle categories, countries and traffic situations are considered.

AGGREGATED RESULTS: MARGINAL COSTS											
€/1000 pkm/tkm		**Road**					**Rail**		**Aviation**		**Wa-ter-borne**
		Car	Bus	MC	LDV	HDV	Pass.	Freight	Pass.	Freight	Freight
Accidents	Marginal	10-90	1-7	36-629	10-110	0.7-11.8	-	-	-	-	-
	Average	30.9	2.4	188.6	35.01	4.75	0.74	-	0.37	-	0
Noise [1)]	Marginal	0.07-13	0.05-4.6	0.25-33	2.4-307	0.25-32	0.09-1.6	0.06-1.08	0.1-4.0	0.3-19	0
	Average	5.2	1.3	16.0	32.4	4.9	3.9	3.2	1.8	8.9	0.00
Air Pollution	Marginal	5.7-44.9	12-18	3.2	15-100	33.5	5.1	7.4	0.2	1.8	8.8
(only health costs)	Average	10.1	16.9	3.3	77.6	34.0	5.1	7.4	0.2	1.8	8.8
Climate Change	Marginal	1.7-27	0.7-9.5	1.7-11.7	8.2-57.4	1.8-12.8	0.3-7.1	0.4-5.3	6.6-46.2	33.7-235.7	4.3
	Average	17.6	8.3	11.7	57.4	12.8	5.9	3.2	46.2	235.7	4.3
Nature & Landscape	Marginal	0-2.1	0-1.3	1.9	10.9	0.8	0.7-1.2	0.1	1.1	6.5	0.8
	Average	2.87	0.69	2.07	10.90	2.03	0.58	0.26	0.75	3.77	0.78
Urban effects	Marginal	1.1-9.6	0.1-2.2	0.7-7.1	3.0-32.3	0.9-7.1	0	0	0	0	0
	Average	1.6	0.4	1.1	5.2	1.1	1.3	0.5	0	0	0
Up- and down-	Marginal	2.0-4.1	2.6-6.0	1.3-2.7	13.0-23.4	3.6-7.4	0.9-8.3	0.2-1.7	0.8-0.9	6.3-8.1	0.8-1.8
stream processes	Average	5.2	3.95	2.98	22.44	7.36	3.22	2.44	0.99	7.38	3.27

Table 4 Marginal costs by cost category and transport mean (the ranges reflect different vehicle categories (petrol, diesel, electricity) and traffic situations (urban, interurban). For urban effects ranges show different marginal costs of space availability and (low values) and separation costs (high values). For comparison average values as shown in chapter 3 are presented for each cost category**.**
Remarks:
1) Average and marginal noise costs are measured by different methods and thus are not fully comparable. The marginal values are to be understood as ranges of usual costs. Considerably higher or lower values are possible in particular cases.

If we compare average to marginal costs, the following general conclusions can be drawn:

› The level of marginal and average cost is comparable. Marginal costs are much more differentiated, since they relate to different traffic situations and types of vehicles.
› Most important for the order of magnitude of marginal accident costs are the assumptions concerning the level of internalisation of the accident risk.

- Due to their decreasing cost function marginal noise costs fall below average costs for medium to high traffic volumes. However, in road and air traffic they may exceed average costs since roads frequently lead through settlements and the alternation of traffic loads over day vary considerably between the modes. The same holds for airports, where approach paths often lead directly over housing areas.
- For air pollution, average values are basically similar to marginal values due to linear dose response functions and model calculations. There are big differences between different vehicle categories.
- For climate change, average costs are equal to marginal costs. The ranges stem from different vehicle categories. The same low-high assumptions are applied.
- For nature and landscape, average costs are close to maximum marginal costs. This is plausible since marginal costs are mostly not relevant in the short run.
- Marginal costs of urban effects are generally higher than average costs. Both values should be compared carefully since marginal costs are calculated using only urban traffic volumes while average costs are calculated with national traffic volumes. Marginal separation costs are significantly higher than marginal space availability costs.
- For up- and downstream processes marginal costs are mainly related to precombustion processes. Therefore marginal costs are generally lower than average costs which include as well vehicle and infrastructure related processes (production, maintenance and disposal of rolling stock and infrastructure). Thus average costs are close to long run marginal costs.

CONGESTION COSTS

Total congestion costs are defined according to economic welfare theory by the deadweight loss measure, which represents the costs arising from an inefficient use of the existing infrastructure. For the EUR-17 countries, total and average road congestion costs, revenues expected from their internalisation via road pricing systems and an "engineering" measure of additional time costs have been estimated for the year 2000. Due to the chosen welfare-economic approach, congestion costs by definition only appear for transport modes where single users decide on the use they make of infrastructure. Consequently, rail and air traffic are not affected by this kind of congestion. A comparison of the three congestion-related approaches is presented by the following figure.

DEADWEIGHT LOSS, CHARGING REVENUES AND DELAY COSTS IN ROAD TRANSPORT 2000

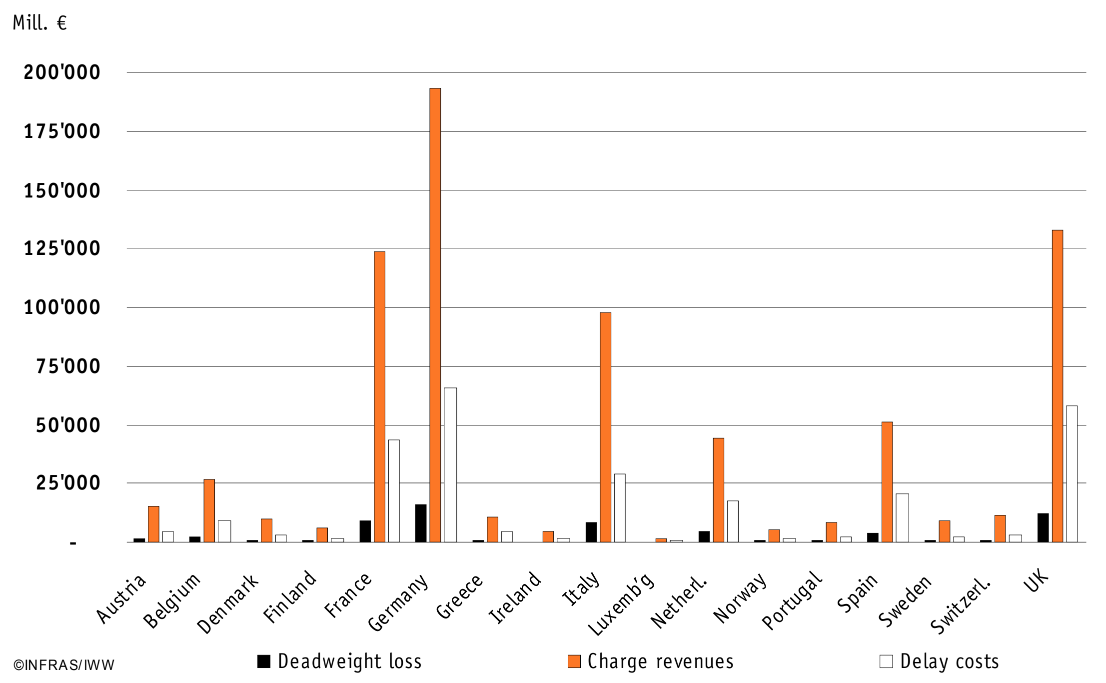

Figure 5 Comparison of the results (2000) based on different congestion cost estimations.

The deadweight loss reflects the economic costs in relation to an optimal traffic situation. The costs are roughly twice as high (63 billion Euro) as the figure presented in the 2000 study (33 billion Euro). The reason for this drastic increase is a methodological one, as

› (1) the networks of the VACLAV traffic model are more dense than the ones used in the 2000 study and
› (2) Traffic volumes, which are not considered by the VACLAV model, had been included here.

The two other approaches show the following results for 2000:

› Revenues from optimal congestion pricing amount to 753 billion Euros (8.4% of GDP).
› Additional time costs amount to 268 billion Euro (3.0% of GDP).

Although road freight transport accounts only for around 20% of traffic demand, its congestion costs are close to those of passenger vehicles. This fact can be explained by the comparably high use of road capacity by freight vehicles.

The charging revenues are the amount of money to be moved in order to remove the deadweight loss. In total across all countries they are roughly 12 times higher as the deadweight loss itself, which implies, that the transaction costs associated with charge collection are in the same order of magnitude as the expected social surplus. The delay cost measure is presented due to its simple definition and its comparability between road and public transport, but it does not reflect an economic measure.

Average external congestion costs in passenger transport are 56% higher than in the previous study. Besides the increase of transport volumes on the European road network between 1995 and 2000, this development is driven by the improved representation of urban traffic conditions and by the more detailed encoding of the inter-urban road networks within the VACLAV transport model.

In general the average cost results draw a realistic picture of the European road network conditions, where areas along the "Blue Banana" (southern England, the Benelux countries, Germany to northern Italy) show comparably high average cost results.

INTERNALISATION POLICY

In order to internalise external costs properly, imbedded in a wider concept of sustainable transport, the following action lines are most important:

› A Km-dependent HDV tax in overall Europe which considers not only accident costs, but also environmental costs like air pollution, climate change and noise. Possible tax levels are according to average shown in this report. It is appropriate to apply such schemes not only for motorways.
› The introduction of road pricing schemes for passenger cars, primarily in urban areas, to consider capacity problems. An additional differentiation according to environmental criteria (e.g. air pollution) is appropriate.
› A fuel price scenario in Europe for all means of transport in order to meet the aims of a long term climate strategy; the rates of the respective CO2-tax should be in line with the proposed shadow prices (at minimum 20 Euro per tonne of CO2 related to the Kyoto targets). Most important is the inclusion of international air transport, in order to reduce tax distortions between transport modes.
› Additional measures in road transport in order to increase effectiveness, such as hi-tech-road management and intermodal information systems, such as improved liability systems

and environmentally friendly and safe driving styles, supported by traffic calming measures (incl. speed limits).
› The application of rail track pricing systems considering external costs according to EU Directive 2001/14.
› More emphasis of the railways to speed up technical progress in improving environmental performance, such as wagon break improvements (see UIC Noise Action Plan) and energy efficiency (see UIC Diesel Action Plan, use of sustainable energy sources).

These most important internalisation instruments should be underlined with a comprehensive multimodal strategy with the following core elements:
› Multimodal financial funds, financed (at least partly) by externality charges from the road sector. These funds secure the necessary financial means for the modernisation of the railways. In order to allocate these financial means properly, the socio-economic return of the investments should be a major criteria and transparent budgetary rules of the fund administration are necessary.
› A priority to internalise external accident and environmental costs in these sectors (road and air transport) first, because these cost categories are responsible for large parts of the total external costs, in order to finance the proposed multimodal fund.