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AN ATTEMPT TOWARDS THE ESTIMATION OF THE EXTERNAL COSTS OF TRANSPORT IN EUROPE

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1 INTRODUCTION

1.1 Background

It has become a common vocabulary that the social costs of transport are steadily increasing over time. In many respects this is obviously true due to the rapid growth of motor vehicle use, but are the problems we face now consistent with what was expected by scientists some decades ago? If not, is it then that technical progress and regulatory measures have shifted the loads carried by society from one burden to another, or they even manage to improve our quality of life? If the balance of the past decades' developments drawn by recent social cost studies turned out to be negative, did maybe the evolution of our knowledge about the causes of social costs or changing social attitude towards several effects of transportation move us to a different point of view?

It is obvious that legislative measures, such as the introduction of compulsory catalytic converters and emission standards for motor vehicles or the prescription of noise exposure targets for new infrastructure projects have eased some parts of the social problem. With their directives 91/441 (in 1991) and 94/12 (in 1994) the Commission of the European Communities (EC) has introduced standards of impact reduction technologies for motor vehicles, which give the member states the power for enforcing new vehicles sold to keep a minimum standard of environmental friendliness. Further they are allowed for adjusting vehicle taxes and motorway tolls according to emission classes and hence in addition to reward the use of clean motor vehicles.

Also in other sectors advantages have been made. The introduction of compulsory and voluntary safety measures at vehicles (enforcement of safety belt usage, anti-blocking systems, airbags, etc.) has reduced the number and consequences of traffic accidents significantly. Also noise problems are attacked by the obligatory selection of silent road surface materials, new engine technologies and type profiles. In the case of noise and safety the consideration of the related social cost problem already in the planning phase of the infrastructure construction or upgrading has turned out to be much more effective than the application of kilometre-depending charging mechanisms.

On the other hand, some drivers of social costs have not been reduced significantly (such as the fuel consumption of cars and trucks) or have even increased dramatically. For the latter case traffic congestion on urban and inter-urban road networks is a commonly stated example. Regardless of major investments in the European road network the big industrial centres along the “blue banana” (from South England vial the Benelux, the German Rhine and Ruhr area to the industrial centres of northern Italy) are facing steadily growing congestion problems. As in particular in densely populated agglomeration areas the available space for infrastructure investments gets more and more scarce, political decision makers are slowly looking for alternative ways to cope with the problem.

The understanding of which cost items the social costs of transport are composed of and how they should be assessed in monetary terms has been developing over time and is still now subject to a controversial discussion of scientists. The basic cost items considered by studies on the topic are (1) traffic accidents, (2) air pollution, (3) climate change and (4) noise. Some more recent studies account for the costs caused to nature and landscape by the deterioration of biodiversity and visual intrusion, up- and downstream effects caused by the production and disposal infrastructure, vehicles and energy and additional effects to urban surroundings.

The valuation basis for these rather indirect costs as well as for the assessment of global worming is generally very weak. Accordingly, the unit values applied can easily differ by a factor 100 or more. For example, latest results on the health effects of road transport emissions published by the World health Organisation (WHO 1999) have drawn the attention towards small-size particles (PM10), which have not been considered seriously in earlier publications. This puts a limit to the reliability of external cost estimates - even if the databases used of good quality. One should therefore be cautious with interpreting the absolute quantitative results of social cost studies.

Nevertheless, statements on the relative external costs between different transport modes or on the development of social cost indicators over time are quite possible.

Except for some elements of accident costs (material damages, medical costs paid by motor vehicle insurance, etc.) the above social cost elements caused by motorised road, rail, air and waterborne traffic are external to the transport system. This means they are not directly covered by those causing them and thus are not part of the travellers decision making. In addition to these effects, which are totally borne by individuals outside the transport system another type of externalities exist, which are borne by the transport sector as a whole. This category of effects includes the costs for planning, constructing, maintaining and operating traffic infrastructure and the costs of traffic congestion. In the case of the costs of privately constructed infrastructure the state in its function of the infrastructure owner is seen as a part of the transport sector. However, due to the usually complex matter of state public funding and tax money allocation, some studies argue that infrastructure costs are external to the transport sector as they are covered by public budgets and thus by the tax payer.

The problem what is traffic congestion and how it should be assessed is usually subject to controversial discussions. It is clear that traffic infrastructure is not dimensioned to be empty and thus that not every small delay should be accounted as a source of economic costs. But what is the minimum standard of quality - if there is any? According to social welfare theory the "optimal" level of congestion is reached, when all users would take into account the additional costs they cause on others due to their behaviour, while in more pragmatic approaches maximum delays are defined arbitrarily. In general, the results of different studies are not directly comparable to each other.

1.2 Goals and Structure of the Paper

In front of this background this paper follows two objectives: First, the state of the art in transport-related social cost accounting in Europe shall be presented by briefly discussion the applied methodologies and the results of a number of past and on-going research projects carried out for the Commission of the European Communities (CEC) and for a number of other bodies. Second, the problem of estimating the social costs of transport concerning methodological difficulties, insufficient data sources and varying goals behind cost estimation are discussed by examining two recent studies.

- The first work to be analysed is the study "External Costs of Transport", conducted by the Institute for Economic Policy Research (IWW) of the University of Karlsruhe (Germany) and the INFRAS Institute, located in Zurich (Switzerland) financed by the International Railway Union (UIC) in Paris (France). This study was finalised in April 2000 and thus provides a contemporary overview on the current discussion. The study is a follow-up of an earlier work carried out for the UIC by the same research team in 1994, which makes it possible to follow the development of methodologies and unit values over time.

- The research project UNITE (Unification of Accounts and Marginal Costs), which is carried out under the 5th research framework programme of the Commission of the European Communities, Directorate Transport and Energy, is approaching the problem of external cost estimates from a different perspective. The project, which has started in January 2000 and which will last until the end of 2002, was launched to push forward the introduction of social marginal cost pricing on the European transport networks in order to achieve a sustainable development. The analysis of the UNITE project brings some insight into the goal of current European transport policy to the reader of this paper.

2 EUROPEAN RESEARCH ACTIVITIES

2.1 The 5th RTD Framework Programme

On the internet pages of the European Union their research framework programme is described as follows:

"The Fifth Framework Programme (FP5) sets out the priorities for the European Union's research, technological development and demonstration (RTD) activities for the period 1998-2002. These priorities have been selected on the basis of a set of common criteria reflecting the major concerns of increasing industrial competitiveness and the quality of life for European citizens.

The Fifth Framework Programme has two distinct parts: the European Community (EC) framework programme covering research, technological development and demonstration activities; and the Euratom framework programme covering research and training activities in the nuclear sector.

FP5 differs considerably from its predecessors. It has been conceived to help solve problems and to respond to the major socio-economic challenges facing Europe. To maximise its impact, it focuses on a limited number of research areas combining technological, industrial, economic, social and cultural aspects. Management procedures have also been streamlined with an emphasis on simplifying procedures and systematically involving key players in research.

A major innovation of the Fifth Framework Programme is the concept of "Key actions". Implemented within the specific programmes, these flexible instruments are targeted at achieving solutions to topics of great concern in Europe. "Key actions" will mobilise the wide range of scientific and technological disciplines - both fundamental and applied - required to address a specific problem so as to overcome the barriers that exist, not only between disciplines but also between the programmes and the organisations concerned.

The following list of "Key actions" is implemented under the Fifth Framework Programme (EC and Euratom)

(1) Quality of life and management of living resources
(2) User-friendly information society
(3) Competitive and sustainable growth
(4) Energy, environment and sustainable development

A budget of 13,700 million euro has been agreed for the implementation of the European Community section of FP5. Combined with the 1,260 million euro allocated to the Euratom programme, this should bring the global budget for research during 1999-2002 to 14,960 million euro. (This represents an increase, in absolute terms, of 4.61% compared to the Fourth Framework Programme.)."

The central goal of the 5th FP is ti transform the basic findings of the previous EU funded research programmes into political action programmes. A better understanding of interdependencies between different sectors of the European economy should be provided in order to enhance a stable, and sustainable future development of the European markets.

2.2 Past European Research in the field of Environment and Transport

Within the 4th Framework Programme the EU Commission has carried out a large number of activities to investigate the inter-relationship between transport and the environment. The following abstracts of a selected number of research projects in this field shall provide a brief overview of what has been done in the EU. The outlook towards current and future research activities and political directions is given in chapter four at the end of this paper.

The ExternE project. The project ExterrnE (= External effects of Energy Production) primarily did (or does) not aim at determining the external costs of transport. The project was launched by the Directorate Generale XII (Energy) as an monitoring centre of different forms of energy production and use. One of these aspects of energy consumption is transport. The project's most cited outputs is their estimate of the value of a statistical life, which was 3.1 million Euro in prices of 1995. The general methodology is based on the impact-pathway approach, in which the effects of transport-related emissions were analysed using emission models, pollutant dispersion models and specific dose response functions. This methodology, which is still developed to date and which is applied as a key element of cost estimation within the UNITE project, allows the estimation of specific marginal costs of air pollution, but a direct measurement of total transport-related costs is not possible.

<u>The PETS project</u>. PETS (= Pricing European Transport Systems) aimed at determining the effects caused by different pricing schemes on the transport sector. The project was started in 1996 and officially closed by mid 1999; a draft final report was distributed among the consortium of 13 European research institutes recently. The project developed a theory of first-best transport pricing, which is based on the idea of the welfare-maximisation through marginal social cost allocation according to the polluter-pays-principle. The external costs were defined as the sum of currently uncovered infrastructure costs plus the costs of air pollution, climate change, noise and traffic accidents. The study applied economic unit cost estimates (e.g. the value of life found by the ExternE project, noise disturbance costs estimated by INFRAS/IWW 1994, etc). to locally based emission or risk models. The marginal social costs of transport provided the basis for the core pricing scenarios assessed within the PETS project, which were:

(1) Pure short-run marginal cost pricing.
(2) Long-run marginal cost pricing (including capacity effects).
(3) Total cost coverage (considering budget restraints).

These pricing scenarios were applied to five case studies covering important transport corridors through Europe:

(1) Cross-Channel passenger and freight transport
(2) Trans-Alpine freight transport
(3a) The Nordic Triangle (Oslo - Stockholm - Gothenburg).
(3b) The Helsinki - St. Petersburg-Route.
(4) The Tagous-River crossing in Lisbon.

The output of the 5 case studies conducted were rather different, but the main conclusion which could be drawn was, that major shifts in demand can not be expected from marginal social cost pricing. These results were mainly in line with the findings of other contemporary EC research

(STEMM, SORT-IT, MINIMISE, etc.), were the importance of regulative actions to obtain a desired structure of the transport market are highlighted.

The FISCUS project. The study "Cost Evaluation and Financing Schemes for Urban Transport Systems" (FISCUS) was focused on urban transport. Besides the pure cost evaluation side, the investigation of cost inter-linkages between different actor groups and the possibilities of developing sustainable financing frameworks stood in the foreground of the research. The costing part did not conclude with hard figures of the social costs of urban traffic, but in a "Real Cost Scheme", guiding urban traffic planners and decision-makers through the process of social cost estimation. The Real Cost Scheme did in particular take into consideration different levels of data availability and varying goals behind cost evaluation.

2.3 The Conclusions of the 4th Framework Programme

Out of the results of the research on pricing instruments, which had been conducted in the 1990s, the Commission has published a white paper on the "Fair and Efficient Payment for the Use of Transport Infrastructure". This paper, which promotes a phased implementation of the marginal social cost pricing principle for all modes of transport in the EU, was heavily attacked as the recommendations made did disregard a number of practical restraints. Further, the promoted economic principle is not agreed in general, as under real conditions it can be shown that a system of multi-part-tariffs, similar to the charges in the telephone markets, are superior to the rigid structure of marginal social cost pricing.

The essence of the 4th Framework Programme was summarised by a project entitled CAPRI (Concerted Action on Transport Pricing Integration). Here, the findings of the past research was analysed recommendations to the political level were prepared. The main conclusion of the project was, that the principle of marginal social cost pricing should be kept in mind as a first-best alternative when transport prices are to be set, but that in practice many good reasons for deviations from this pure economic welfare theory are existing. Such second-best solutions may be motivated by budget restraints, equity considerations or technical problems.

The quantification of the burden, transport and other economic activities are loading on people and the environment is required not only for the purpose of price setting. As laid down in the FISCUS project, the pure information in which direction we are moving is required to assess the success or the failure of environmental policy. This fact has motivated the European Environment Agency (EEA) recently for organising an expert workshop on this topic, were the composition of a comprehensive indicator of environmental development was to be discussed.

The following chapter therefore aims to present the methodology and the results of a recent study carried out in order to quantify the social external costs of transport in Europe. Moreover, possibilities of alternative cost measures shall be discussed, as cost estimation is always depending on the goals behind it.

3 THE INFRAS/IWW STUDY ON THE EXTERNAL COSTS OF TRANSPORT

3.1 Motivation of the Study

Caused by the liberalisation of the European transport markets in the early 1990s freight rates in road haulage and inland waterway and maritime shipping dropped rapidly At the same time freight rated and service offers of the European railway companies remained unchanged. This non-reaction is possibly based on the self-understanding of the still state-owned railway companies as pubic service suppliers, who are therefore not participating in free market competition. The result was (and still is) a stagnation in rail shipment volumes, while the road haulage market is growing with a rate of 5% to 6% each year. In spite of the much stronger efforts undertaken in rail passenger transport in many European countries, their growth also lags significantly behind the development in the road and aviation sector. Facing this development, the European railways were seeking for arguments to draw more subsidies from the national governments in order to be able to maintain their market share.

For this reason, the International Railway Union (UIC, Paris) first gave the mandate to the Institute for Economic Policy Research (IWW) of the University of Karlsruhe, Germany and the INFRAS institute in Zurich, Switzerland to carry out a study on the External Costs of Transport. The study estimated the costs of traffic accidents, air pollution, climate change and noise for several modes of passenger and freight transport (road, rail, aviation and waterborne transport) and for 17 western European countries (EU plus Switzerland and Norway).

Due to the partially weak data situation the results of the study diverged widely between countries. Nevertheless, a number of clear results have been found:

- Accidents are the most important cost driver in road transport, while they are of secondary important for the railways.
- The external costs of road passenger (freight) transport is in average five (eight) times above the figures for rail.

With the aim to update the databases and unit values to the year 1995 and to extend the estimate of social costs to a number of additional cost items, the same institutes (INFRAS/IWW) were given a new mandate to carry out a follow-up of the 1994 study in 1998. This report, which was finalised in April 2000, is presented briefly throughout the following sections. Besides the presentation of methodological issues and results, the main purpose of the review is the description of difficulties in data collection, compilation and valuation.

The latest version of the INFRAS/IWW study on external costs of transport had in many respects a much broader view of the problem of transport externalities, compare to the 1994 study.

- Firstly, the cost items were extended to effects on nature and landscape, urban effects and up- and downstream effects for all modes. For road traffic in addition the costs of congestion have been estimated. Most of these additional effects play a minor role in the overall cost figures compared to the "classical" externalities. Congestion costs are considered separately from the other cost items because they reflect a different level of externality.

- Secondly, not only the external costs for the base year 1995 have been estimated, but also forecasts to the year 2010 have been made. The results of the forecasts, which are based on the prediction of traffic volumes, vehicle fleet compositions, emission factors, accident rates and unit values, are presented in a rather qualitative way in the final report in order to reflect the uncertainties going along with cost forecasts in general.

- Thirdly, in addition to total and average costs, marginal costs of transport have been addressed as the principle of marginal social cost pricing is currently promoted by the European Commission as the first-best policy to achieve efficient transport systems. In contrast to the total cost estimates, the marginal cost figures are based on bottom-up computations for various traffic situations.

- Finally, the marginal cost values have been applied to four pan-European passenger and freight corridors considering multi-modal transport chains. This exercise was presented to demonstrate the context-specific difference between national average cost figures and marginal external costs.

The Table 1 gives an overview of both, the 1994 and 2000 study "External Costs of Transport" by IWW, Karlsruhe and INFRAS; Zurich.

Two major items related to social costs have been omitted in the study: The costs for providing, financing and maintaining traffic infrastructure and public vehicle fleets and the contribution of the transport sector to cover its social costs. This has been done because in an ideal case infrastructure costs should be covered by transport user tax and fare payments. However, as taxes by definition are not earmarked contributions of citizens to the public budget, it is in practice impossible to say which part of transport users' contributions is transport-related and which not.

3.2 Scope and Methodology

The term "external" as it s used by the INFRAS/IWW 2000 study is defined according to the welfare maximisation approach, which is based on the individual's point of view. This means that all those costs are external, which are not directly covered by the transport user. Accordingly external costs are to be computed as the difference between the costs an individual imposes on society and the contribution he makes to cover these costs.

Table 1: Comparison of INFRAS/IWW 1994 and INFRAS/IWW 2000

Item	1994-Study	2000-Study
Cost estimates for year	1991	1995, 2010
Area	EU-15 Switzerland Norway	EU-15 Switzerland Norway
Cost categories	Accidents Noise Air pollution Climate change	Accidents Noise Air pollution Climate change Nature & landscape Additional effects in urban areas Up- and downstream processes Congestion
Transport modes	Passenger cars Motorcycles Buses Heavy duty vehicles Rail passenger Rail freight Aviation passenger Aviation freight Inland waterway shipping	Passenger cars Motorcycles Buses Light duty vehicles Heavy duty vehicles Rail passenger Rail freight Aviation passenger Aviation freight Inland waterway shipping
Outputs	Total costs per country 1991 Average costs by mode 1991	Total costs per country 1995 Average costs by mode 1995 Total cost by country 2010 Average costs by mode 210 Marginal costs by traffic situation Corridor estimates

In the base year of the study, which is 1995, environmental fees have not been introduced in Europe and thus annual vehicle taxes, fuel taxes and road tolls can at most be considered as contributions to infrastructure costs, which are not considered in the study. This holds for all modes of transport. The only contribution of transport users to cover their social costs remaining are risk-related insurance premiums internalising parts of accident costs.

For all accident and environmental cost categories total external costs are defined as the sum of all individual costs regardless of which cost reduction could be achieved by a full internalisation of transport externalities. An exception was made concerning congestion costs It was argued that the immediate sufferers of extra travel time and vehicle operating costs are identical with those who are causing these costs. Consequently summing up total time losses would lead to no useful result. The approach chosen for the determination of total congestion costs was the dead weight loss computed from marginal external cost functions and demand reaction curves.

The main output of the study are total, average and marginal costs per traffic mode. While total and average costs were generally estimated top-down the treatment of marginal costs differed between cost category. Whenever there was an indication that either multiple input factors are determining marginal costs (air pollution, climate change) or marginal social costs are non-linear to traffic volume (noise, congestion) estimation models were applied. The only cost category were average costs are used as a proxy for marginal costs were accidents.

Table 2 overleaf provides a brief overview of the methodology applied for each cost category. The most important methodological issues are presented in the subsequent sections.

<u>a) Accident costs</u>. The analysis of road accident costs in Europe is based on the number of fatalities and injuries reported in the International Road Traffic Accident Database (IRTAD), bublished by the German highway research office (BASt). These figures were adjusted by the estimated share of under-reported incidents, which is getting highly relevant for slight injuries. For rail and air traffic the numbers of casualties and injuries reported by the UIC and the ICAO were used. For inland waterway shipping no accidents were reported in the available statistics.

For all modes only those accidents, which happened during the normal operation of vehicles and which were not including professional operating personnel were considered. “Normal operation” in this case excludes accidents on private ground during loading or unloading of trucks or during marshalling of trains. Further, suicides were totally excluded from the consideration because these casualties are not in the responsibility of the transport sector. On the other hand, self inflicted accidents - willingly or not - were treated in the same way than “multiple-party” accidents.

Table 2: Methodological issues by cost category in INFFRAS/IWW 2000

Type of effect	Share of total costs (EUR 17 1995 in %)	Cost components	Most important assumptions
Accidents	29%	Additional costs of - medical care - opportunity costs of society - suffer and grief.	- A value of human life of 1.5 million Euro is considered. - Average costs are equal to marginal costs. There is no specific relation between vkm and accident rates assumed. - Insurance payments are considered in order to estimate external cost components.
Noise	7%	Damages (opportunity costs of land value) and human health.	- The valuation approach is based on a willingness to pay for silent space above 55 dB(A). - Average costs are estimated by a top-down approach based on ECMT data. - Marginal costs are estimated by a modelling approach.
Air pollution	25%	Damages (opportunity costs) of - human health - material - biosphere.	- The results are based on a new and consistent data basis for emissions for all countries (TRENDS/Eurostat). - Health costs are based on a WHO study estimating health costs for France, Austria and Switzerland. - Building damages, crop losses and forest damages are based on results of Swiss expert studies. - Marginal costs are computed by the ExternE model. In order to be compatible with the top-down approach for total and average costs, building damages are adjusted.
Climate change	23%	Damages (opportunity costs) of global warming.	- The data basis is TRENDS. - A unit cost value of 135 Euro per tonne of CO_2 is considered. - Marginal costs are assumed to be equal to average variable costs. - The unit costs of air transport are doubled in order to consider the specific risks of emissions in higher altitudes.
Nature and landscape	3%	Additional costs to repair damages, compensation costs.	- A repair cost is used, estimating the desealing costs for different types of infrastructure. - A reference level (unspoilt nature) of 1950 is assumed. - The effects are not relevant for social marginal costs, since these costs are infrastructure related.
Separation in urban areas	1%	Time losses of pedestrians.	According to the methodology used in Germany (EWS), time losses are estimated based on random samples of different type of cities.
Space scarcity in urban areas	1%	Space compensation for bicycles.	- According to the methodology used in Germany (EWS), time losses are estimated based on random samples of different types of cities. - The effects are not relevant for social marginal costs, since these costs are infrastructure related.
Additional costs from up- and downstream processes	11%	Additional environmental costs (air pollution, climate change and risks)	- Based on the energy consumption, additional costs for precombustion, production and maintenance of rolling stock and infrastructure is estimated. - For nuclear risks, a shadow price of 0.035 Euro per kWh is assumed, based on willingness-to-pay studies for risk aversion.
Congestion	not taken into account for %.	External additional time and operating costs.	- Use of a traffic model to compute marginal and average costs. - Time values are derived from EU research projects (PETS). Three approaches: - Net welfare loss for road transport facing an optimal congestion tax, - Revenues of an optimal tax, - Time losses relative to a better level of service.

For fatalities, severe and slight injuries several types of social costs have been estimated. These embrace:

- The **Risk Value**, which expresses society's preference for saving a human life or for avoiding severe injuries. The associated social costs are of non-monetary nature and are considered as fully external to the transport sector as the private risk perception by the drivers is extremely small.
- **Production losses** account for the net loss of the societies production potential taking into consideration the lost future consumption of the victims. Some ethical considerations occurred as due to the theory of social costs the net production loss would be negative for elderly victims. To avoid this conflict, an average age of casualties was assumed.
- The costs of **medical treatment, replacement** of the victim at his former working place and **reintegration costs**. These categories are based on actual expenses of the health sector. Depending on the legislative framework of national liability insurance systems, some of these costs are internalised by transfers from the liability sector to the health system.
- **Administrative costs** for justice, police and the insurance sector reflect the direct costs of public and private bodies to manage traffic accidents.

The cost of material damages have been omitted as they are considered being completely internal.

<u>b) Noise costs</u>. The assessment of traffic noise is based on 1991 data on the share of inhabitants per country exposed to different noise levels caused by road, rail and air traffic. This data set, which had been taken out of the OECD environmental data compendium, was completed for missing or implausible values. For the transfer to 1995 it was assumed that the negative effect of increasing traffic volumes and the positive effect of improved vehicle and infrastructure technology equalled out and thus the number of affected inhabitants has remained at the level of 1991.

Two main impacts of traffic noise on society have been identified:

- The **disturbance** of affected inhabitants was valued by the observed willingness to pay for quieter living areas. The review of existing independent studies carried out in Europe showed a surprising similarity of the increase in peoples' WTP per dB(A) of noise exposure. As an average of day and night values a maximum acceptable steady noise exposure of 55 dB(A) was assumed for the whole of Europe.
- The additional risks of **cardiac infections** was found by several studies carried out in the UK and in Germany to be up to 20% for constant noise exposure levels above 65 dB(A) while for

exposure levels above 75 dB(A) risks of +70% have been identified. These values were weighted by the risk value use for accidents and applied to the number of exposed inhabitants.

c) Air pollution. The costs of air pollution subsume the effects of substances in the air, stemming from exhaust fumes or resuspension of motor vehicles. Total costs are estimated on a top-down basis taking account of the rough interrelation between emission and exposure. Total emissions are computed using information of vehicle-specific emission factors and the composition of national vehicle fleets. The interdependency between emissions and concentration level is derived from the WHO health cost study (WHO 1999).

In the study it is accounted for the following effects:

- **Health costs** denote the increase of morbidity and mortality rates due to emission exposure. The approach applied is based on the results found by the WHO health cost study, carried out in 1999 for Switzerland, Austria and France. The new results of this study is the high valuation of PM10 particle exposure. This drives health costs related to transport emissions to extremely high values compared to earlier estimates.
- **Damages to materials and buildings, agricultural crop losses and forest damages** are of comparably minor relevance. The estimates are based on estimates for Switzerland and are then transferred to the rest of Europe according to NO_X-emissions, country size and sector-specific characteristics.

d) Climate change. Estimating the costs of global warming is an extremely uncertain task as many unknown variables influence the future development of the global climate. Thus, although they also face many difficulties, in the INFRAS/IWW study it was decided to use avoidance costs for the achievement of a particular target values instead. This approach of course attacks a lot of political issues, such as the decision on who (or which sector) has to reduce CO_2-emissions how much, the consideration of regional system delimitation and the decision on reduction targets.

According to the Kyoto-conference, a reduction goal of 50% until 2030 compared to 1990. The respective shadow value was found to be 135 Euro per tonne CO_2, which is comparably low compared to other studies.

e) Nature and landscape, up- and downstream effects and additional costs in urban areas. In addition to these four main cost categories a number of smaller effects was investigated. These costs mainly refer to the existence of traffic infrastructure rather than to its use. These cost categories and their estimation approaches are introduced briefly in turn.

- The costs due to the deterioration of **nature and landscape** include effects caused by the presence of transport infrastructure as well as effects which are caused by their utilisation. The first category embraces barrier effects, the reduction of the quality of landscapes and the loss of natural biotopes. Utilisation effects on the other hand include the pollution of soil and groundwater and the pollution caused by accidents. As the valuation of these cost categories is highly subjective the study compares the results of there different approaches: (1) Peoples' willingness-to-pay for intact nature, (2) a prevention costs approach and (3) a repair cost approach.

- **Additional costs in urban areas** aim to assemble the influence of the quality of life in densely populated areas by the existence and use of traffic infrastructure. Contained are the cost categories time losses due to separation effects and scarcity effects Separation effects are determined by the probability of big arterial roads to be crossed by pedestrians and by the additional time per crossing. Scarcity is expressed by the absence of bicycle lanes and hence the approach to estimate related social cots is to estimate the installation costs of missing cycle lanes.

- **Up- and downstream processes** characterise the production and disposal of energy, vehicles and infrastructure. The social costs associated with these effects are partly consistent with the cost categories elaborated above, but as they are not related to the direct performance of traffic for reasons of transparency they are considered separately in the study. The assessment of these costs starts from the percentage of air pollution and climate change costs caused by the production of assets and energy. In addition the risk of the production of nuclear power is added.

f) Congestion. The costs of congestion plays a special role within the INFRAS/IWW study as there are basic difference in the characteristics of congestion to other external costs, such that they can not be added up to each other. Congestion costs in general are a internal problem of the transport sector because actors willingly decide to participate in the system, even when capacity limits are reached. This argumentation does not only concern private traffic users, but also the economy as a commercial user. It is argued that traffic infrastructure is not built to be empty and thus there is no natural right to be not affected by other users.

The external part of congestion, from the individuals' point of view, is the difference between the increase in private costs and the costs imposed on each other when entering a congested system. According to Pigou (1920) the total external loss of welfare is determined by the dead-weight loss. This is defined as the difference between the social costs caused by an additional user and the maximal price he is pay for making the trip. This approach requires the estimation of an optimal level of congestion based on cost and demand information for the considered infrastructure link.

These costs express the inefficiency of user behaviour or - more friendly - the costs due to the missing information on the social effects of the single user's action. In scheduled transport which is using its own infrastructure it was argued that a "central planning unit" allocates slots for single units and this planning unit is totally aware of the effects an additional slow assignment entails. Therefore, in rail and air transport this kind of efficiency-related congestion costs do not exist and thus congestion was only computed for road transport.

The approach applied starts from a database of the entire European inter-urban road network, attributed with road type, capacity, length, etc. Traffic data was generated by a traffic model based on UN traffic census data for the year 1995. Assuming an average price elasticity and demand patterns of traffic, the dead weight loss was computed for every road link.

This approach turned out to be not very transparent to non-economist readers. Therefore, two alternative measures of congestion have been generated: (1) the expected proceeds of a congestion internalisation fee and (2) the engineering-style approach of adding additional time and operating costs compared to an (arbitrary) minimum quality level. In a final step the transaction costs for collecting the tax revenues have been estimated and compared to the expected social benefit.

3.3 Results

a) Total system-external costs 1995. The term "external" was defined as system-external in INFRAS/IWW (2000) and thus congestion costs as a transport-internal "club-good" are presented separately from classical system externalities. The main results found for the EU, Switherland and Norway for the year 1995 can be summarised as follows:

- Total external costs (excluding congestion) amount to 530 billion Euro for 1995, being 7.8% of the total GDP in the EUR-17 countries.
- Accidents are the most important cost category with 29% of total cost, which are by 87% caused by road traffic. The most important cost driver is the Risk Value, which is responsible for 85% of total accident costs in 1995.

- Air pollution is estimated to amount up to 25% of total costs, whereas the most important cost element are health costs caused by particle emissions and resuspension. Crop losses and damages to forests and buildings are of respectively minor importance.
- The valuation of greenhouse gases emitted by combustion engines and traditional power plants are estimated to be somewhat below the costs of air pollution at a percentage of 23% of total costs in 1995.
- The costs for nature and landscape deterioration and additional urban effects are of minor importance, upstream effects (11%) are quite significant, due especially to the fact that they are strongly related to air pollution and climate change.
- The most important mode is road transport, causing 92% of total cost, followed by air transport, causing 6% of total external costs. Railways (2%) and waterways (0.5%) are of minor importance.
- Two thirds of the costs are caused by passenger transport and one third by freight transport.

The results for the country-wise estimation of the transport-external costs are presented in Figure 1 below.

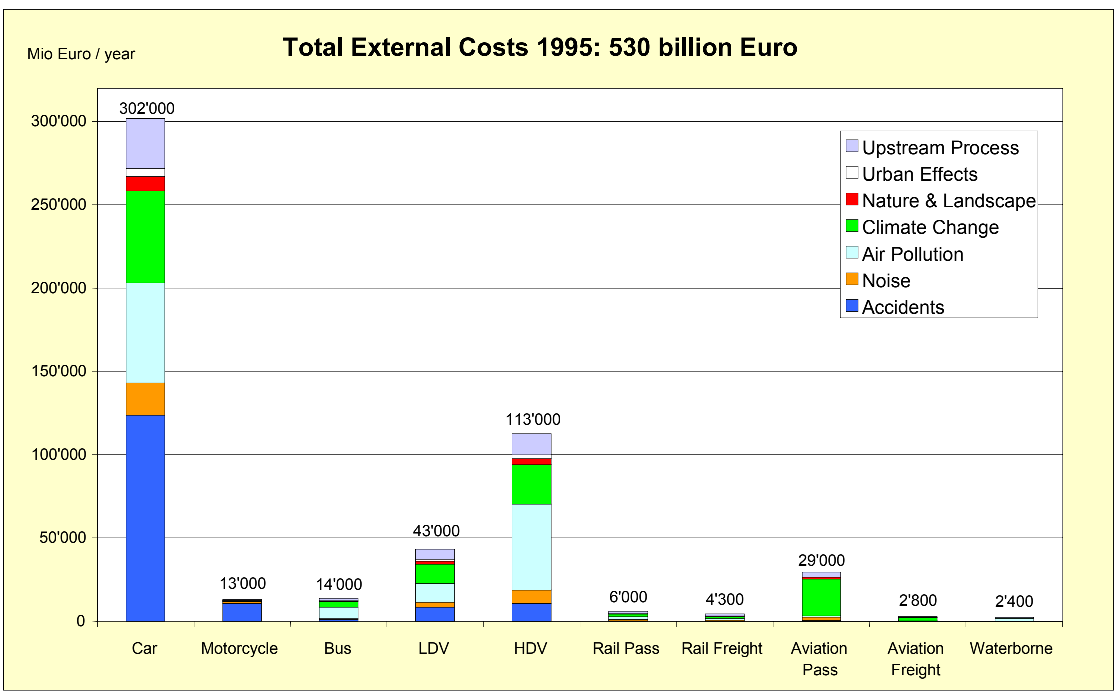

Figure 1: Total external costs of transport 1995 (EUR 17) by transport means and cost category.

b) Average costs 1995: Average costs are expressed in Euro per 1'000 pkm and tkm. Within the passenger transportation sector, passenger cars reach 87 Euro. Railway costs amount to 20 Euro, which is 4.4 times lower than costs for the road sector. Most important for the railway sector are the effects on climate change, noise and air pollution. In aviation the predominant effect 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 due especially 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 72 Euro per 1'000 tkm, which is 3.8 times higher than the cost for railways.

The average cost figures calculated by INFRAS/IWW (2000) are significantly higher than the values estimated for 1991 (IWW/INFRAS 1995). A detailed comparison is difficult, firstly because a new and more consistent database was used. Secondly, additional cost categories were estimated; they amount to 15% of total costs. Thirdly, the values for air pollution (esp. impacts on health) and for climate change risks increased with the new approaches were used. The figures estimated for 1995 are illustrated by figure 2 overleaf.

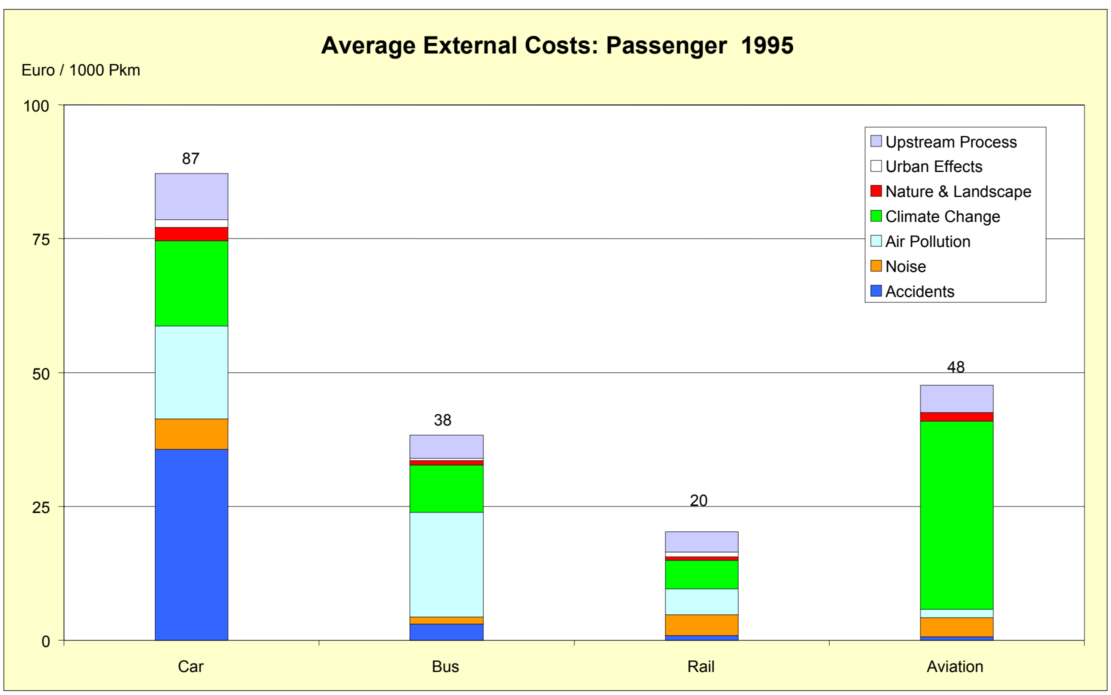

Figure 2: Average external costs 1995 (EUR 17) by means of transport and cost category: Passenger transport (without congestion costs).

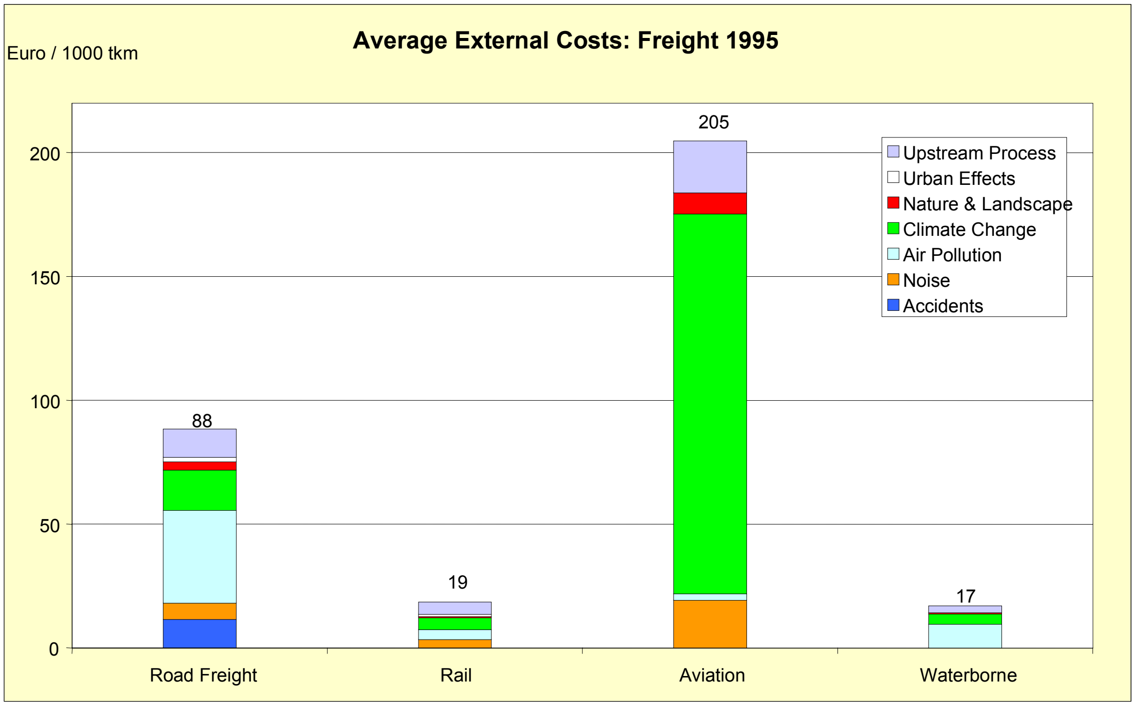

Figure 3: Average external costs 1995 (EUR 17) by means of transport and cost category: Freight transport (without congestion costs).

c) Marginal costs. In contrast to average costs, which are computed by dividing total costs by the mileage performed by different means of transport, marginal costs take into consideration specific traffic situations and constellations of surrounding variables. The latter might e.g. include the time of day, weather conditions, population densities or building structures, while traffic situations refer to the technical equipment of vehicles, traffic density and traffic mix. The relevance of these parameters alters strongly by the cost category considered. For example emission reduction standards are only decisive for the costs of air pollution, while the time of day considered is of particular interest for noise effects only. On the other hand, parameters like traffic density and type of infrastructure as a determinant of the vehicle speeds are relevant for nearly all cost components.

Accordingly, the marginal social costs caused are presented by individual classifications of driving factors for each cost components throughout the report. However, in order to make the results comparable, a minimum differentiation of traffic-related situations has been developed, to which the detailed estimates of each cost category have been aggregated. These main clusters distinguish between (1) urban and inter-urban traffic and (2) vehicle technology (gasoline, diesel, electric).

As even this simple classification produces a high number of permutations for all modes of transport, the results of the marginal cost estimates shown in Table 1 are aggregated by type of vehicle. The values are shown by ranges in Euro per 1'000 passenger- or ton kilometres, calculated on the basis of average occupancy rates. The ranges are quite significant, since different vehicle categories, traffic situations surrounding ding conditions are considered. The values in brackets show average cost figures, which might in some cases be used as a proxy for marginal costs. .

The ranges of marginal costs are based on different traffic situations. In urban areas for example, marginal costs are considerably higher than for interurban transport. Road passenger transport costs amount to 113 Euro per 1'000 pkm in urban areas and 34 Euro for interurban transport. For HDV, the figures are 91.5 Euro per 1'000 tkm (urban) and 40 Euro (interurban), respectively.

Table 3: Ranges of marginal costs by cost category and means of transport (average costs in brackets).

Marginal Costs (Average Costs)	Road					Rail		Aviation		Water-borne
[Euro per 1000 Pkm/Tkm]	Car	MC	Bus	LDV	HDV	Pass	Freight	Pass	Freight	Freight
Accidents 1)	11-54 (36)	79-360 (250)	1-5 (3.1)	44-163 (100)	2.3-11 (6.8)	0-1 (0.9)	0 (0)	0-1 (0.6)	0 (0)	0 (0)
Noise	0.2-21 (5.7)	0.6-53 (17)	0.1-7.5 (1.3)	5.3-496 (36)	0.6-52 (5.1)	0.2-23 (3.9)	0.1-1.6 (3.5)	2.3-17 (3.6)	17-87 (19)	0 (0)
Air Pollution 2)	5-17 (17)	14 (7.9)	4-25 (20)	28-118 (131)	14-50 (32)	2-24 (4.9)	1-6.8 (4)	0.8-2 (1.6)	0.8 (2.6)	4.5 (9.7)
Climate Change	12-25 (16)	9.6 (14)	5.5-11 (8.9)	125-134 (134)	15-18 (15)	4.2-8.9 (5.3)	4.2-5.3 (4.7)	36-42 (35)	117 (154)	4.7 (4.2)
Nature & Landscape	0-1.8 (2.5)	0-1.8 (2)	0-1.3 (0.8)	0-23 (23)	0-8.9 (2.2)	0-0.8 (0.7)	0-0.3 (0.5)	0-2.9 (1.7)	0-8.5 (8.5)	0-0.5 (0.5)
Urban Effects	10.7-11.7 (1.5)	6.7-7.4 (1.1)	3-3.2 (0.5)	75-83 (12)	8-9 (1.3)	0 (0.9)	0 (0.9)	0	0	0
Upstream Process	3.3-6.7 (8.6)	2.7-5.4 (6.0)	2.8-6.5 (4.3)	40-72 (69)	4.2-8.8 (8.7)	1.1-9.8 (3.8)	0.4-3.4 (5)	4.1-4.6 (5)	18-23 (21)	0.6-1.4 (2.6)

1) Average of countries considered.
2) Values for specific traffic situations in Germany, adjusted to European average.

Comparing marginal and average costs, the following general conclusions can be drawn:

- For accidents, figures are based on the assumption that the average of marginal costs is equal to average costs. The figures' range results from differences between countries. Urban transport values for cars are about 4 to 5 times higher than those for motorways and up to 1.5 times higher than those for country roads.

- For noise, average costs are well above marginal costs, since additional costs decline with increases in traffic. However, the important night time noise is not considered within the range of marginal costs. The values at night are more than double daytime values.
- For air pollution, average values are in principle similar to marginal values. Constant dose-response-relations are assumed. However, different cost estimation approaches have been used. Thus, a complete comparison is not possible. There are also considerable differences between different vehicle categories. For example a EURO 3 car in urban areas causes about 4 times lower costs than today's average car. Diesel trains cause 7 to 10 times higher costs than electric trains.
- For climate change, average costs are equal to marginal costs. The ranges result from different vehicle categories. Marginal costs per pkm of urban petrol cars for example are about 30% higher than the costs for interurban traffic. Diesel trains cause up to double the climate change costs of electric trains.
- For nature and landscape, average costs are close to maximum (long run) marginal costs. In the short run however, no marginal costs will occur, since the costs are infrastructure related and thus not relevant for social marginal cost pricing approaches.
- For urban effects, only marginal costs of separation are relevant, being above average because of a progressive increase with the amount of traffic. In addition the average values presented in Table 1 reflect national averages, whereas the marginal costs are related to specific urban traffic situations.
- For upstream effects, short-run marginal costs are only related to precombustion processes such as production, transportation and storage of fuels.[1] Therefore they are lower than average costs which include also vehicle and infrastructure related processes. Thus, average costs are close to long-run marginal costs.

All marginal values reflect existing situations. In order to deduce optimal prices and transport taxes respectively, the reaction of transport users to the price changes has to be considered as well. For this reason, general optimisation model applications should be used. Thus optimal prices are usually slightly below the values presented here.[2]. Average costs can be used as approximate values for marginal costs for mean traffic situations.

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1 Note that the emissions of electricity production (mainly for the railways) are considered within the air pollution and climate change costs.

2 These applications are carried out in ongoing EU-research projects (e.g. TRENEN).

d) Congestion costs. Total congestion costs are defined according to economic welfare theory as the costs arising from an inefficient use of the existing infrastructure. Due to the specification of the road traffic congestion and the three different approaches used, congestion costs are treated separately throughout this study.

For the EUR-17 countries, total and average road congestion costs, the revenues expected from their internalisation via road pricing systems and an "engineering" measure of additional time costs have been estimated on the basis of an extended network analysis for the year 1995. 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 measures is presented by the following figure.

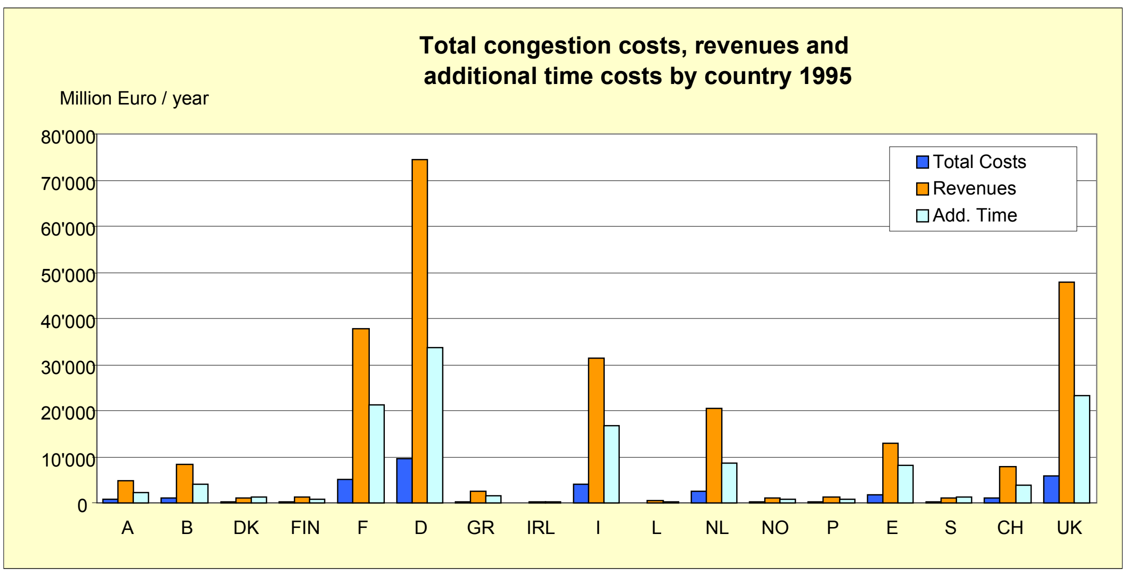

Figure 4: Economic congestion costs, potential internalisation charge revenues and additional time costs by country 1995 (in 1'000 mio. Euro)
Source: INFRAS/IWW 2000.

On the basis of reduced consumer surplus, the external costs of road traffic congestion are estimated approximately 33.3 billion Euro for 1995, which corresponds to a share of Europe's GDP of 0.5%. Road congestion costs are not equally spread across Europe. As expected, the big industrial countries along the "blue banana" (UK, France, Germany and northern Italy) contribute by far the most to total road congestion costs in the EUR-17 countries.

A rough estimate concludes that 70% to 80% of total congestion costs and revenues in passenger transportation result from urban traffic while the remaining share of costs occur in long-distance travel. In freight transport the share of urban congestion is considerably lower; it is estimated to range between 25% and 45% within the EUR-17 countries.

- Revenues from optimal congestion pricing amount to 254 billion Euro (3.7% of GDP).
- Additional time costs amount to 128 billion Euro (1.9% of GDP).

Marginal external congestion costs per vehicle kilometre are defined as the difference between the marginal social costs which a user imposes on the whole system and the private costs perceived by him. They are evaluated on the basis of speed-flow diagrams and are presented by road type as a function of lane occupancy. The following table shows the most important values.

Table 4: Short-run marginal external costs (SRMC), optimal user charges and average dead-weight-loss (DWL) of road congestion for passenger cars. Source: INFRAS/IWW 2000

Marginal congestion values (Euro / 1000 km)	Marginal values per vkm			Marginal values per pkm / tkm		
	SRMC	Charge	Av. DWL	SRMC	Charge	Av. DWL
Passenger car on motorway						
- relaxed traffic	11	11	0'	6	6	0
- dense traffic	1'980	1'000	78	1'040	529	41
- congestion	2'030	1'480	195	1'070	778	102
Passenger car on rural road						
- relaxed traffic	37	37	0	20	20	0
- dense traffic	1'250	803	2	660	423	1
- congestion	1'950	1'690	28	1'030	888	15
Passenger car on urban road						
- relaxed traffic	26	26	0	19	19	0
- dense traffic	2'710	1'590	60	1'900	1'140	43
- congestion	3'100	2'210	179	2'210	1'580	128

e) Corridor estimates. In order to draw a clearer picture of the relative external costs compared between different transport modes, a set of passenger and freight transport corridors were analysed. In contrast to the general average values presented in Figure 2 and 3, these case studies provided the opportunity to compare real travel alternatives to each other.

The results found clearly show, that the consideration of whole trip chains is decisive for intermodal comparisons. In particular: If we assume for passenger air transport to consist of a 20 km car trip through urban areas at the beginning and at the end of the journey, the clear advantage of air travel to passenger car travel is vanishing. The same holds for rail freight transport, were under some conditions the use of rolling motorway services (due to the long initial and final haulage by roads and due to the low net loading factors of trains), road haulage might even get favourable (compare corridor III in figure 5).

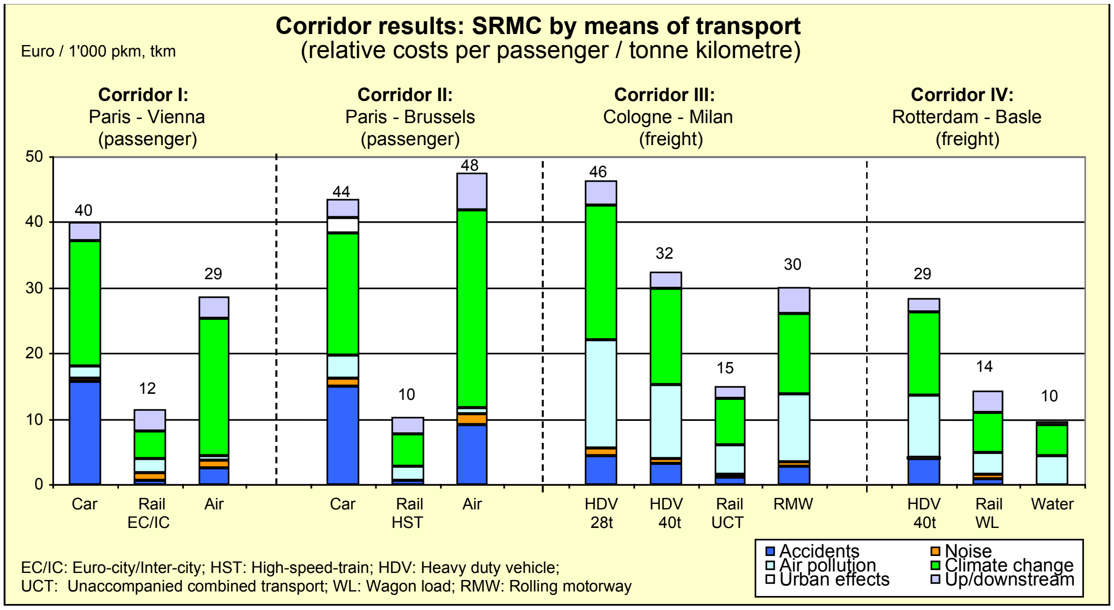

Figure 5: Corridor results: Accidents and environmental costs for different means of transport
Source: INFRAS/IWW 2000

3.4 Concluding remarks

Estimations of external costs on a European scale face several challenges. Firstly, a solid and comparable data basis is needed for all countries and all means of transport. Secondly, robust dose response functions and valuation principles for different cost categories are necessary in order to produce defendable results. Although the situation in comparison with previous studies has significantly improved, it is still important to interpret the results in an appropriate manner.

Most important are the relations between different means of transport. In spite of several uncertainties, the relations remain stable and show the level of specific external costs. Within passenger transportation, railways are still the means of transport with the lowest level of external costs. For freight transport rail and waterborne transport are about equal.

The comparison also shows the relevance of different cost categories. Not surprisingly, the better known externalities (accidents, noise) remain rather stable, whereas the risks of air pollution and climate change have led to increased costs. It is important that natural science research in to emission data and cost estimation has improved significantly in these areas during the past few years. Especially for air pollution related health costs and future climatic changes which are rather recent research fields. New risks may possibly be added and integrated in cost estimations in future.

In this report average costs and marginal costs are compared. The definition of marginal costs plays a major role in this comparison. Whereas it is very obvious that marginal costs differ from average costs for congestion and noise, because dose response and cost functions are not linear, it is rather difficult to conclude anything like that for other cost components. There are, however, two other elements which became visible making this comparison. Firstly, the marginal cost approach – being mainly a bottom-up approach – is very appropriate to provide differentiated results for different types of vehicles and different traffic situations, in order to make the range of costs visible. Secondly, it is helpful to distinguish between short-term impacts (directly related to the amount of traffic) and long-term impacts (which consider production and life cycles as well). This is especially true for nature and landscape and of up- and downstream processes.

It is also important to read, understand and interpret the results in a 'top-down manner'. The general statements made above are very robust and should help to provide a sound basis for further cost estimations and for policy implications (especially in the field of pricing). However, it has to be considered that the aggregated results are much more robust than the desegregated results, for example for specific countries or for specific traffic situations, since these values were derived from aggregated results. Thus, the more detailed the results are, the more illustrative they should be considered.

The study has shown the strengths and weaknesses of the estimation of external costs which is useful for future studies. We conclude the following major issues should be treated in more depth:

- **National accounts and marginal costs for different traffic situations**: For these two data sets the purpose of the estimation and the approach employed is quite different. Whereas the former can be used as statistical and strategic information on national level, the latter is directly relevant for pricing issues. The comparability of the approaches employed should be improved. More information is needed on the shape of the cost curves varying with the most important factors of influence.
- **Risk values**: Being one of the most critical assumptions in estimating external costs, the definition of risk values needs a lot of accurate evidence, including political and societal discussions of risk.
- **Air pollution costs**: More research is needed in the field of particulate matter (modelling, relevance of different particulates) for the estimation of health costs. The other cost elements

(especially building damage, damage to the biosphere) have to be improved by new estimations of dose-response relationships.

- **Costs of climate change risks**: In-depth discussions are necessary on the question of the target level to be chosen as this is the main element of cost uncertainties.
- **Congestion**: Although there is enough evidence to estimate marginal congestion costs, the relevance of total (external) congestion costs is still not finally determined.
- **Other external costs**: Upstream effects are in certain cases considered especially for fuel production and for electricity production used by electric trains. Due to lack of scientific data, electricity used for vehicle production by example is not considered. Although their relevance is quite limited compared to the main cost categories, it is important to include them more accurately in future in order to communicate their levels properly.

4 CURRENT EU-ACTIVITIES - THE UNITE PROJECT

4.1 Current State of the Project

One of the most important lessons we have learned while conducting the INFRAS/IWW study was, that the statistical standards of the different European countries widely differ from each other. This concerns very basic items, such as the delimitation of cars, station wagons, vans and trucks. Further, in most cases basic data (such as the number of vehicle kilometres, average occupancy rates) is missing or only available in a incomplete form. Respectively, the comparison of the social cost structure between member states of the EU is not really possible.

However, the knowledge of the social costs of traffic is essential in order to push forward a sustainable development of the transport sector. This is a central goal laid down by the EC Commission in their 1998 White Paper "Fair and Efficient Payment for Transport Infrastructure", in which the welfare-economic approach of marginal social cost pricing is promoted. On this basis the 5th Framework Programme of the EC (1998 - 2002) seeks for ways to bridge these gaps and to transform the economic principles detected in the 4th Framework Programme (1994 to 1998) into practical implementation plans. Respectively, the character of EU-funded research has changed from fundamental research towards policy support. In the transport sector the GROWTH programme (Competitive and Sustainable Growth) plays an important role in this field.

The accompanying measure UNITE (Unification of Accounts and Marginal Costs for Transport Efficiency) was launched within the GROWTH programme as the attempt to work out principles for the refinement of European transport statistics with respect to the computation of social costs. The background of the project task is that for the implementation of the Commission's 1998 White Paper a sound and comparable information basis on the social external costs of transport is required. Further, clarification on the interdependency of marginal costs and total or average costs is required as this question has not been addressed by the 4th Framework research projects. The understanding of the interdependency between charges levied, marginal social costs, total costs and the attitudes of users as well as the role of the general economy, however, is essential in order to work out a sustainable and equitable transportation policy. That is why the integration of accounts and marginal costs is a core task of the UNITE project. Starting from these three core items, the structure of the project is moving along the following dynamic three-step structure:

- The first part of the project works out recommendations for the structure of total and marginal cost accounts for six cost and revenue categories.
- In Parallel, a work package on the integration of accounts and marginal costs analysis the potentials for use of misuse of marginal costs and transport account information for transport policy purposes.
- The second phase of the project, which comprises six specialist work packages for each cost category (infrastructure costs, supplier/operator costs, user costs, accidents, environmental damages and taxes and charges), supports the definition process. In the other direction, the definition part feeds into the specialist work packages as one of its main tasks is to make the procedures proposed for each category consistent to each other.
- Each specialist work package carries out a number of marginal cost case studies, which aim to cover a wide range of modes and traffic situations and demonstrate the application of the cost computation framework proposed
- In a further stage of the project, pilot accounts for the years 1996, 1998 and 20ß5 are produced for 18 European countries. .

The UNITE research has started in January 2000 and will last for 36 months. The consortium, which is lead by the Institute for Transport Studies (ITS), Professor Chris Nash, University of Leeds, UK, constitutes 17 partners, located across the EU, Switzerland, Hungary and Estonia. This ensures a coverage of many different regions, all having their special problems, perspectives and futures visions of the transport sector.

The first phase, which concludes with the proposition of methodologies for accounts and marginal cost estimates, is currently in its final stage. The first round of reviews of the specialists' recommendations for establishing social cost accounts has clearly indicated the problem of consistency. In parallel, the elaboration of pilot accounts for Germany and Switzerland, were the data situation is expected to be rather good, and the conduction of the marginal cost case studies, have been started. First results are expected in April 2001.

4.2 Comparison of the methodology to the INFRAS/IWW Study

In general the structure of the UNITE project is rather similar to that of the INFRAS/IWW study, which has been presented in section three. However, the number of partners involved and the time and financial resources available provide the opportunity to go much more into detail concerning particular countries and cost items. Moreover, a number of lessons have been learned from the INFRAS/IWW study, a fact, which fed into the methodological baseline of the UNITE project. In fromt of the background provided by Section 3, in the subsequent paragraphs the UNITE approach and its delimitation fo the infrast/IWW study is presented briefly.

The main goal of UNITE is to provide an information basis for setting appropriate transport prices. Therefore, the estimation of marginal social costs and their generalisation is standing much more in the foreground of the research. In contrast, the motivation of the International Railway Union (UIC) to publish a second volume of the 1994 study on the external costs of transport was to show, that (1) that the UIC is still at the cutting edge of research and (2) that the ecological advantage of rail transport is still obvious. Thus, the main goal of the INFRAS/IWW study is the presentation of total and average cost figures for intermodal comparisons. .

In the UNITE project transport internal costs infrastructure and supplier operating costs are determined. The methodology applied for infrastructure costs here is based on the work of the German Institute for Economic Research (DIW) (compare DIW et. al (1998) and DIW (2000)), where a detailed framework for valuing the existing traffic networks is set. This is in particular in terms of transport pricing as the directive 1999/62 of the European Commission explicitly states, that road user charges on the European motorway network must be based on infrastructure cost estimates.

The significance of the estimating supplier operating costs is to show in detail the subsidies going from the general budget to transport operators. Using traditional national accounting systems, this information can often not be extracted easily. Nevertheless it is decisive for moving the transport sector towards a fair and equitable state.

For the goal of a direct cost comparison between modes both cost categories (Infrastructure and supplier operating costs) are not very much in favour of the railways and thus the concept of system-externalities (or the Club-Good-Theory, compare INFRAS/IWW 1994) has been introduced. As the research goal of UNITE is price setting instead of intermodal cost comparison, the introduction of total pricing-relevant costs (including infrastructure and supplier-operating costs), is of major importance.

The scope of total user costs defined in the UNITE project basically differs from the definition of congestion applied to the INFRAS/IWW study, where total external user costs are defined as the deadweight loss arising from the introduction of an equilibrium (optimal) user charge. The basic idea of this concept is that the inefficient behaviour of users due to their limited knowledge of the total effect they cause, is corrected by letting them pay their external costs. If we further assume that in scheduled transport services, slots are planned by a central agency, which is aware of the impacts an additional traffic unit has on the whole system, congestion effects are assumed to be already internalised. In General this approach is in line with latest research in the topic of congestion costs (Prud'home (1998), Proost et. al. (1999)). This concept was altered in the UNITE methodology because the total costs of congestion is not a meaningful figure, but requires a not of input information if it is computed according to the economic welfare theory. The only relevant information for pricing purposes is the marginal costs per vehicle kilometre. Total costs relating to increasing transport demand, however, are expressed as extra costs related to a minimum standard of traffic quality. As this engineering-style approach has nothing in common with the economic definition of congestion, the terminology used in UNITE is "(additional) user costs" or "delay costs".

The delay cost approach is simple and communicable, but bears the danger of relying on a arbitrarily based definition of acceptable service quality. On the other hand, no transport mode is per-se excluded from the problem of delay costs. For political decisions the additional cost approach can be used to support network investment decisions, as the share of heavily disturbed traffic gives an indication of the relation between transport demand and supply. In political terms, this information is seen to be more valuable than the theoretical social benefit from raising congestion taxes[3].

In terms of traffic accident costs, internal cost components, such as material damages and deductibles paid by the user directly) are considered in order to show the current charging structure and the way it could be improved towards a more risk-related system. Considerable efforts are undertaken to improve the understanding of marginal accident costs and their relation of user behaviour and traffic parameters.

The approach towards the quantification of air pollution, greenhouse gas emissions and traffic noise followed in the UNITE project is to compute total costs bottom-up using the ExternE model. In the INFRAS/IWW study effects related to transport emissions have been estimated on a top-down basis and therefore the comparison of the two outputs is interesting in scientific

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3 Further concerns have been raised about how existing time variant charges (e.g. on French motorways) must be considered when determining the current user cost structure, which is decisive for the level of the deadweight loss.

terms. Setting an appropriate value of human life was the starting point of an in-depth discussion throughout the UNITE project. On one hand, this value is used for the assessment of accident costs, on the other hand it is a major input variable for the determination of the costs of mortality and morbidity stemming from air pollution and constant exposure to traffic noise. the review of a large amount of studies has indicated, that the value of a statistical life is within the range of 1 and 2 million Euro. In contrast to these findings, the value used within the ExternE model was set by the ExternE project to 3.1 million Euro. As an agreement could not be found, the conflict was solved by arguing that health damages due to pollutant exposure, which are leading to a more of less minor decrease of life time expectation, are somewhat different from the instant death or steady health effects caused by accidents. Finally, two separate values are applied to both cost categories.

4.3 Future demand for research

The quantification of what the external costs of transport are is a urgent requirement of the Comission of the European Communities. Therefore, a project was launched in January 2001 to quantify sound ranges of the external costs of each transport mode within a time frame of six months. Following the methodological baseline set by the UNITE project, the project team is asked to produce an in-depth review of past research on the topic and conclude with a set of reliable cost figures by mode and traffic situation.

According to the EU's white paper on fair and efficient infrastructure payment (EC 1998), the knowledge of the marginal costs of transport is a prerequirement for the determination of a sustainable transport policy. In the field of the technical feasibility and the appropriate design of transport pricing systems, a number of current research has started. As an example, the DESIRE project (Design of Inter-Urban Road Pricing Schemes for Heavy Goods Vehicles) is dealing with these questions on a European level with the focus on the technical feasibility and the general economic consequences of introducing a Europe-wide motorway toll system for HGVs(DESIRE 2001). On the national level in Germany, in-depth discussions on the appropriate form of introducing a HGV-toll on motorways are taking place. In a running impact analysis from the ecological point if view, carried out by the University of Karlsruhe on behalf of the German Environmental Agency (Umweltbundesamt) it is indicated that the reactions of hauliers and shippers towards a more environmentally friendly transport will take place only if particular threshold levels of cost increases are exceeded. In contrast, negative reactions, such as traffic shifts from the primary road network towards the ecologically more sensitive secondary road network play an important role and should not be neglected. As in this field the information basis is very week, the DESIRE project is expected to provide more solid answers to the question of how to include external social costs within charging regines and in order to avoid undesirable negative impacts.

As indicated by the FISCUS project (FISCUS 1999), the monitoring function of social cost estimates is an important one in order to judge the effectiveness of policies made in the past. For this task, however, one-off studies, such as INFRAS/IWW (1994 and 2000) or the UNITE project's country accounts, which are carried out for three years only) are not suitable, because cost indicators are in post cases underlying externally caused fluctuations. Accordingly, only a system of periodic accounts is capable to monitor trends and deviations of the environmental quality development and its dependency on political actions.

In order to start the discussion on this topic, the European Environment Agency (EEA) has called for a workshop in November 2000 in order to discuss the appropriate way of establishing a sound environmental indicator for the transport system. In this sense, the computation of total social costs of transport is - even if it is considered as a second-order goal by the EU Commission - a necessary tool, which enables to correct undesirable developments in transport policy.

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