CE
Solutions for environment, economy and technology

Oude Delft 180
2611 HH Delft
The Netherlands
tel: +31 15 2 150 150
fax: +31 15 2 150 151
e-mail: ce@ce.nl
website: www.ce.nl
KvK 27251086

The price of transport

Overview of the social costs of transport

Summary

Summary

Delft, September 2004

Author(s): J.P.L. (Joost) Vermeulen (CE)
B.H. (Bart) Boon (CE)
H.P. (Huib) van Essen (CE)
L.C. (Eelco) den Boer (CE)
J.M.W. (Jos) Dings (CE)
F.R. (Frank) Bruinsma (VU)
M.J. (Mark) Koetse (VU)

vrije Universiteit amsterdam

Publication Data

Bibliographical data:
J.P.L. (Joost) Vermeulen, B.H. (Bart) Boon, H.P. (Huib) van Essen, L.C. (Eelco) den Boer, J.M.W. (Jos) Dings,
F.R. (Frank) Bruinsma, M.J. (Mark) Koetse
The price of transport
Overview of the social costs of transport
Delft, CE, 2004

Traffic / Transport / Costs / Social factors / Infrastructure / Safety / Emissions / Noise nuisance / Hand use / Congestion / Taxes / Subsidies

Publication number: 04.4671.26

CE-publications are available from www.ce.nl

Commissioned by: Ministerie van Verkeer en Waterstaat, DGP
Further information on this study can be obtained from the contact person Joost Vermeulen.

Summary

Background

The Dutch Ministry of Transport, Public Works and Water Management is currently preparing a key policy paper on transport and mobility issues and in this context the ministry's Passenger Transport Division commissioned CE to review the social costs of the principal modes of transportation used in the Netherlands today.

Among the principal elements of these costs are those of infrastructure maintenance and operation. Calculation of these costs and their allocation across transport modes has been the subject of an Interdepartmental Policy Study with the working title 'Charging freight transport for infrastructure use'. This IPS study was carried out in parallel to the present study, allowing us to incorporate the results here.

Besides the costs of infrastructure maintenance and operation, there is a wider array of external costs which - for reasons stemming from welfare-theoretical and/or 'fairness' principles - deserve to be passed on in the pricing of transport and mobility.

In 1999 our institute carried out a similar, extensive study of the external costs and infrastructure costs associated with passenger and freight transport entitled 'Efficient prices for transport' [CE, 1999]. The present report, which can be seen as an update of the 1999 report, has been prepared in collaboration with the Free University of Amsterdam.

Aim of this study

The main aim of this study is to provide insight into the social costs of the various modes of transport in use in the Netherlands. To this end we have established:

- The specific cost items to be included.
- The respective magnitude of these costs.
- The share of the costs borne by the transport sector itself, via taxes and charges.
- The extent to which existing payment structures are keyed to cost drivers[1].

The study addresses all the main categories of road and rail transport (both passenger and freight) and inland shipping (freight only).

[1] Shedding light on whether current charging structures create an incentive for transport behaviour desirable from the perspective of optimum social welfare.

The results of this study will provide policy-makers with a useful tool for assessing how these costs might best be passed on to the various user categories. The methodology for cost allocation will be one of the factors determining the structure and level of any price incentives established.

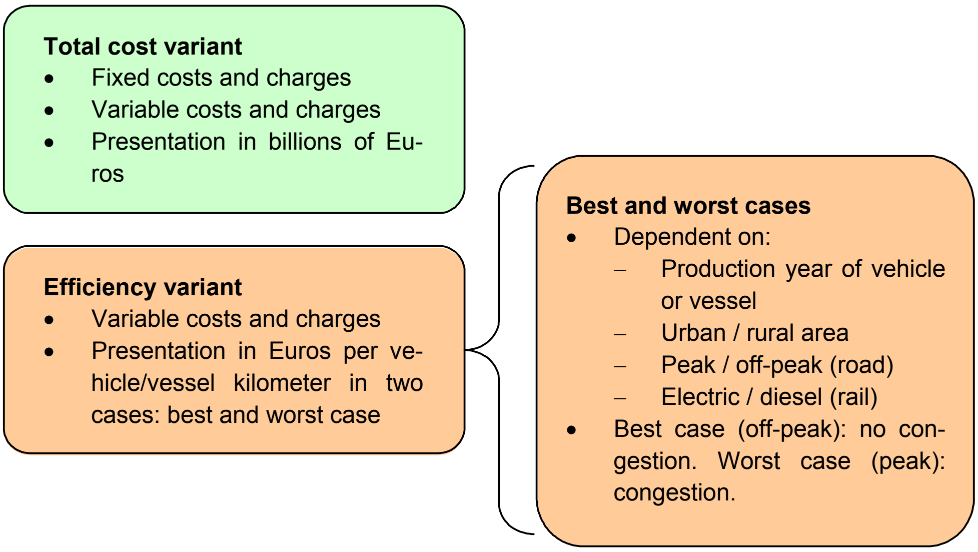
Two calculation methods

In this study we have inventoried the social costs of transport using two variant methods, rooted in two alternative principles for allocating costs to the parties involved (shown schematically in figure 1):

1 The first approach proceeds from the ‘fairness’ principle, taking as at its point of departure that every mode of transport should be confronted with the sum total of social costs to which it gives rise: the total cost variant. This means that both variable and fixed costs are allocated to users.

2 The second approach employs pricing policy as a means to optimise social welfare, by charging all variable costs to users: the efficiency variant. Because the precise level of these costs depends strongly on a variety of real-world parameters of the transport mode in question, in this variant we distinguish a best and a worst case, defining the former (latter) as that in which there is least (greatest) difference between variable costs and the variable charges actually paid.

figure 1 Two calculation methods: total cost variant and efficiency variant, with best and worst cases for the latter



The difference between these two variants lies mainly in the cost items for infrastructure renewal and the fixed costs of its maintenance and operation.

For each of the transport modes investigated, the best and worst cases are summarised in table 1 and table 2. In each case the following cost factors were taken into account, as appropriate:

- *Production year of vehicle or vessel*: for a given fuel type, old vehicles/vessels have significantly higher per-kilometre emissions of air pollutants than new (particularly in the case of road), the result of progressively more stringent European emission standards.
- *Urban/rural*: in the urban environment, the kilometre-indexed external costs of air pollutant emissions, noise and accidents are higher than in rural areas. For health damage and noise nuisance, this is because a greater number of people are exposed. In the specific case of road transport, accidents are relatively more frequent (per km) in urban areas.
- *Peak/off-peak* (road only): in peak traffic, vehicle hours are lost in traffic jams, while in off-peak periods we have assumed zero congestion. This distinction has only been made for road transport, i.e. we take there to be *no* congestion on the rail network or inland waterways.
- *Electric/diesel* (rail only): the air pollutant emission profile of diesel locomotives is very different from that of their electrically driven counterparts. As there is also wide variation within this latter category, related mainly to train weight (and thus energy use), we have here calculated with two extremes.
- *Large/small vessel* (shipping only): large vessels burn more fuel per kilometre than small vessels and emissions are therefore higher. Energy consumption also depends on load factor, river flow and direction, vessel speed and engine age.

table 1 Definitions of best and worst cases for passenger transport and light goods vehicles (LGV, i.e. vans)

Vehicle type	Best case	Worst case
Car, petrol	Rural, off-peak, 2002 model	Urban, peak, 1993 model
Car, diesel	Rural, off-peak, 2002 model	Urban, peak, 1993 model
Car, LPG	Rural, off-peak, 2002 model	Urban, peak, 1993 model
Bus (town/district)	Rural, off-peak, 2002 model	Urban, off-peak, 1993 model
Rail	Local service (*Sprinter*), 250 seats, rural	Intercity (*Regiorunner*), 1200 seats, urban
	Local service (diesel, *DM 90*), 125 seats, rural	
LGV	Rural, off-peak, 2002 model	Urban, peak, 1993 model

table 2 Definitions of best and worst cases for freight transport (HGV = heavy goods vehicle)

Vehicle type	Best case	Worst case
HGV, 3.5-12 tonne	Rural, off-peak, 2002 model	Urban, peak, 1993 model
HGV >12 tonne, single-unit truck	Rural, off-peak, 2002 model	Urban, peak, 1993 model
HGV >12 tonne, tractor-(semi)trailer combination	Rural, off-peak, 2002 model	Urban, peak, 1993 model
Rail	Non-bulk service, electric, empty, 80 km/h	Bulk service, diesel, 1,700 tonne load, 80 km/h
Inland shipping	'Spits' barge (*M1*, 350 tonne, smallest inland vessel), empty, downstream, 15 km/h, year 2000 engine	Quadruple pushed barges (*BII-4*, 8,000 tonne) fully laden, upstream, 10 km/h, 1990 engine

Scope

Reference year

All the data used for our quantitative analysis are for the year 2002, with two exceptions:

1 The costs of road infrastructure maintenance and operation, which are based on the government's 'Basic Maintenance' programme, as described in [DWW, 2002].
2 The costs of rail infrastructure maintenance and operation, which are based on the 'standard cost' approach for keeping the infrastructure at its present level of upkeep; we have used the 'standard costs' for 2004, converting these to 2002 prices.

In the case of both road and rail, then, we have used a form of 'standard costs', i.e. the estimated costs of an optimum maintenance regime. In both cases these figures exceed actual expenditure in 2002: by about 8% for road and about 20% for rail[2].

Cost elements and charges considered

Our analysis encompasses the following cost items:

- The costs of infrastructure building.
- The costs of infrastructure maintenance and operation (M/O) and infrastructure renewal, in the former case distinguishing variable and fixed costs.
- The costs of land use, distinguishing direct and indirect land use costs and parking costs.
- The external costs of traffic accidents.
- The external costs of climate emissions (CO_2).
- The external costs of other air pollutant emissions (NO_X, PM_{10}, HC, SO_2).
- The external costs of noise nuisance.
- The external costs of road traffic congestion.

[2] In the aforementioned IPS study 'Charging freight transport for infrastructure use', the standard costs for road and railway maintenance were scaled down to actual 2002 expenditures. The calculations in the present report proceed from the standard costs, however, with no scaling down.

Our analysis includes the following taxes and charges[3]:
- Vehicle Circulation Tax (VCT, for all road vehicles).
- Passenger Car and Motorcycle Purchase Tax (VPT).
- The ‘Eurovignette’.
- Parking dues.
- Charge for rail infrastructure use.
- Harbour and fairway dues[4].
- Fuel excise duty.
- Regulatory Energy Charge (REC).

We consider the following subsidies and exemptions:
- Public transport operating subsidies.
- Special VAT rates.

In this study we do *not* consider the social costs of:
- Visual intrusion.
- Habitat fragmentation.
- Barrier effects.
- Scarcity costs (rail only).

There is presently too little (methodological) information available for these four items to be quantified and assigned an appropriate value.

Vehicle categories
The study covers the following categories of passenger transport vehicle:
- Passenger car, petrol.
- Passenger car, diesel.
- Passenger car, LPG.
- Motorcycle.
- Moped / scooter[5].
- Local / district bus.
- Long-distance coach.
- Train, electric.
- Train, diesel.

The study covers the following categories of freight transport vehicle:
- Heavy goods vehicle (HGV), 3.5-12 tonne.
- HGV >12 tonne, single-unit truck.
- HGV >12 tonne, tractor-trailer or -semitrailer combination (i.e. rigid or articulated).
- Inland shipping vessel.
- Train, electric.
- Train, diesel.

---

3 Value Added Tax (VAT) has been ignored.
4 Subsequently referred to simply as ‘harbour dues’, these being by far the largest item.
5 Motorcycles and mopeds/scooters are included in the ‘total cost’ variant only. As these vehicle categories were added in a later phase of the study, there was no time to define best and worst cases for inclusion in calculations.

Vans, or light goods vehicles (LGV), have been included as a separate category, as they are used for both freight and passenger transport:

- LGV, diesel.

Differences from the 1999 CE study

Additions to the 1999 CE study

The 1999 study has been augmented in two important ways, to include:

- The costs of land use.
- The costs of parking and revenue from parking dues.

Methodological improvements

Relative to the 1999 study the following methodological improvements have been made:

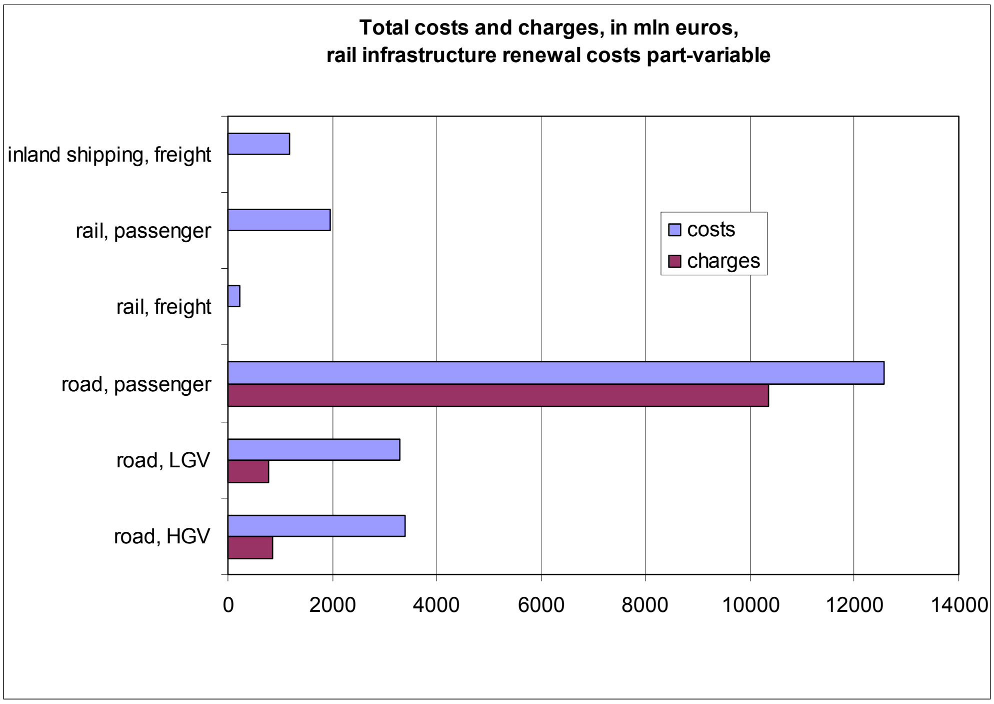
- *Allocation of infrastructure costs* (construction, but particularly M/O) has been handled differently. We now follow the method used in the aforementioned IPS study. For the cost of rail infrastructure renewal, we also present a second variant in which this item is taken as 100% fixed (in the IPS method these costs are assumed partly variable).
- *Congestion costs*, although included in the 1999 study, have also been treated differently. We now distinguish, in the *efficiency variant*, a worst and a best case (with and without congestion). After all, it is more efficient, for society as a whole, to allocate the external costs of congestion (always variable) to the party causing them. In the *total cost variant* we have ignored congestion costs, because this variant proceeds from the 'fairness' principle and *confronts every mode of transport with the sum total of the social costs to which it gives rise.* The social costs of congestion caused by road users are also borne by this group as a whole, however.
- Although the reference year (2002) remains the same as in the 1999 study, we were now in a position to use *actual costs* and empirical data rather than estimates. For example, we have used government expenditure reports rather than budgets as well as new accident statistics, computed new cost figures for noise nuisance, tracked down the latest traffic volume statistics for the various vehicle categories and employed more up-to-date emission data.

Results and conclusions, total cost variant

General

1 In 2002 the total social costs of domestic transportation in the Netherlands, *excluding* aviation, ocean shipping, recreational shipping, high-speed rail, cycling and walking, amounted to approx. € 22.5 billion. Over half this figure (about 55%) is due to passenger transport by road, followed by HGV (i.e. road freight) and LGV (both approx. 15%), rail passenger transport (approx. 9%), inland shipping (5%) and rail freight (approx. 1%). Note that *these figures do not cover all social costs*, in particular those associated with the habitat fragmentation, barrier effects and visual intrusion due to transport infrastructure (figure 2).

figure 2 Total social costs and user charges, principal categories of passenger and freight transport (€ mln/year)



2 There is not a single category of transport, road, rail or shipping, that is fully charged for all the social costs to which it gives rise. The only potential exception are petrol-driven passenger cars, for which we calculate that the estimated social costs are approximately covered by the user charges paid. Note again, however, that not all social costs were included in the quantitative analysis (see conclusion 1). Note also that the share of petrol-driven vehicles in the passenger car fleet has been declining in recent years and that of diesel vehicles increasing (figure 3 to figure 8).

3 For all the transport modes considered, fixed social costs exceed fixed user charges, with the possible exception of petrol and diesel passenger cars. This does not necessarily mean the fixed charges for these vehicle categories are presently too high, as the social costs of fragmentation, barrier effects and visual intrusion have not yet been factored in. Only after realistic figures have been worked out for these items can it be calculated whether or not current fixed charges are too high and should be reduced for considerations of welfare optimisation (figure 3 to figure 8).

figure 3 Total social costs and user charges, passenger road transport (€ mln/year)[6]

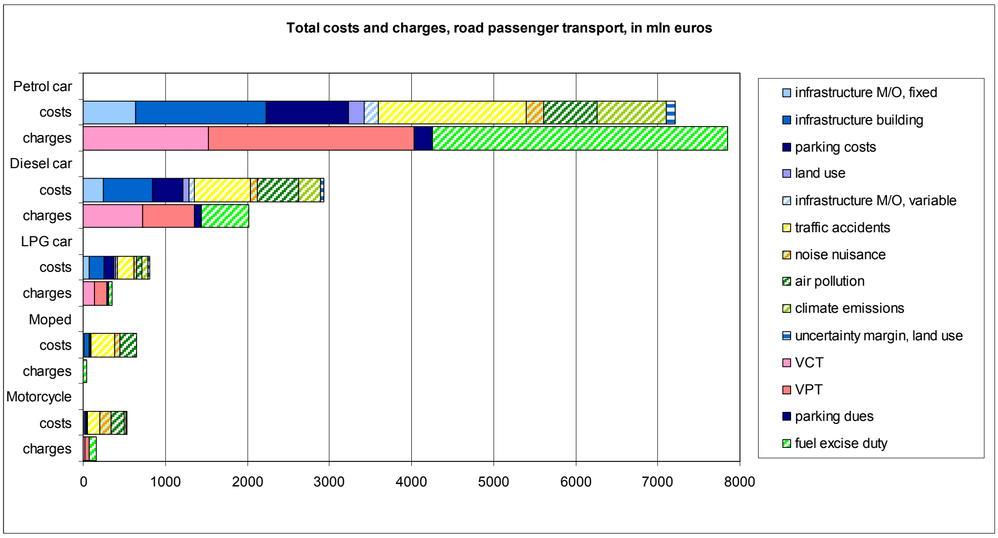
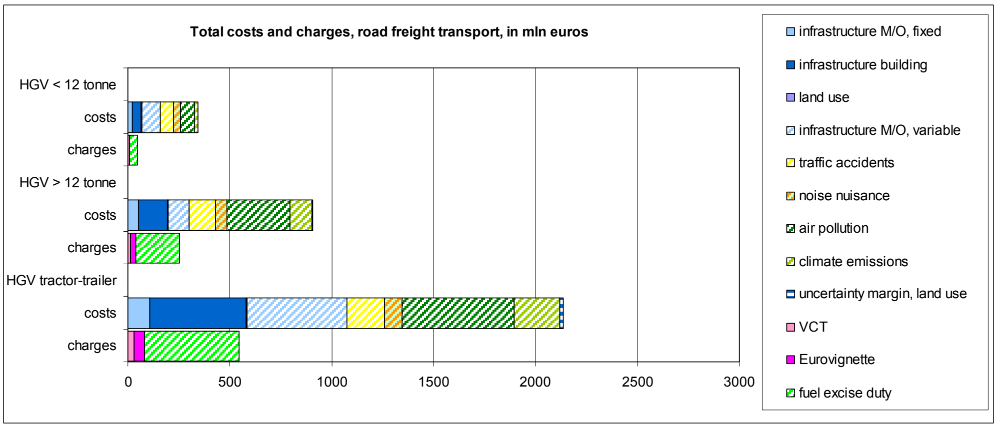


figure 4 Total social costs and user charges, three categories of HGV (€ mln/year)

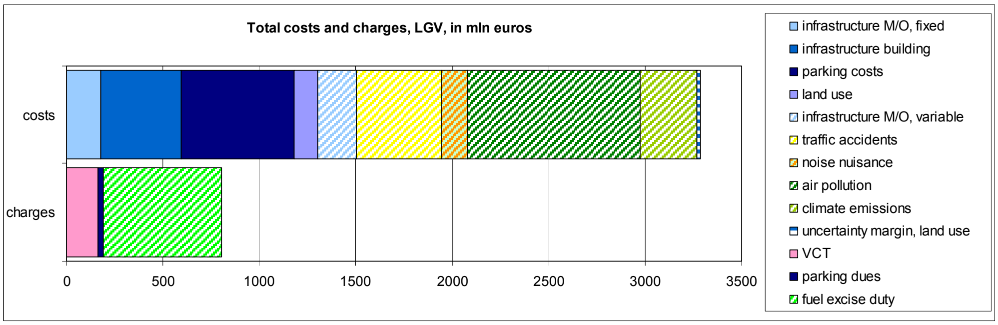


Road transport

4 In 2002 the total social costs attributable to transportation by LGV (vans) approximately equalled those of domestic road freight carriage by HGV (trucks); given the steady growth of the Dutch LGV fleet, they are now (2004) probably greater. In transport and environmental policy circles, however, there appears to be relatively little interest in LGVs (figure 2 and figure 5).

[6] In all the figures, solid colours indicate *fixed* costs or charges, hatched colours *variable* costs or charges.

figure 5 Total social costs and user charges, LGV (€ mln/year)



Rail transport

5 With rail transport, the fixed costs of infrastructure (M/O and renewal) predominate. In the case of passenger rail these account for about 75% of total social costs (not shown here; see main report), in the case of freight for over half these costs. Taking the costs of infrastructure renewal as fixed (current Transport ministry practice) or (part-)variable (IPS variant; see above) does not significantly affect this picture (figure 6 and figure 7).

figure 6 Total social costs and user charges, rail freight transport (€ mln/year; costs of infrastructure renewal assumed part-variable)

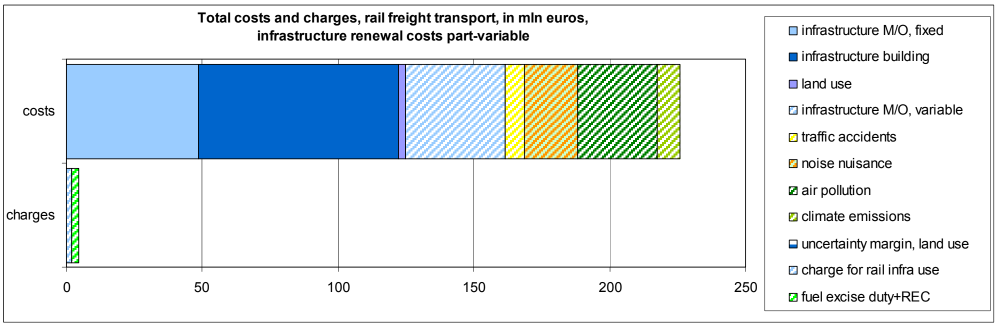
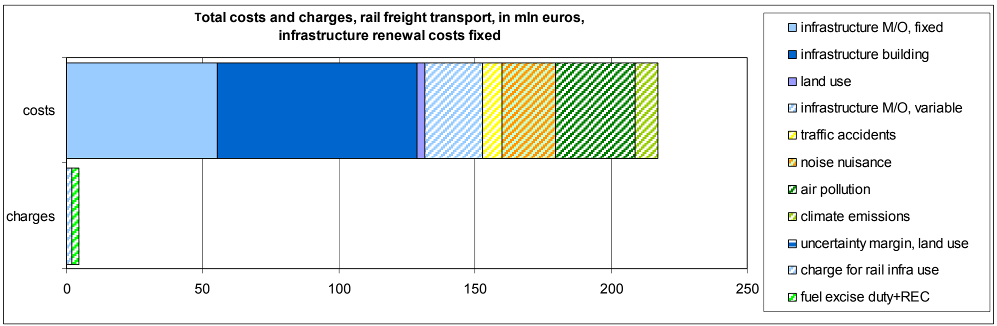


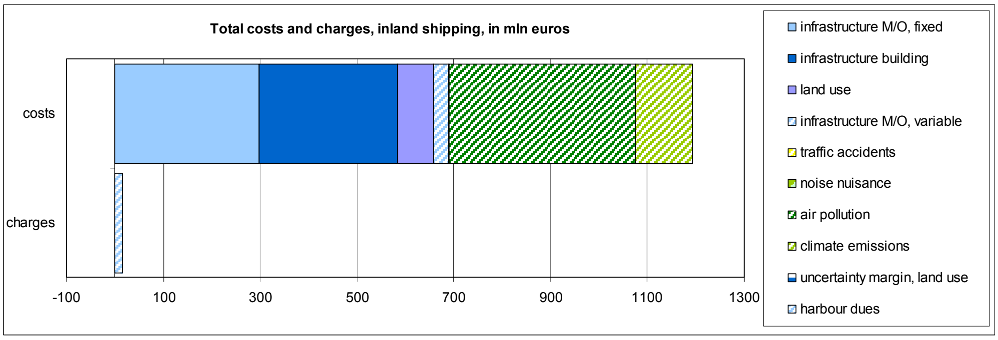
figure 7 Total social costs and user charges, rail freight transport (€ mln/year; costs of infrastructure renewal assumed fixed)



Inland shipping

6 For inland shipping, the fixed costs of infrastructure (M/O and renewal) account for about 50% of total social costs. Compared with rail freight transport, though, variable M/O costs are proportionally lower, consisting almost entirely of the costs of pollutant emissions (climate and other) (figure 8).

figure 8 Total social costs and user charges, inland shipping (€ mln/year)



Results and conclusions, efficiency variant

General

7 For all transport modes considered, with the exception of ‘best case’ petrol-driven passenger cars, current variable charges are lower than variable social costs. This means that for all these categories of vehicle and vessel, full allocation of variable social costs will lead to an increase in variable costs.

8 A comparison of the results of this study with those of earlier European studies on these issues shows good agreement for all vehicle categories, for both best and worst cases (as detailed in an appendix to the report).

Road transport

9 For virtually no category of road vehicle do variable charges cover variable social costs, even if congestion costs are assumed to be zero (these exceeding all other items by far; see, for example figure 10 and figure 12).

10 In the case of passenger cars, besides congestion costs the main variable costs are those associated with accidents and air pollution. However, in the best case (new vehicle, rural) the latter cost item is already significantly lower than in the worst case (10 years old, urban), an improvement due mainly to the introduction of progressively tighter EU standards for NOx and fine particle emissions over the intervening 10 years. There is far less difference with respect to CO_2 emissions, for which no European emission standards are (yet) in force (figure 9 and figure 10).

11 Petrol-driven cars are the only means of transport for which variable charges are not definitely lower than variable costs. If the costs of congestion are included, however, variable charges come to cover only

about 12% of variable costs. Ignoring congestion, even in the worst case (10 year-old petrol-driven car, urban environment) variable charges prove to cover only just over half the variable costs. Thus, the conclusion that petrol passenger cars 'pay their way' in terms of social costs is not generally valid, applying only to certain categories of vehicle in an uncongested situation (figure 9 and figure 10).

figure 9 Variable social costs and user charges, passenger car transport, best case (€ct/vehicle kilometre)

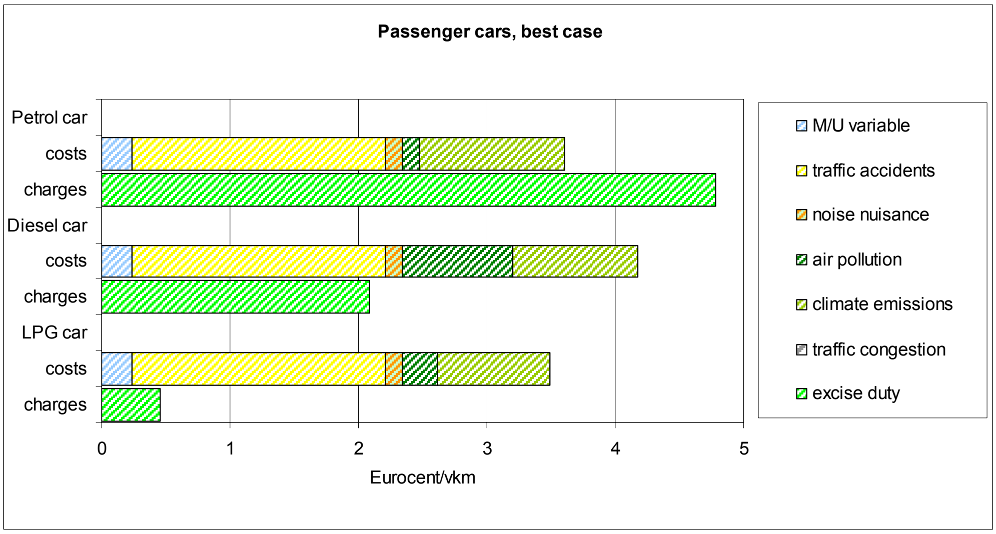
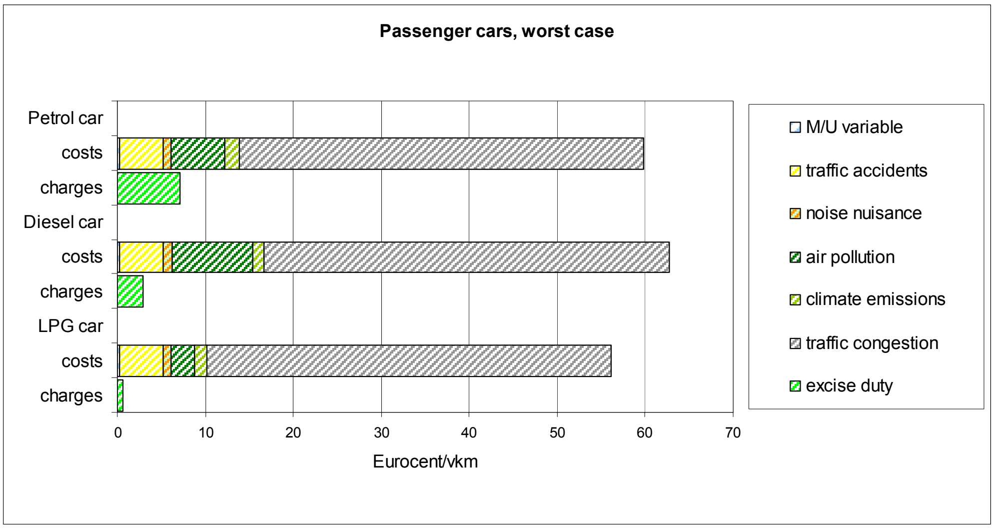


figure 10 Variable social costs and user charges, passenger car transport, worst case (€ct/vehicle kilometre)



12 In the case of diesel and LPG passenger cars and diesel LGV, variable charges (currently, only fuel excise duty) cover between 50% (diesel car, best case) and 1% (LPG car, worst case) of variable costs. Due allocation of these latter costs will therefore bring user charges for diesel and LPG vehicles more in line with those for petrol vehicles.

13 In the present situation, variable charges for passenger cars are not structurally, directly related to the cost drivers in question. In particular, the influence of such factors as vehicle emission class, safety and noise level, as well as journey time and location - all of which are major factors determining overall variable costs - is not currently reflected in the cost structure at all (figure 9 and figure 10).

14 For the various categories of HGV the situation is fairly similar, with variable charges covering about half to a quarter of variable costs. Coverage is greatest for tractor-(semi)trailer combinations, as these make most use of motorways, where the costs of accidents, air emissions and noise are lowest, in relative terms, and pay the most excise duty per kilometre driven (figure 11 and figure 12).

figure 11 Variable social costs and user charges, HGV, best case (€ct/vehicle kilometre)

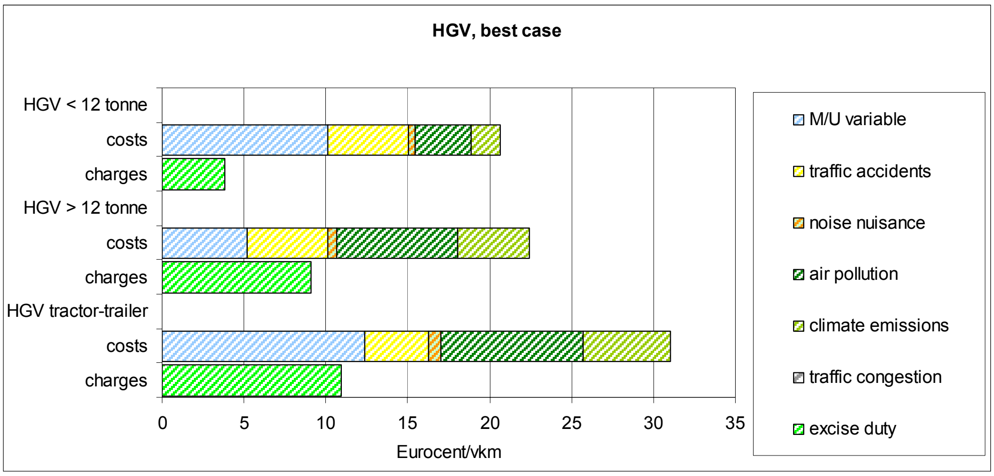
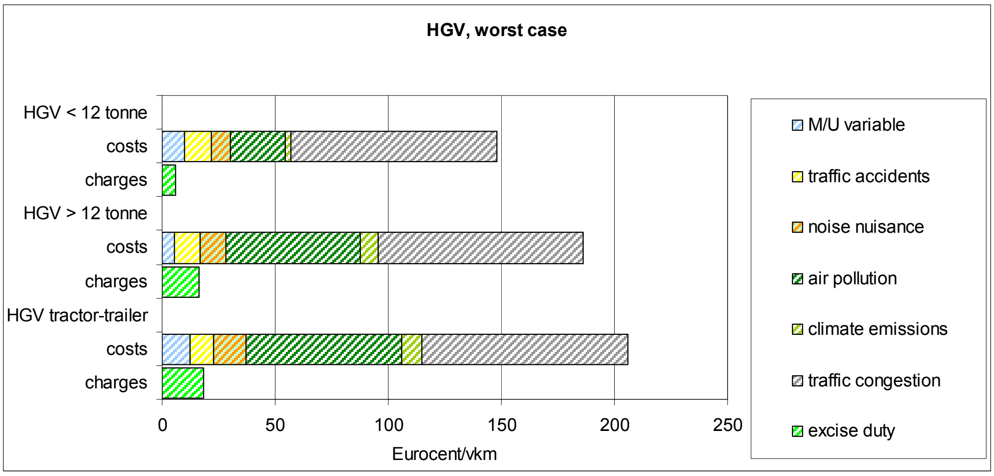


figure 12 Variable social costs and user charges, HGV, worst case (€ct/vehicle kilometre)



Rail transport

15 With rail transport, both passenger and freight, variable costs can vary enormously, depending on aggregate train weight, type of traction and urban vs. rural. In all cases, though, variable charges (and particularly those paid for infrastructure use) are only a mere fraction of variable costs. Increasing both the capacity and utilisation of the existing rail grid provides a means of achieving greater coverage of variable costs via the infrastructure charge at only a fairly minor increase in cost per passenger or tonne kilometre (figure 13 to figure 18).

16 In the case of passenger rail, the variable costs of infrastructure maintenance and operation account for 60-65% of total variable costs, if renewal costs are assumed part-variable (see figure 13). If the costs of infrastructure renewal are taken entirely fixed, the figure still exceeds 50% (figure 14). In the case of rail freight, the variable costs of maintenance and operation still figure prominently, but here air pollution (due to the relatively high share of diesel traction) and noise nuisance also both contribute significantly, particularly in the worst case (figure 15 to figure 18).

figure 13 Variable social costs and user charges, rail passenger transport (electric), best and worst case (€ct/train kilometre; costs of infrastructure renewal assumed part-variable)

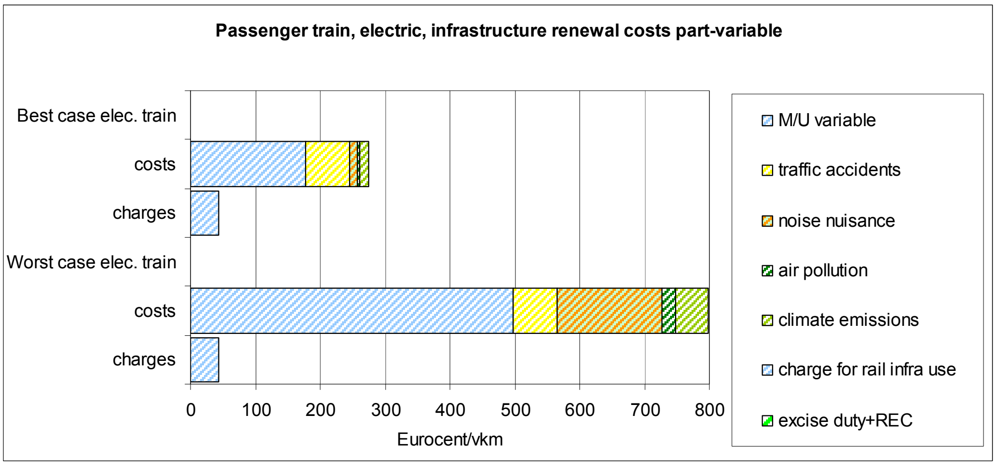


figure 14 Variable social costs and user charges, rail passenger transport (electric), best and worst case (€ct/train kilometre; costs of infrastructure renewal assumed fixed)

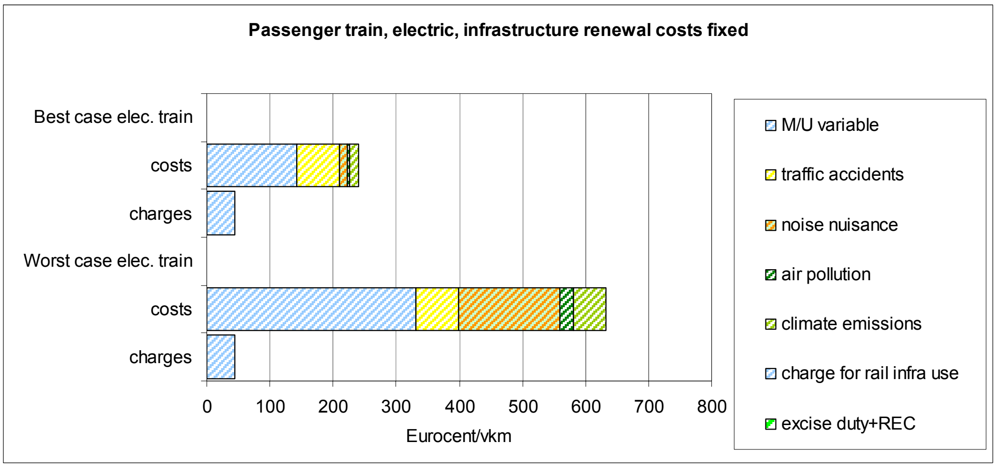


figure 15 Variable social costs and user charges, rail freight transport, best case (€ct/train kilometre; costs of infrastructure renewal assumed part-variable)

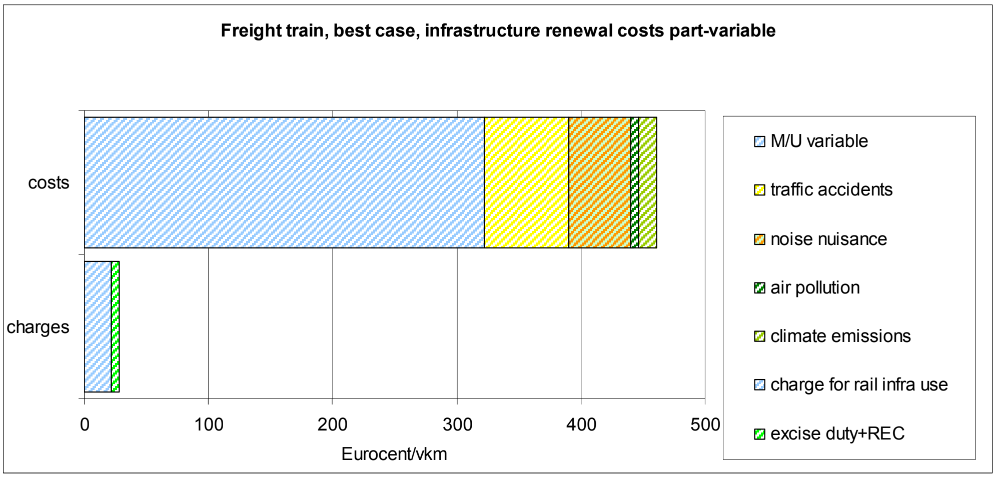


figure 16 Variable social costs and user charges, rail freight transport, best case (€ct/train kilometre; costs of infrastructure renewal assumed fixed)

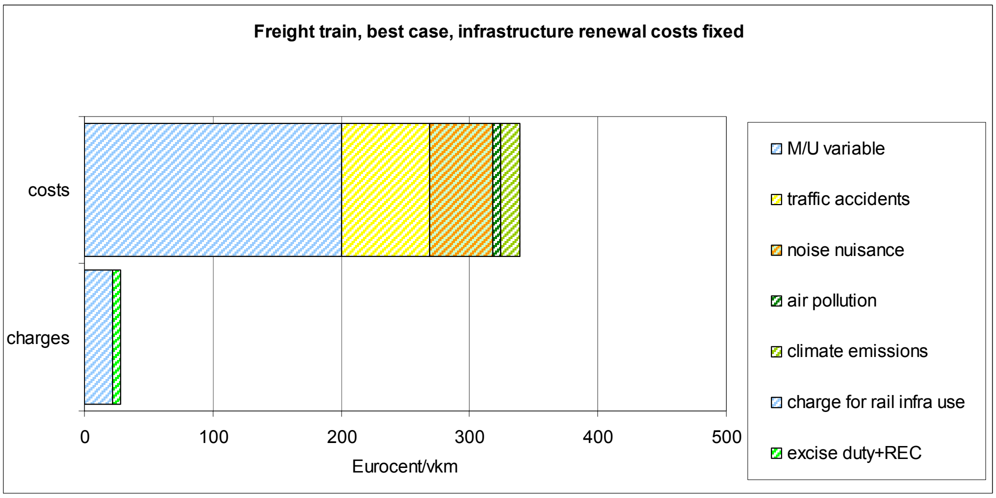


figure 17 Variable social costs and user charges, rail freight transport, worst case (€ct/train kilometre; costs of infrastructure renewal assumed part-variable)

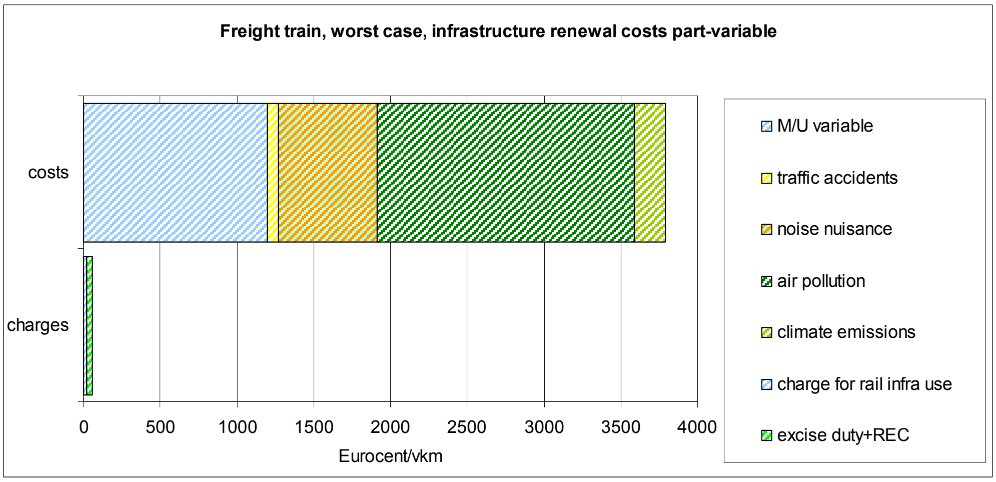
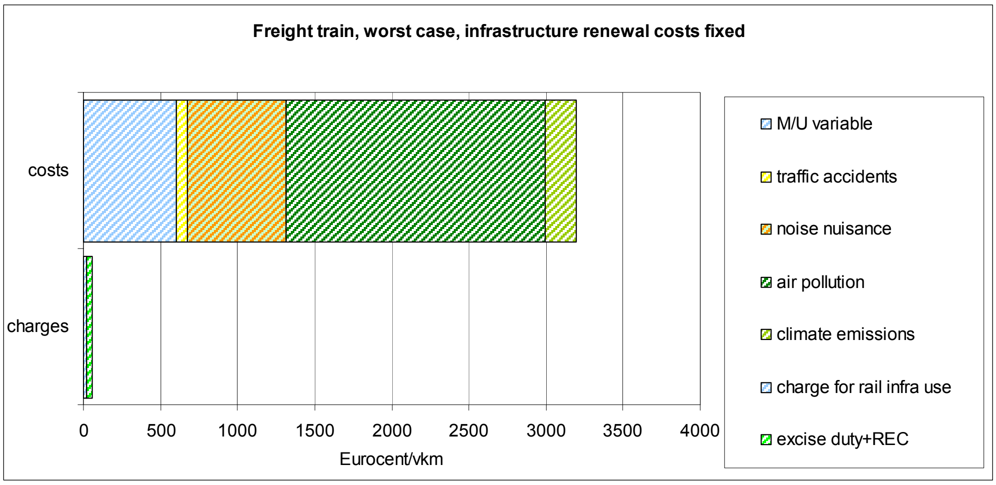


figure 18 Variable social costs and user charges, rail freight transport, worst case (€ct/train kilometre; costs of rail infrastructure renewal assumed fixed)



Inland shipping

17 For inland shipping the picture is broadly similar to that for rail freight, although here there are virtually no variable charges and in the worst case these are lacking entirely (figure 19 and figure 20).

figure 19	Variable social costs and user charges, inland shipping, best case (€ ct/vessel kilometre)

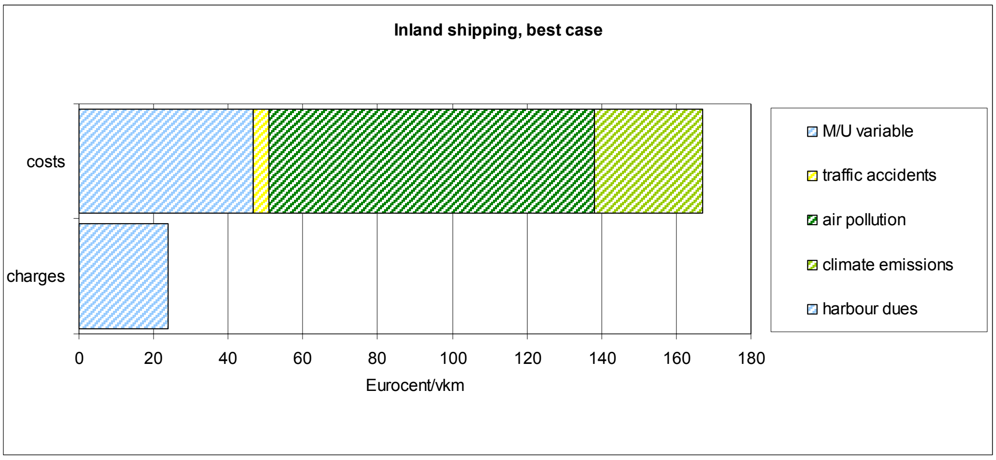


figure 20	Variable social costs and user charges, inland shipping, worst case (€ ct/vessel kilometre)