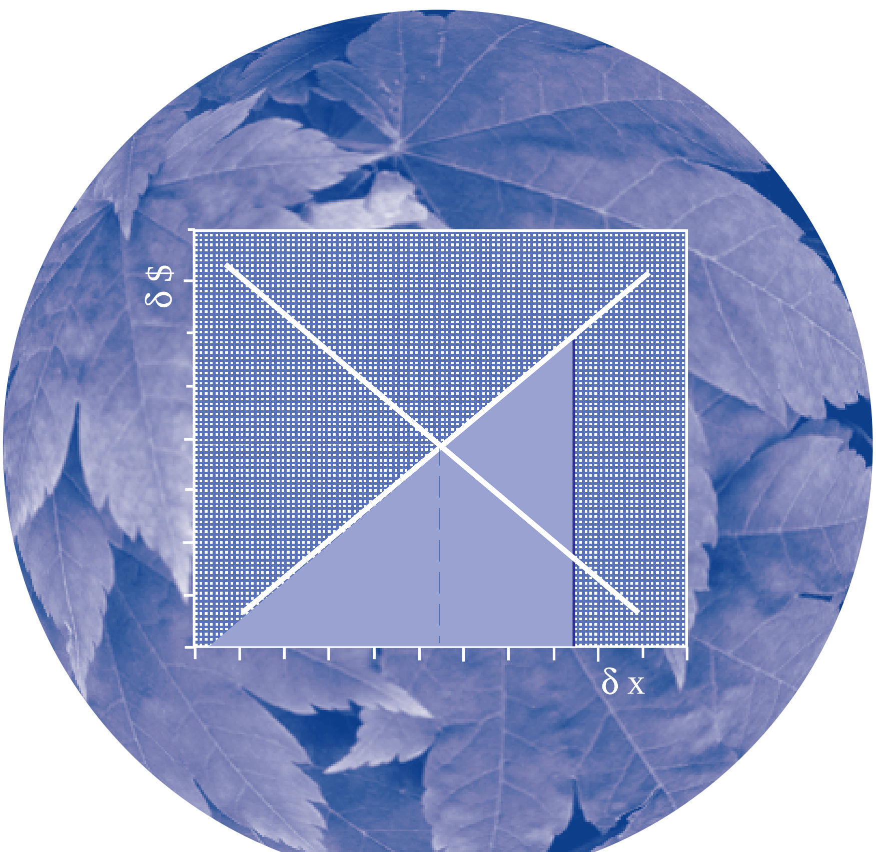
EUROPEAN CONFERENCE OF MINISTERS OF TRANSPORT

Efficient Transport for Europe

Policies for Internalisation of External Costs



EFFICIENT TRANSPORT FOR EUROPE

Policies for Internalisation of External Costs

EUROPEAN CONFERENCE OF MINISTERS OF TRANSPORT

EUROPEAN CONFERENCE OF MINISTERS OF TRANSPORT (ECMT)

The European Conference of Ministers of Transport (ECMT) is an inter-governmental organisation established by a Protocol signed in Brussels on 17 October 1953. It is a forum in which Ministers responsible for transport, and more specifically the inland transport sector, can co-operate on policy. Within this forum, Ministers can openly discuss current problems and agree upon joint approaches aimed at improving the utilisation and at ensuring the rational development of European transport systems of international importance.

At present, the ECMT's role primarily consists of:

– helping to create an integrated transport system throughout the enlarged Europe that is economically and technically efficient, meets the highest possible safety and environmental standards and takes full account of the social dimension;
– helping also to build a bridge between the European Union and the rest of the continent at a political level.

The Council of the Conference comprises the Ministers of Transport of 38 full Member countries: Albania, Austria, Azerbaijan, Belarus, Belgium, Bosnia-Herzegovina, Bulgaria, Croatia, the Czech Republic, Denmark, Estonia, Finland, France, the Former Yugoslav Republic of Macedonia (F.Y.R.O.M.), Georgia, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Moldova, Netherlands, Norway, Poland, Portugal, Romania, the Russian Federation, the Slovak Republic, Slovenia, Spain, Sweden, Switzerland, Turkey, Ukraine and the United Kingdom. There are five Associate member countries (Australia, Canada, Japan, New Zealand and the United States) and two Observer countries (Armenia and Morocco).

A Committee of Deputies, composed of senior civil servants representing Ministers, prepares proposals for consideration by the Council of Ministers. The Committee is assisted by working groups, each of which has a specific mandate.

The issues currently being studied – on which policy decisions by Ministers will be required – include the development and implementation of a pan-European transport policy; the integration of Central and Eastern European Countries into the European transport market; specific issues relating to transport by rail, road and waterway; combined transport; transport and the environment; the social costs of transport; trends in international transport and infrastructure needs; transport for people with mobility handicaps; road safety; traffic management, road traffic information and new communications technologies.

Statistical analyses of trends in traffic and investment are published yearly by the ECMT and provide a clear indication of the situation in the transport sector in different European countries.

As part of its research activities, the ECMT holds regular Symposia, Seminars and Round Tables on transport economics issues. Their conclusions are considered by the competent organs of the Conference under the authority of the Committee of Deputies and serve as a basis for formulating proposals for policy decisions to be submitted to Ministers.

The ECMT's Documentation Service is one of the world's leading centres for transport sector data collection. It maintains the TRANSDOC database, which is available on CD-ROM and accessible via the telecommunications network.

For administrative purposes the ECMT's Secretariat is attached to the Organisation for Economic Co-operation and Development (OECD).

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Further information about the ECMT is available on Internet at the following address:

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FOREWORD

Pollution, accidents and congestion all cause unnecessary welfare losses, and while transport services are an essential component of economic and social development, their negative side effects are drawing increasing political attention. Internalisation aims to maximise efficiency and create incentives to reduce these external costs by factoring them into markets.

This report:

- summarises the theoretical and practical dimensions to internalisation;
- reviews recent estimates of external costs;
- explores the mix of regulations and economic instruments that might be used to promote internalisation successfully;
- estimates in monetary terms the size of incentives required.

Every effort has been made to render the assumptions behind the calculations in this report as transparent as possible so that other analysts can use the data it contains. The work was undertaken by the ECMT Task Force on the Social Costs of Transport, a group of government economists from across Europe supported by private sector experts.

The Task Force was established by Ministers of Transport in 1994 following an initial report published under the title *Internalising the Social Costs of Transport* (out of print but available on the ECMT Website). The Task Force presented its conclusions to Ministers at their Berlin Council and completed its work in 1998 with finalisation of the present report and preparation of a draft Resolution for Ministers on the policy approach to internalising the external costs of transport.

The ECMT wishes to thank the members of the Task Force (a list is included at the end of the report) for their time, effort and expertise. Special thanks are due to Sami Mauch, chairman of the Task Force, and to the governments of the Netherlands and Switzerland for supporting its work. Thanks are also due for expert assistance: to Arie Bleijenberg of CE in Delft, particularly in regard to the chapters on policy options and economic impact and for computing the data on road transport; to Robert Tinch, initially at the Department of Transport in London and now at the University of York, for work on the valuation of externalities and on marginal shadow prices; and to Rolf Iten and Sami Hess at INFRAS in Zurich and Bern, particularly in regard to the chapter on the concept of internalisation and the annex on infrastructure costs. Thanks for input to the chapter on internalisation in economies in transition go to the Ministry of Transport and Communications in the Czech Republic, to experts at the Ministry of Transport and Maritime Economy and the Ministry of Finance in Poland and to researchers at the University of Gdansk.

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CONCLUSIONS

Significant welfare gains could be realised through an adjustment of charges and taxes to provide incentives for reducing the external costs of transport. Internalisation aims to achieve this efficiently by factoring these costs into markets. The ECMT Task Force identified four major categories of cost that internalisation policies should be designed to manage: accident externalities (loss of life, injury and uncovered costs to health and welfare systems); environmental damage (principally air pollution, noise and climate change); uncovered infrastructure costs; and congestion.

Internalisation policies can be implemented through economic instruments, and/or regulations, designed to reduce externalities to the optimal level (it should be noted that increasing taxation without creating incentives for optimisation does not contribute to internalisation). This report deals with pricing at greater length than regulation only because economic instruments are relatively under-utilised.

Internalisation has implications for both the structure and the level of prices. For some transport services with high external costs, internalisation is likely to lead to price increases. However, internalisation will primarily involve structuring prices more efficiently, rather than increasing prices overall.

The tax systems of many countries already internalise some external costs, either as a result of overt policy or as an implicit by-product of revenue raising through taxes specific to transport. Though full internalisation will include higher overall transport charges in many countries, the change for some groups, including many car users, will be small. Very rough estimates suggest that transport costs might increase on average by 15-30% in Europe as a result of full internalisation of the main externalities.

Internalisation does not necessarily result in increased overall taxation. It simply redirects certain financial flows to make economies more efficient, and in the long run more competitive. Revenues arising from internalisation will provide resources for governments to use as they see fit, creating opportunities to reduce general taxes, for example, or for investment in environmental protection.

Internalisation raises some adjustment problems through its impact on different categories of transport user and at the international level. The adjustment to more efficient economic conditions will have costs for agents that benefit from current distortions. The benefits of internalisation, however, will outweigh the costs. Any compensation judged necessary to ease the adjustment period should be provided in ways that do not undermine the incentives that internalisation measures are designed to produce.

In the newer Member countries of the ECMT, quantitative estimates of external costs are far from complete. However, the adjustment to more market oriented economies has already led to adoption of instruments suited to implementation of internalisation policies. Though barriers to the use of certain instruments exist in some countries, internalisation policies can be adopted in transition economies on the basis of first order cost estimates. In some of the newer member countries existing use-charges are currently very low and it may take longer to reach levels required for internalisation. However, initiating a gradual process of internalisation now in small steps would have the major advantage of laying the basis for containing external costs during the coming period of rapid projected growth in road and air transport services.

In all ECMT countries, full internalisation can only be viewed as a long term objective because of the wide gap between the present structure of costs and prices in transport markets and the ideal. However, it is a goal towards which a firm commitment is required, and progress has to begin now.

THE COST OF FAILING TO INTERNALISE

The external costs of transport impose significant burdens on the economy through losses of welfare. Even low estimates amount to several points of GDP. These inefficiencies also imply unfairness, since costs are imposed on certain companies and individuals without compensation or assent. Although absolute values for external costs remain uncertain, factoring the minimum estimates established by the ECMT Task Force into charges for transport services would pose little risk of overestimation, and would certainly lie closer to optimisation than an implicit zero valuation. Taking all modes together, accidents appear to represent the largest category of externality, followed by environmental costs. Some estimates of total road congestion costs are larger than either of these categories, but few recent or reliable estimates are available.

IMPACT OF INTERNALISATION

The primary effects of internalisation policies are expected to be significant welfare gains. The main responses anticipated are technological change and increases in operational and organisational efficiency. It is likely that only small changes in modal split will occur, together with a small reduction in the overall growth in demand for mobility.

Internalisation is expected to have little impact on GDP growth or on competitiveness of industry as a whole. The effects of increased costs will be offset by increases in efficiency and opportunities for reducing general taxes. Internalisation may have a small positive effect on labour markets.

The impact of internalisation on competitiveness is likely to be greater for rail than for road transport due to the weight of uncovered infrastructure costs and the greater sensitivity of rail markets to price increases. However, provided that potential productivity gains are realised in rail transport, internalisation is likely to have little impact on modal split for passenger or freight traffic in the long term.

EXTERNAL BENEFITS

The economic and social benefits of transport are large. However, as they are almost all ultimately captured by the market, no allowance should be made for them when factoring external costs into charges for the use of infrastructure. All benefits should, nevertheless, be accounted for in social cost-benefit analyses, such as those undertaken to determine whether to build new infrastructure.

To the extent that internalisation policy leads to decreased traffic growth, external benefits measured in terms of GDP will also be constrained.[1] However, the overall changes in social costs and benefits, taking into account reductions in external costs and the dynamic adaptation of economic structures, will result in a net increase in welfare.

POLICY AND STRATEGY

Internalisation of external costs should be an objective of transport policy. Internalisation can increase economic performance through a more efficient allocation of resources with significant gains in terms of social welfare. It also presents opportunities to reduce budget deficits through more efficient management of government expenditure. Internalisation is a key element of strategies for fostering sustainable development and providing for effective integration of environmental, social and economic development goals.

Effective internalisation policies will be based on a mix of regulatory and pricing instruments. Existing regulations could be better enforced, tightened, and combined with incentives that are designed to encourage attainment of stricter second-stage standards. Existing charges and taxes should be differentiated to link them more closely to external costs. Higher use-charges for transport may be appropriate in many cases.

Some promising instruments – electronic km-charges and, most particularly, road pricing – will take time to mature, so some priority should be assigned to their development.

To be effective, economic instruments require functioning markets. Measures aimed at internalisation will therefore necessitate co-ordination with financing arrangements and subsidies in the transport sector. This should be addressed within a coherent policy for reducing distortions in transport markets.

Internalisation should treat all transport modes and economic sectors equally. For example, charges for CO_2 emissions should be levied at the same unit rate regardless of whether they arise from road, rail, air or waterborne traffic, or indeed from industry or power generation.

IMPLEMENTATION

Initiatives to internalise social costs can be expected in many sectors of the economies of Member countries over coming years. Transport Ministers must ensure that in their sector such initiatives are implemented in ways that minimise disruption to the users and providers of transport services. This is most likely to be achieved if changes in prices are introduced gradually to a clearly defined schedule. Abrupt changes, especially in monetary charges, must be avoided to minimise stress on economic agents. The need for gradual change implies that action to tackle existing and growing distortions must be taken early.

Internalisation instruments should be dynamic; that is, they should take account of expected changes in technology and respond to changes in estimates of external costs. (This implies, for example, that where agreed schedules for tightening emissions standards exist, such as those for passenger cars in the European Union, charges should be based on the new standards rather than existing emissions rates.)

Changes in levels of external costs over time, together with progress in monitoring and measuring technologies, can also be accommodated in a step-wise internalisation process.

Implementation should be based on a mix of the following main instruments and approaches:

1. Continued development of dynamic regulatory standards for vehicles and fuels; in particular this entails raising emissions standards for all light duty road vehicles to the levels for passenger cars.
2. Strengthening of laws related to road safety, and their enforcement, and development of preventive measures based on education and policing.
3. Development of vehicle insurance systems or surcharges to increase *a)* variabilisation of premiums, *b)* their relationship to driver safety records and *c)* cost coverage.
4. Increases in fuel charges to address a substantial part of external costs until general road pricing becomes available. Continued efforts towards international coherence in fuel taxation across ECMT countries will be important in this context.
5. Differentiation of annual vehicle taxes to accord more closely with air and noise emissions factors.
6. Introduction of congestion charging, especially where tolls already exist, to improve traffic flows on trunk roads.
7. *Ex ante* negotiation and contracting of public service obligations, linking them to services rather than modes.
8. Phased increases in charges for the use of rail infrastructure (except in the relatively rare cases where this has already been done).
9. Phasing out of distortions to competition arising from mode-specific tax advantages (*e.g.* in air transport).

10. Development of more differentiated use-charge systems employing electronic km-charges[2] (axle weight distance charges) for heavy goods vehicles and the gradual introduction of road pricing systems in metropolitan areas and on national/international networks. Experience from pilot cities should indicate which instruments road pricing can replace to best advantage.

In timing the introduction of internalisation instruments there should be some linkage with productivity increases in rail services. The relationship is twofold. Internalisation could spur urgently needed productivity improvements, but implementation should be co-ordinated to avoid modal split changes that would be uneconomic in the long term.

Independent of the implementation of new internalisation instruments, emphasis should be placed on enforcement of existing legislation, especially in regard to road safety and road freight transport measures (maximum driving hours, health and safety regulations, etc.). It does not make much sense to add legislation if more could be achieved by improving enforcement of existing laws.

LEVEL OF GOVERNMENT INTERVENTION AND INTERNATIONAL CO-OPERATION

Several practical considerations necessitate international co-ordination, including control of "tank tourism" (caused by cross-border fuel price differentials), internal market requirements, cross-border externalities and the distribution of revenues raised by charges levied on international traffic.

International co-ordination will continue to be important in setting emissions standards, harmonising technical norms and supporting co-ordinated reductions in transport market distortions (*e.g.* reducing subsidies). Co-ordination on matters such as tax floors will be important to avoid potential impediments to international trade and to facilitate the recommended shift in emphasis from fixed taxes to variable charges. This applies particularly to fuel excise duties and aviation charges. International co-operation is also recommended to facilitate eventual deployment of one of the most promising long term instruments, electronic tolling, through harmonisation of technical norms and operational procedures so that systems are interoperable.

At international level the emphasis should be harmonisation of the *approach* to internalisation. Determining the level of charges within the agreed framework should be left to the most decentralised level of government with sufficient competence. International policy should aim to complement national approaches rather than replace them.

NOTES

1. This effect, however, will be offset by the positive effects of opportunities for reduced general taxation.
2. Assuming technological development and testing of electronic tolling systems continues to progress.

Chapter 1

EXECUTIVE SUMMARY

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1.1. INTRODUCTION

1.1.1. Background

The problem

Significant growth in the demand for and supply of transport infrastructure and services has occurred over the past 20 years. While transport services are an essential component of economic and social development, negative side effects are causing considerable concern and drawing corresponding political attention to the social costs of transport.

Pollution, accident costs, degradation of landscapes and ecosystems and reduced quality of life have long been of concern. Congestion and uncovered infrastructure costs have become the subject of particular attention more recently. These problems cause significant and unnecessary welfare losses to the economy and society, losses that may total several percent of GDP, corresponding to hundreds of billions of ECU per year for Europe as a whole.

There is increasing awareness that the root causes of most of these problems are deficiencies in, or barriers to, the efficient operation of markets. Environmental costs and other externalities are systematically neglected or underestimated in transport prices. As a result, the individual transport user receives distorted price signals. Failure to respect a fundamental economic principle – that resources should be paid for at their marginal social cost – results in waste, characterised in the transport sector by high accident, health, environmental, finance and congestion costs that persist because users perceive them only indirectly.

The opportunity

Significant welfare gains could be realised by adjusting regulations, charges and taxes to provide incentives for reducing the external costs of transport. Internalisation aims to provide such incentives by factoring these costs into markets. It promises in theory to maximise efficiency and optimise resource allocation.

Achieving this in the short or even medium term is difficult given the current divergence from optimal conditions in transport markets and the difficulties in quantifying externalities. Therefore, internalisation should be considered one of a number of tools for addressing imbalances in current transport markets, rather than a recipe for achieving perfection. Difficulties in designing perfect instruments should not, however, be an excuse for neglecting the opportunities that internalisation offers for significant social welfare gains. Introducing appropriate market price signals where they are lacking and developing incentives in existing transport charges to reduce external costs are powerful tools for ensuring more balanced economic development, reduced accidents, reduced environmental damage and more efficient transport services.

1.1.2. Mandate of the Task Force

Transport and other Ministers are aware of these problems and have been seeking solutions through various forums, as shown by documents such as the 1989 ECMT Transport Ministerial Resolution, various OECD Environment Ministerial Communiqués and the 1992 European Union White Paper on transport. At their June 1994 meeting in Annecy, France, following discussion of the ECMT/OECD report *Internalising the Social Costs of Transport*, ECMT Ministers decided to establish an *ad hoc* Task Force on the issue. Its mandate included: clarifying the issues, concepts, definitions and terms used in the discussion of external costs and benefits; indicating which methods of internalisation are most appropriate and what improvements are needed; and developing appropriate policy options for internalisation in the context of overall transport policy.

The Task Force aimed to build on important work completed in other institutions and to co-ordinate with initiatives taken elsewhere after its work began. The most significant of the latter was the European Commission's contribution to the debate, its 1995 green paper entitled "Towards Fair and Efficient Pricing in Transport". The present report both builds on this green paper and the results of discussions subsequent to its publication, and addresses in detail the theoretical issues which are the foundation of policies oriented towards internalisation.

The Task Force produced a series of technical papers with the help of specialised experts:

- a glossary of terms and definitions, which should provide a basis for agreement among governments on what classes of social effects require internalisation and where intervention is appropriate;
- a discussion of the techniques available to evaluate externalities, setting out conditions for good practice and for making international comparisons;
- an overview of recent estimates of the size of externalities, confirming the ranges of estimates reported to Ministers at Annecy with an increasing degree of confidence;
- an analysis of the marginal costs implied by these estimates;
- an examination of the economic impact of internalisation;
- an overview and discussion of internalisation policy options, placing these into the context of overall transport policy.

The Task Force also held a hearing with international non-governmental organisations, representing industries, transport users and environmental organisations, at which issues and solutions were discussed. All of these elements are incorporated in the present report. The Task Force completed its work in 1998 with preparation of a draft Resolution on the policy approach to internalising the external costs of transport to be considered by the Council of the ECMT meeting in Copenhagen in May 1998.

1.2. THE CONCEPTS

1.2.1. Internalisation policy

Co-ordination of economic activities by market price signals leads to an optimum allocation of resources, assuming that prices reflect all relevant costs and benefits and that transport users are conscious of the price signals. Regulatory intervention can be, and frequently has been, used in cases of market failure and also influences prices. It is widely recognised that price signals in current transport markets do not reflect all the relevant costs. As a result, transport markets are distorted. For example, costs of environmental damage and accidents are not fully reflected in transport prices, implying that, if taxes of a purely revenue raising nature are excluded, prices are generally too low. Even including purely fiscal taxes, the prices of some transport services are too low. This in turn implies that current levels of transport demand are generally inflated and the sector is structurally distorted. The distortions hamper technical progress which could improve efficiency.

Internalisation policies aim at integrating the external effects into the market. The objective is to improve the economic efficiency of the market, be it by adjusting market prices directly or through indirect regulatory instruments. The key to internalisation is the establishment of incentives that alter behaviour so as to reduce external costs.

Internalisation in the transport sector should not be viewed in isolation. To achieve efficient improvements in environmental quality the most cost-effective measures to reduce externalities should be sought across sectors. In tackling sulphur emissions, for example, bigger potential pay-offs at lower unit cost might exist in some other sector, so the problem should be addressed in that sector before, or at least simultaneously with, intervention in transport markets.

1.2.2. Social *versus* external costs and benefits

Internalisation policy has to be based on a clear, rational and consistent methodology for assessing externalities. The work of the ECMT Task Force was based on the following generally accepted definitions of crucial terms and concepts:

- Social effects are the totality of repercussions – direct and indirect effects – of an action, be it the provision of transport infrastructure or its use by a vehicle.
- Social effects, whether costs or benefits, are the sum of internal (or private) and external effects.
- The boundary between internal and external is set at the level of individual decision makers. Externalities must be measured relative to these decision makers (transport users), and individuals must be confronted with all the costs and benefits of their actions.

1.2.3. The use of marginal *versus* total costs and benefits

Figures for total external costs, for example in terms of percent of GDP, give an indication of the significance of welfare losses but are not always of use in striking an optimal balance between costs and benefits. For this, marginal values must be used. Achieving equilibrium, where marginal costs equal marginal benefits, is a condition for economic efficiency. The rationale is straightforward: a small increase in any activity yields a marginal benefit but has a marginal cost. Clearly, if the marginal benefit exceeds the marginal cost, the increase in the activity will increase total net benefits. Conversely, when the marginal cost exceeds the marginal benefit, a small decrease in the activity will increase total benefit. Only when the marginal cost equals the marginal benefit does an optimal situation exist.

1.2.4. Are there relevant external benefits?

Government intervention is justified only where costs or benefits are not automatically processed by market forces. Such external effects are called technological externalities (as opposed to pecuniary externalities, or external effects that are eventually processed by market forces). Important parts of the social costs of transport are not internalised by the market; therefore, government intervention is justified. Empirical analyses show that transport generates large external benefits, possibly of the order of several percent of GDP. However, most of these are eventually captured by market processes, either directly (*e.g.* time savings) or indirectly (*e.g.* regional development and globalisation effects). They are thus pecuniary externalities.

Because almost all external benefits are eventually processed by markets, no allowance should be made for them in the use of infrastructure. *All* benefits should, nevertheless, be accounted for in social cost-benefit analyses, such as those undertaken to determine whether to build new infrastructure.

To the extent that internalisation policy leads to decreased traffic growth, external benefits measured in terms of GDP will also be constrained.[1] However, the overall changes in social costs and benefits, taking into account reductions in external costs and the dynamic adaptation of economic structures, will result in a net increase in welfare.

1.2.5. Differences between infrastructure provision and use

It is convenient to distinguish between decisions whether to build (or expand) transport infrastructure, on the one hand, and decisions by transport users whether to undertake certain trips using a certain mode of transport, on the other. The two types of decision have different policy implications. The decision to build or not build an airport, seaport, road or railway must be made on the basis of the balance between all incremental social costs and benefits. A standard method of analysis is a comprehensive social cost-benefit analysis, looking at all social costs and benefits that would arise from an infrastructure project, including possible net economic growth effects that would be processed by the markets once the system was in operation. At the level of pricing transport infrastructure use, only marginal costs and benefits are of interest.

The provision and use of infrastructure become linked, however, when it comes to recovering historic infrastructure costs. In debate over how to cover infrastructure costs, the premise that users must recover all relevant costs is frequently cited. However, charging the full costs of infrastructure over and above short-run marginal costs is not efficient in circumstances where high resulting charges will lead to very low rates of infrastructure use.

Where infrastructure is uncongested, users should be charged the *short-run* marginal costs of the infrastructure (including external costs). This level of charge will generally be insufficient to recover sunk costs, but these can be covered by an additional fixed charge, which can be viewed as an entry fee. As traffic grows close to capacity limits the first policy response should be to adjust use-charges, basing them on *long-run* marginal costs of infrastructure provision. These will be roughly double the short-run marginal costs for most roads. If under these economic pricing conditions traffic continues to grow, using revenues for expansion of capacity should be considered. This linkage between economic pricing and infrastructure provision relates specifically to capacity expansion. By contrast, where infrastructure is built to improve accessibility of, for example, underdeveloped regions, use-charges should reflect only short-run marginal costs; the remaining infrastructure costs should be covered by a fixed charge or by transparent budget transfer in a manner analogous to payments for public service obligations.

1.2.6. How does internalisation relate to general taxation policy?

Two main kinds of incentive are produced by charges designed to promote internalisation: i) influence over the choice of technology – for example, vehicle fuel economy and fuel type, where elasticities may be relatively high; and ii) influence over the intensity of demand for transport services, where the response is determined by the overall price elasticity of demand. Both types of incentive are influenced by both general and specific taxes.

Different sectors of the economy are subject to different rates of general taxation, resulting in distortion. In the transport sectors of ECMT countries there are some particularly large anomalies. For example, civil aviation is exempt from value added tax on ticket sales, and duty-free commodity sales distort a number of markets. The relation of internalisation policy to general taxes is not straightforward. If all activities were subject to the same rates of general taxation, internalisation policy could be applied without reference to general taxation. The significant distortions that exist may also undermine any fine-tuning of transport prices designed to reduce externalities, they may therefore have to be reduced or eliminated as part of internalisation policy.

In addition to making a contribution to general taxation, transport is often subject to specific taxes to cover identified costs, such as annual vehicle taxes. In some countries, part of the revenues from excise taxes are specifically identified by transport policy as contributing to infrastructure costs, and in some cases excise duties have been partly replaced with taxes related to air pollution, carbon emissions, etc. Such specific taxes have to be explicitly incorporated into internalisation policy in so far as they are already designed to internalise non-private costs.

Existing relatively high rates of specific taxation for some transport services present opportunities for restructuring taxes to produce the incentives required without increasing the overall tax burden on services that are already heavily taxed. Existing excise taxes and differentials already influence externalities to a degree (*e.g.* in the choice of passenger cars in relation to fuel economy and diesel *versus* gasoline engines), and the incentives produced could be better related to external costs.

Determination of general tax levels is a normative, political decision: VAT rates are sometimes differentiated by types of goods and services; and factors such as labour and income are taxed at much higher levels than some other production factors. Internalisation policy would ultimately require all these taxes – usually the result of *ad hoc* revenue raising initiatives – to be adjusted to remove distortions and promote efficiency (and serve the purposes of explicit policy objectives, such as reducing unemployment). Ultimately, therefore, internalisation should not result in higher overall taxation.

Revenues from charges introduced for internalisation purposes can provide opportunities to reduce general taxation, or to fund public spending.

1.2.7. Which categories of cost should be addressed or accounted for?

Four main classes of costs are the most relevant for internalisation policy: environmental externalities, accident costs, uncovered infrastructure costs and congestion costs.

Environmental externalities

For internalisation policy it is important to distinguish between two categories of impact. The first relates to infrastructure provision and includes impairment of the value of landscapes and effects due to surface sealing (by roads, parking lots, etc.). This group is most relevant to project cost-benefit analysis and is not dealt with in detail in this report. The second category is due to use and includes air, soil and water pollution, noise, effects on quality of urban life, separation effects and resource depletion.

Accidents

Only some accident costs are relevant for policy: *i.e.* the parts not already covered by vehicle insurance premiums. These include a part of hospital costs, loss of production and loss of human life. Material damage and part of hospital and welfare costs are covered by vehicle insurance.

Congestion costs

Congestion costs are a special case, being external with respect to individual driver decision making but largely internal to the club of users that cause congestion. An efficient transport system demands the internalisation of external congestion costs in terms of the time losses one individual driver imposes on other road users. External effects to the general public are also generated – higher pollution rates and possibly accidents – but these are dealt with above.

Infrastructure costs

Uncovered infrastructure costs must be addressed by transport pricing. Those not covered by public service obligations or specific charges can be considered externalities.

1.2.8. Public service obligations (PSO)

Governments can decide, for social or regional policy reasons, to provide certain basic transport services, even if they are not viable under market conditions. In such cases public service obligations (PSOs) should be defined. Today, most such services consist of public transport. It must be stressed that this need not necessarily be so. The objective is to provide mobility, not to support any particular mode. Taxis or para-public services can be more efficient than mass transit in certain cases – for example, in rural areas or at low demand times. The most important condition for efficiency is that public service obligations need to be clearly defined and public payments for them negotiated and contracted in advance. The calculation of cost coverage must include consideration of public service obligation payments.

1.2.9. Fairness

The primary concern of internalisation policy is economic efficiency. In this endeavour, market forces are used where possible and externalities are internalised where the efficiency of transport markets can be improved by government intervention. However, efficiency is not the only criterion. Fairness – the sharing of costs and distributional effects – is also a politically relevant target. Internalisation policy must be placed in this broader framework of policy making. Both efficiency and fairness have to be factored in. For example, when high costs for capacity expansion would call for marginal charges leading to significant overcoverage of historic costs, a compromise can be found by deviating from strict marginal pricing or through lump-sum redistribution of excess revenues. From an efficiency standpoint, these are second-best solutions, in favour of fairness. Clearly, normative – *i.e.* political – decisions have to be made in such cases.

The principle of fair and efficient pricing should be applied not only within the transport sector, between different modes of transport, but also in the economy as a whole. In so far as transport causes higher (external) costs than some other economic activities, some transport prices should be increased and prices for other, environmentally less harmful activities decreased correspondingly. Such an approach could yield reductions in taxes on labour, capital and production.

1.2.10. Economic impact of internalisation

The primary effects of internalisation policies are expected to be significant welfare gains. The main responses are likely to be technological change and increases in operational and organisational efficiency. End-use transport costs (as perceived by freight forwarders, private car users and rail passengers) may increase on average 15-30% in Europe as a result of full internalisation of the main externalities, according to rough estimates. Probably only small changes in modal split will occur, together with a small reduction in growth in overall demand for transport services. The increased efficiency consequent on internalisation should ensure that industry as a whole remains competitive. Internalisation is expected to have little or no effect on GDP growth and could have a small positive effect on labour markets.

Internalisation may lead to political costs of adjustment, for which additional policy measures could be adopted. This makes it possible to achieve both economic efficiency and the desired distribution of costs and benefits, so long as the additional measures are applied in ways that do not undermine the incentives that internalisation measures are designed to produce. Distributional issues must be addressed in internalisation policy to ensure that issues surrounding the distribution of costs and benefits among countries do not become barriers to the realisation of potential efficiency gains for the ECMT countries taken as a whole.

The adjustment to more efficient economic conditions will also have costs for agents that benefit from current distortions. The benefits from internalisation, however, will outweigh the costs. Again, any compensation judged necessary to ease the adjustment period should be provided in ways that do not undermine the incentives that internalisation measures are designed to produce.

1.3. ESTIMATION OF EXTERNAL COSTS

1.3.1. Approaches and methods for valuing externalities of transport

The purpose of all valuation approaches is to derive estimates of values of non-marketed goods, such as environmental quality or health, in order to assess the damage costs due to transport activities. There are a number of valuation approaches, each associated with specific advantages and disadvantages and examined in detail in Annex A. The core approach is to establish what the price would be if there were a market.

All techniques are not equally suitable for the different effects. Moreover, each technique has its merits and demerits, from an economic point of view, and needs to be executed carefully according to well-established criteria. Annex A identifies the most appropriate valuation techniques for different types of effects. A methodological good practice principle is that in general it is advisable to use more than one method to estimate the same effects, preferably to generate lower and upper bound values. The methods should be as independent from each other as possible.

1.3.2. Estimates of total and average externalities

General remarks

The valuation of non-marketed goods is not an exact science. There are a number of sources of divergence for the different values of externalities cited in the literature: some estimates include non-material damage, some do not; some are based on prevention costs, some on damage costs; and where prevention cost approaches are used, targets differ. Consistent choices on these issues will result in a fairly small range of estimates. Even with relatively large error ranges, estimated values are likely to be more accurate than the tacit assumption that costs are zero (which would be the implicit value if the effect was ignored).

When monetary estimates of external effects are compared among countries, there are two main reasons for divergence (assuming that the same valuation technique is used):

- physical'' differences due to real variation in the areas considered (*e.g.* topography, weather patterns, landscape vulnerability, levels of traffic and pollution), which result in, for example, differing numbers of deaths or injuries from marginal increases in air pollution;
- differences in economic valuation per unit of external effect, resulting from variations in levels of economic development and in socio-cultural value structures.

To make up for the GDP effect, monetary estimates across countries are often weighted according to purchasing power parity to make them more comparable.

Accident costs

The valuation technique is crucial for the level of estimated accident costs. This is because techniques based on willingness to pay (WTP) reflect the fact that fatalities and injuries (*i.e.* ''human costs'') are valued dearly by people. Putting a value even on small changes in the risk of death (used to derive the ''value of a statistical life'') is a sensitive issue and one which more properly belongs to the realm of ethics. However, in this case it may be approximated by the price society is willing to pay to reduce the risk of death by a given amount. If human costs are valued purely by economic output forgone (the approach most government statistics take), the figures are considerably lower than when willingness to pay is the basis for evaluation. Chapter 3 concludes that external accident costs,[2] estimated by willingness to pay, total ECU 148 billion per year (1991, 17 European countries, EU plus Norway and Switzerland), or roughly ECU 400 per capita. Road accidents account for over 99% of these costs. ECU 148 billion corresponds to 2.5% of overall GDP.

Traffic noise

The results retained from studies in different countries, largely based on the prevention cost approach, value the transport related external costs of noise at 0.06-0.75% of GDP (with a mean value of 0.3%). Most estimates of the cost of noise nuisance are based on the revealed preference approach, measuring the reduction in market value of housing exposed to noise compared with similar housing in quieter areas. Other studies, based on stated preferences, yield estimates generally towards the upper end of the range. Studies of prevention costs, based on expenditure on programmes to reduce noise impact, generally yield estimates at the lower end of the range (see Annex B; and Annex A for a discussion of appropriate evaluation techniques). Research by the Frauenhofer Institute in Karlsruhe, concluding that road traffic accounts for 64% of total transport noise, rail traffic 10% and air traffic 26%, would suggest that total transport noise nuisance costs might represent close to 0.5% of GDP. Within road traffic, one heavy goods vehicle (HGV) causes roughly as much noise as ten cars, although different types of noise (car, lorry, train, aircraft) are difficult to compare.

Air pollution

Although strict emissions standards for cars and lorries have been mandated in the European Union and in many non-EU countries, and emissions per vehicle-kilometre are therefore expected to fall, there remain considerable external costs of pollution to the environment, mainly due to NO_x, VOCs and particulates. This is because future growth in traffic volumes, especially in freight transport and aviation, is assumed to be high. On average, studies arrive at estimates of 0.25-0.65% of GDP (usually excluding air traffic) for the external costs of air pollution. There are difficulties in applying the results of epidemiological studies, arising, *inter alia,* from the valuation of a statistical life. In most cases prevention cost approaches were used to estimate costs. Basing estimates instead on the results of recent epidemiological research on fine suspended particulate matter (from diesel fuel, tyres and brakes) would probably lead to significantly higher figures for the external costs of air pollution.

Climate change

CO_2 emissions are directly proportional to fuel consumption. Although the fuel efficiency of new vehicles improved considerably in the 1980s, market demand has favoured heavier vehicles and vehicles with larger engines since then.[3] This has outweighed progress in fuel efficiency and means that traffic growth tends to translate directly into increased CO_2 emissions unless additional measures are taken. Estimates of the total external costs of transport related to greenhouse gas emissions are subject to a high degree of uncertainty, largely because the implications of climate change are unclear. Most studies base their estimates on the prevention cost approach. INFRAS/IWW (1995) estimates that cutting back CO_2 emissions by 40% from 1990 to 2025 would lead to avoidance costs of some 0.5-1% of GDP. Other studies, estimating the costs of damage caused by the atmospheric concentration of CO_2 rising to twice the level of the pre-industrialised age, put the costs at 0.75-2% of GDP (excluding catastrophic events). These estimates may change over time as scientific evidence develops. This report uses estimates based on political targets[4] (0.5% of GDP).

Infrastructure

Uncovered – *i.e.* external – infrastructure costs are most significant for rail, in absolute terms and per unit of transport. For 17 European countries (EU plus Norway and Switzerland), a total value of some ECU 8 billion per year has been estimated (INFRAS/IWW, 1995). Assuming no decrease in demand, an increase in rail passenger and freight fares of the order of 30-40% on average, or an increase in efficiency of 30-40%, would be needed to cover these costs. The important aspect with respect to rail, however, is not the high level of uncovered costs, but the basic trend of a continued increase. Twenty years ago, uncovered rail infrastructure costs were comparatively small; today, however, they are exorbitant.

In Europe, uncovered infrastructure costs appear to be much lower overall for roads than for other modes. Within the road mode, however, there are major variations. While passenger vehicle users pay charges (specific taxes) that generally exceed infrastructure costs, tax revenues related to HGVs do not generally cover the track costs allocated to them. It should be noted that there are significant uncertainties both in track allocation and in accounting for road infrastructure costs, although road transport exhibits fewer data problems than air, rail and water.

Part of the uncovered infrastructure costs of rail result from non-commercial objectives in past political decisions, including public service obligations imposed without adequate compensation, and inefficiencies arising from inadequate price regulation of rail monopolies. A further part can be considered as having arisen because prices were too low to cover environmental costs in the modes with which rail competes (road, for bulk transport and containers; and air, for short haul services). In addition, national transport policies neglected modernisation of state controlled rail systems during a period when economically and financially the market strength of the rail system might have allowed it. In most cases, data are not available to quantify these effects separately.

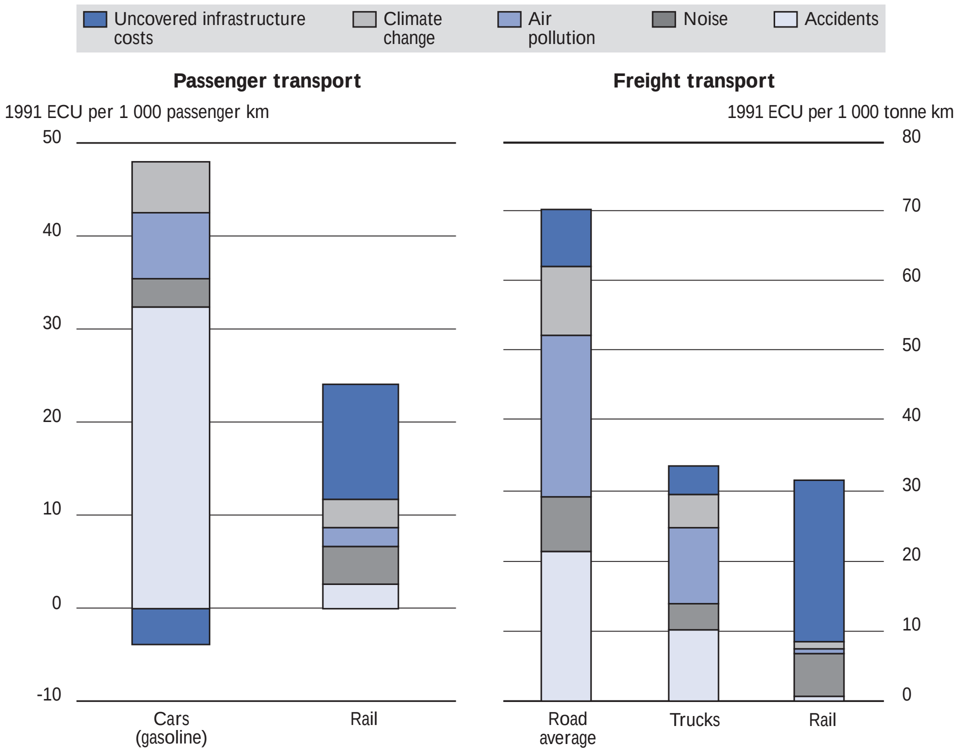
Congestion

Congestion occurs mainly in metropolitan areas and on major bridges, in tunnels and on intercity axes and some transalpine links. Estimates for congestion costs in metropolitan areas vary; studies suggest that congestion costs are significant, mainly due to time lost in traffic jams. Effects of congestion on environmental external costs are less well-proven. In general, results are difficult to compare, as local conditions are very important. The key assumption is the monetary valuation of "lost" travel time of passengers, drivers and vehicles. The size of some estimates suggests the value of travel time might be overestimated and that the yardstick of comparison is wrong; the economically optimum level of congestion is not zero as it is often mistakenly assumed.[5] There are few recent or reliable estimates of congestion.

Synthesis

Overall, the part of external *environmental* and *accident* costs of transport that has been quantified amounts to 5.2-7% of GDP (willingness to pay) or as low as 2.2-3.2% (prevention cost). For policy making, around 4-5% of GDP seems to be a reasonable floor (see Figure 10), although it underestimates certain external costs (*e.g.* air pollution, climate change) and neglects others (*e.g.* separation effects, damage to landscapes). Figure 1 illustrates the distribution of these costs between road and rail modes.

◆ Figure 1.***Average external cost estimates for road and rail transport in the first half of the 1990's***



Note: Figure 1 may give the initial impression that any internalisation of external costs is likely to have much less impact on rail than on road passenger transport. However, for roads much of the incentive required for internalisation should be created through changes in the structure of existing charges rather than through an increase in the overall level of charges. In many countries current charges on passenger transport related to the use of road infrastructure raise revenues in excess of infrastructure expenditure. In a revised charging system this excess could partially offset increases in charges required for internalisation. For rail, apportioning infrastructure costs between passenger and freight services is difficult. However, rail services tend to exhibit higher price elasticities of demand than competing road services. Rail markets will tend therefore to be more vulnerable to the impact of internalisation charges than road services. Rigidities in rail labour markets may, moreover, make responses through increased productivity difficult and slower than in the road sector.

Source: ECMT Task Force estimates.

Uncovered *infrastructure* costs are considerable. They are most significant for the rail mode, amounting on average to around ECU 10/1 000 p-km or ECU 20/1 000 t-km.[6] There is some uncertainty in these figures because public service obligations are not reported in all national statistics. For roads, there are cross-subsidies between cars and freight in many countries, but overall for Europe as a whole, revenues and long term costs are roughly in balance.

Studies available on empirical *congestion* cost valuation are less comprehensive and systematic than those on environmental and accident costs. In most countries, where only small fractions of road networks are congested and for relatively short periods, these costs cannot usefully be related to total transport volumes.[7]

Magnitude of externalities in terms of variable costs

Another way to illustrate the order of magnitude of the externalities in road transport is to recalculate them in terms of costs per litre of fuel. It should be stressed that this is not intended as a policy recommendation. Various studies estimate that total environmental and accident external costs for road transport correspond, on average, to roughly ECU 1.0 per litre of fuel. After improvements that are expected in accident rates, fuel efficiency and air emissions, external costs will be halved to around ECU 0.4 per litre of fuel. For the rail system the internalisation of environmental and infrastructure externalities correspond to an increase of present tariffs of some 20-30% providing that current levels of government contributions to operating costs are continued in relation to public service missions.

1.3.3. From average costs to marginal costs

The total and average external cost estimates presented above are useful for indicating the significance of externalities but do not necessarily provide sufficient indication of the efficient level for charges designed to reduce them to the optimum. Economic efficiency is achieved and welfare is maximised when marginal benefits equal marginal costs. Moreover, the impact of many externalities is highly dependent on location and time, and changes at the margin are critical. Policy must, therefore, concentrate on influencing decisions at the margin. Analysis of costs and benefits needs to be brought to bear on the decisions that determine whether a trip, a freight run, etc., should be undertaken and by what means. Creating incentives that have a direct bearing on such decisions is the key. Chapter 3 and Annex B explore approaches for estimating marginal costs and, where empirical marginal estimates are not available, derive appropriate estimates from total and average costs.

Table 1. **Estimated European averages for current marginal costs of road transport, 1990-1995**

ECU/v-km

Cost component	Passenger cars		Freight (truck, van)
	Gasoline	Diesel	Diesel
Infrastructure [a]	0.023	0.023	0.041
Congestion [b]	–	–	–
Accidents [c]	0.060	0.060	0.060
Climate change	0.010	0.009	0.028
Air pollution [d]	0.013	0.009	0.066
Noise nuisance [d]	0.005	0.005	0.023
Total	**0.111**	**0.105**	**0.218**
Memo item:			
Average fuel excise tax for EU countries, January 1996	0.041	0.022	0.067

a) Short run marginal costs.
b) Congestion omitted, as it occurs in relatively few locations and at specific times.
c) Related to all injuries and deaths (drivers and other victims).
d) Average for rural and urban areas.
Source: ECMT Task Force estimates; see Annex D for details.

1.3.4. Dynamic considerations

Technological advances can have a major impact on the generation of externalities. For example, conformity to Euro III emissions limits should in the long term reduce specific passenger car emissions to a fraction of those characteristic of vehicles in current circulation. Internalisation policies have to be designed to account for such changes. This report, for example, recommends Euro II standards as more relevant to future emissions charges than the current average emissions characteristics. Part of such gains may be offset by traffic growth. Estimates of external costs will also change over time as a result of improvements in scientific and socio-economic research.

As internalisation policies begin to work, external costs should fall, along with the revenues generated by transport charges. Internalisation policy foresees this fall in revenues and should not respond by increasing charges.

1.3.5. Accuracy and policy making

The inherent inaccuracy of any estimates of external effects is a good argument for the policy of introducing internalisation measures gradually; this also helps avoid economic shocks. Where utility based estimates of effects are not available or not reliable (*e.g.* for the effects of climate change), basing charges on standards may be more promising: an environmental standard is politically defined, and measures, including charges, designed so that the standard is attained. In this case, estimates of external effects serve only as a supporting argument for the measures implemented.

1.4. POLICY OPTIONS

1.4.1. Basic principles for policy formulation

The function of internalisation instruments is to provide incentives for reducing external costs. These incentives have to be highly visible to economic agents so that they are taken into full account in the decisions that determine demand for transport services.

Optimal mix of instruments

Overall transport policy should consist of an optimal mix of different types of instruments: negative and positive economic incentives, command and control instruments (such as regulatory standards), moral suasion, information, etc. Existing standards and regulations must be enforced effectively. Adding finely tuned economic instruments to laws that are routinely ignored (*e.g.* in regard to road safety) makes no sense where the existing legislation should in theory have the most significant effects. Introducing instruments that cannot be enforced effectively is similarly counterproductive.

Command and control versus economic incentives

In the options developed in this report, economic instruments are discussed in more detail than others. This is because past transport policy has made relatively little use of market based approaches. However, it must be stressed that – at least in the short and medium run – economic instruments are not generally substitutes for, but rather must complement, existing instruments, in particular command and control regulations. In the longer run, well-targeted economic instruments are likely to become more practical and effective. The approach proposed uses command and control regulations for the immediate implementation of best available technology, while economic instruments provide sustainable incentives for guidance of market based development processes in the long-run.

All modes treated the same

Internalisation should contribute to making competitive conditions fair. So, for example, CO_2 emissions should be charged at the same unit rate regardless of whether the source is road, rail, air or waterborne traffic. With respect to public service obligation policy, this means that, contrary to what many sometimes seem to believe, there is no reason for public service obligation payments to be given only to a certain mode or only to publicly owned transport agencies.

The road mode is treated in more detail than rail, air or shipping in this report because road transport has become the most significant mode in terms of both its economic role and its external effects (except in regard to infrastructure costs, where rail is of more concern).

1.4.2. Criteria for selecting policy instruments

The following criteria have been considered in the policy options developed:

– effectiveness in achieving the main objectives of efficiency and fairness;
– low costs for administration and high level of compliance;
– distributional equity (among social groups, regions, countries[8]);
– transparency;
– few, or insignificant negative side effects;
– synergy with existing instruments and continuity with existing frameworks;
– legal compatibility and related political acceptability;
– time-frame for implementation.

1.4.3. Road transport

Depending on the detail of their design, variable charges can be employed to affect all kinds of decisions by road transport users and by vehicle owners and producers, from driving styles and distance driven to vehicles fuel efficiency and environmental performance.[9] Fuel taxes, electronic km-charges and electronic road pricing are the main instruments under consideration.

Fixed charges are available at two levels:

i) Annual charges. Paid in the form of vehicle taxes or vignettes, these can be viewed as a ticket of admission to a defined road network. They have no incentive effect on annual distances driven or on driving styles, but they do influence the purchase of a new car (if they vary according to vehicle characteristics) or decisions on whether to have a car at all.

ii) One-time sales taxes on vehicles. These charges influence the decision whether to buy and keep a car and, possibly, what kind of car. Driving styles and distances are not affected.

Infrastructure and congestion

On average, 50% of total infrastructure costs depend on actual road use and 50% are fixed costs (including depreciation and interest on capital). Internalisation instruments need to account for this split. To deal with congestion, a shift from fixed to variable charges is required. Congestion tolling is attractive. Theoretically, electronic road pricing on main routes, combined with general use-charges, would be most effective, although it is expensive and international harmonisation of technical standards for road pricing equipment will take time to implement. Urban road pricing is similarly attractive but difficult to implement. Fuel charges, as a base charge, are effective, simple and cheap to administer and might therefore be considered as a short term option, although fuel duties are an imperfect instrument for infrastructure and congestion costs. For HGVs, a kilometre-dependent charge is attractive, particularly for transit countries, to avoid tank tourism.

Accidents

A large part of accident costs is already internalised. Three instruments should be combined to internalise remaining external costs: 1) further develop road safety through technical means and enforce stricter penalties for dangerous driving; 2) introduce risk adjusted insurance premiums and extended liability (or insurance surcharges as a short term alternative); and 3) employ use-charges for the remaining external costs (currently around 20% by official estimates, excluding non-material costs). Increased insurance premiums could reduce government subsidies for health and welfare systems, etc.[10] An optimal spread of the range of insurance premiums dependent on individual safety records is the ideal, with long term no-accident records reducing premiums to between a third and a half of maximum rates. It is envisaged that half of remaining uncovered accident costs would be internalised through extended insurance liability and half through use-charges.

Climate change due to CO_2 emissions

A fuel charge is the most appropriate instrument here, as it provides a direct incentive for users to reduce fuel consumption and thus CO_2 emissions, and at the same time an incentive for manufacturers of vehicles to improve specific fuel consumption. If a CO_2 fuel charge generates insufficient incentive for industry and consumers to develop and buy fuel efficient vehicles, this may be an argument for a differentiated vehicle tax related to specific CO_2 emissions and/or for standards with respect to fuel efficiency (*e.g.* a more flexible version of the US legislation on corporate average fuel efficiency, the so-called CAFE standards).

Air pollution

In the past, the main instrument has been vehicle emissions standards. These have been an effective means of enforcing the polluter pays principle. For passenger traffic, they have helped reduce specific as well as total emissions significantly (although for NO_x a rise is expected again after 2000 due to growth in traffic volume). The problem, typical for standards, is that no incentive remains to reduce emissions further once the standards are reached. Such an incentive can be introduced through differentiation of annual vehicle tax according to emissions characteristics, or through purchase tax incentives. Both can be designed to encourage attainment of stricter second stage regulations.

Since air pollutant emissions are partly related to fuel consumption and distance driven, it is practical to include part of these costs in use-charges. Fuel charges could be appropriate until more targeted instruments become available.

Pollution costs due to particulate matter are particularly relevant for diesel fuel and appear to justify differentiation of fuel taxes (implying an increase in current diesel excise taxes). If an electronic km-charge for HGVs were to be introduced in Europe, it should be differentiated according to specific air pollution.

Motorcycles require specific measures including dynamic standards and emissions-dependent yearly registration charges for air pollution and noise. Enforcement is critical to prevent post-registration tampering with engines and exhaust systems.

Noise

Standards on noise emissions and surface design can be combined with emissions-dependent yearly registration charges, with a small use-charge for remaining externalities. The effectiveness of using standards can be enhanced if a long term policy including steady tightening of the standards is adopted, with future steps announced as far in advance as possible to induce anticipatory behaviour on the R&D and production side. Urban road pricing offers an even better targeting, at least in theory, although it would be necessary to distinguish among vehicle types.

Policy mix and priorities

Based on detailed analysis of individual cost components, an optimal mix of instruments must be determined. This mix should:

- contain economic as well as command and control instruments, plus traffic management and infrastructure development elements;
- be differentiated between rural and urban areas, and between short and long term horizons;
- be adaptive to technological progress, in particular in metering and monitoring technologies;
- include adequate enforcement of regulations.

Variable charges

Analysis suggests it would be better to rely more on variable price components rather than to use high fixed charges alone. For effective internalisation, policies should be based on the following elements:

a) Increase fuel charges in steps to reach a level determined by the lower bound estimates of variable accident costs, air pollution, noise and climate change effects. Fuel charges are the only instrument applicable to cars and vans used in rural areas (which account for half of all road transport externalities), until general road pricing becomes available.

b) For HGVs, introduce electronic km-charges (given sufficient technological progress) to cover costs over and above those covered by fuel charges.

c) Ensure that insurance premiums are differentiated to reflect accident risks as closely as possible (with a spread of about 2-3) and that liability is extended (via a government surcharge if necessary). In addition, a use-charge (incorporated in the fuel tax) will be required to cover remaining social costs and to establish a linkage with distance driven.

d) In urban areas use parking fee schemes and command and control regulations to account for ‘‘hot spot’’ effects (higher externalities). Local solutions are required.

e) Incorporate congestion pricing in existing tolls, using part of the revenues for the efficient expansion of saturated capacity.

f) Introduce urban road pricing in pilot projects, as technological progress allows, and arrange for international harmonisation of technical norms to prepare for the widespread introduction of road pricing systems in the long term.

g) Introduce generalised road pricing in steps, according to technological progress, in urban areas and on long distance highways first. (As an alternative: introduce electronic km-charges for passenger cars as well as for HGVs.) This would replace other instruments to a large extent.

The external costs of driving cars and vans in rural areas account for roughly half of all road externalities. Because these can be practically internalised only through fuel charges, at least until general road pricing becomes available, fuel charges are an important instrument for internalisation in the short and medium term. Table 2 presents estimates of the average fuel charges required in Europe to internalise road costs in rural areas after the improvements in accident rates, emissions and fuel

Table 2. **Estimated average fuel charges [a] for internalisation in road transport**

ECU/litre

Cost component	Passenger cars		Freight (truck, van)
	Gasoline	Diesel	Diesel
Infrastructure	0.28	0.35	0.22
Congestion [b]	–	–	–
Accidents	0.35	0.43	0.15
Climate change	0.12	0.13	0.13
Air pollution	0.02	0.06	0.13
Noise nuisance	0.06	0.08	0.12
Total	**0.83**	**1.04**	**0.74**
Memo items:			
Average excise duty in EU countries, January 1996	0.48	0.32	0.32
EU minimum excise duty	0.287 [c]	0.245	0.245

a) Dynamic estimates for base level surcharges (further measures would be required for internalisation in urban areas) applied in combination with tighter vehicle standards and increased insurance liability.
b) Not included, as rural areas are generally free of congestion.
c) Unleaded gasoline.
Source: ECMT Task Force estimates; see Annex D for details.

efficiency that can currently be foreseen have been realised. These fuel charges will have to be complemented by other instruments to internalise mainly urban externalities such as congestion and the impact of particulate emissions and noise.

Fixed charges

The two kinds of fixed charge described earlier can be applied so that the leverage effects of each incentive reach a maximum:

- Annual vehicle taxes and/or vignettes. These should cover part of the fixed (sunk) cost for non-saturated infrastructure and should vary with vehicle characteristics, particularly specific pollution and noise characteristics.[11]
- One-time vehicle sales taxes. These have lower administration costs than annual vehicle taxes and affect rates of vehicle ownership. Differentiation can have major effects on the type of car purchased.

Fixed charges complement variable charges in respect of specific vehicle characteristics. Where the use of fuel taxes is constrained by considerations such as tank tourism, and other use-charges are not available, the use of fixed charges – differentiated according to vehicle characteristics to achieve cost coverage and provide incentives for cleaner vehicles – is particularly important.

Command and control regulations and voluntary agreements

Command and control instruments, in particular technical standards, continue to play an important role. They are necessary in the fields of safety of roads and vehicles, speed management regimes, minimum noise standards, air pollution emissions standards, etc. For specific urban policies, parking management systems will be an additional policy element. Voluntary agreements between governments and industry are receiving increased attention, particularly in regard to climate change.

1.4.4. Rail transport

For the rail mode the main issue is deterioration of productivity, relative to road and air, and an inability to cover infrastructure costs. In terms of environmental externalities, the most important aspect is noise from freight traffic.

Infrastructure cost coverage

It is estimated that for most national railways, after subtracting operating costs, revenues cover no more than 20% of infrastructure costs (INFRAS/IWW, 1995). This is mainly due to low productivity and to politically driven investment decisions in the past that were not adequately covered by compensation. A related problem is that, in most countries, public service obligations – which are significant for railways – are not clearly defined, leading to a situation where services are offered without clear *ex ante* negotiations on cost coverage. Revenues are limited by competition from road transport. Road freight transport has realised very significant productivity increases during the past 20 years. Increases in personal income have boosted car ownership. Internalisation policy should be directed at *a)* infrastructure management (governmental or private) and *b)* rail service operating companies. The following proposals and options assume that in the future infrastructure and service operating companies will be separated.

Full coverage of infrastructure costs would require increasing tariffs by around 20-30% (assuming current government contributions to operating costs are maintained). This calls for prudent procedures. The first and most needed change is to restructure the rail system commercially, technologically and institutionally, so that a significant increase in productivity results. Second, stepwise implementation is advisable, to avoid economic shocks. Third, to avoid modal shifts that would be uneconomic in the long-run, tariff increases for rail could be introduced in the wake of – not isolated from – corresponding steps to internalise environmental costs of road transport. To what extent rail tariffs are increased in the long-run also depends on public service obligation policy, which must be made explicit in any case.

Where capacity is saturated, infrastructure operators should apply congestion pricing (with prices related to long-run marginal costs) to calculate infrastructure charges.

Environmental accident costs

The main environmental problem stemming from rail transport, at least in countries with important rail networks in densely populated areas, is noise from locomotives and freight cars.

Possible approaches include regulatory standards for new freight cars, combined with the possibility for countries to levy km-charges differentiated according to noise standards. Such charges would be an incentive for programmes to reduce noise at the source, for example by retrofitting existing rolling stock and accelerating stock renewal.

The internalisation of externalities related to air pollution should be based on the same principles as those for the road mode: environmental charges relative to the fuel cycle should be charged for electric traction at the power plant (in the case of air pollution, safety risks, climate issues, etc.) or, for diesel locomotives, at the point of fuel purchase.

Rail has a good safety record as a result of high safety standards and operating procedures. Remaining accident costs should be covered, as for road, through expanded insurance liability and differentiation of premiums to bear a closer relation to risks.

1.4.5. Air transport

For air transport, internalisation of environmental externalities – climate concerns, air pollution and noise – is of first priority. NO_x emissions at high altitude[12] may have climate change effects that are significantly higher per tonne of fuel burnt than those from road, rail or water; the evidence is as yet incomplete.

International air transport has benefited from duty free fuel and exemption from VAT on ticket sales. VAT exemption has resulted in an uneven playing field in favour of air, a situation both unfair and inefficient.

In most countries the statistical basis of infrastructure cost coverage for air transport does not allow satisfactory accounting and monitoring; however, it appears that major airports cover their infrastructure costs, whereas small regional airports do not.

Air transport is excluded from the direct responsibilities of the ECMT. (ECAC and ICAO are the international agencies concerned.) The following proposals and options are presented nonetheless as a basis for discussion and in the interests of co-ordination. Competition, to drive efficiency, requires a regulatory environment that treats all modes equally. A particular need for action arises from the fact that changes in taxes and charges must be co-ordinated among modes.

Internalising environmental costs

Climate change effects related to CO_2 emissions can in theory best be internalised by means of a fuel tax. Except in regard to high altitude emissions of NO_x; here, a combination of a distance charge with a fixed charge related to emissions characteristics would be more appropriate. High altitude emissions could also be internalised through a landing charge if fuel taxes are not an option. Part of other air pollution costs could be covered by a fuel charge or surcharge on landing fees as well. International harmonisation is important.

Air pollution and noise costs can be internalised more effectively by landing charges at airports, variable according to aircraft pollution characteristics and time of day/night. Many countries began to employ this instrument some time ago; it should be further developed and more widely applied.

Internalising infrastructure and accident costs

Cost coverage factors for infrastructure should be monitored with a comprehensive, publicly accessible accounting system meeting the same standards as the monitoring systems for road transport. Possible undercoverage at low volume airports could be corrected by increasing airport charges (to be levied on airlines, for administrative simplicity) or, alternatively, covered by transparent public service obligation type payments.

Congestion pricing for the allocation of scarce infrastructure capacity by auctioning slots is not new, but could be applied more rationally in many cases.

The external costs of accidents, including costs to society, should be completely internalised through insurance by airlines and airports, on the same principles as those proposed for road and rail.

Regulatory safety standards must remain a key instrument and dynamic standards for environmental emissions should continue to set the baseline for performance. Economic incentives should be employed to drive economically efficient technological change.

1.4.6. Inland waterways and maritime transport

For waterways and maritime transport, external cost data are not as complete as for other modes. On the basis of the available information it can be assumed that environmental externalities are smaller, per unit of transport, than for road and air. The dominant effects are related to fuel combustion and environmental risks associated with transport of substances such as oil and chemicals. Non-respect of regulations on tank cleaning and waste disposal at sea is a major problem.

With respect to infrastructure costs, the situation appears similar to that for air, though the information base is weak. To get reliable data so as to monitor cost coverage factors, a more comprehensive and reliable statistical database must be established.

Internalising environmental effects

Dynamic environmental standards for air, water and noise emissions are appropriate to establish a baseline. The International Maritime Organisation has prime responsibility for regulating maritime shipping. Enforcement of environmental (and safety) regulations in respect of the minority of shipowners that disregard regulations is a key issue.

A fuel tax, at the same unit rate of damage as for other modes, should be introduced to internalise climate change effects and part of air pollution costs. Incentives to introduce clean engine technologies could be created through yearly vessel registration fees differentiated according to emissions factors for air and water (and possibly noise, where applicable). Environmental risks should be covered through an insurance system based, ideally, on the maximum possible damage event, without hidden or open liabilities for either society or taxpayers.[13]

Infrastructure costs

The situation and principles are similar to those for the air mode, and a reliable statistical database for cost coverage factors must be established. Once hypothecated revenues and full historic costs are reliably accounted for, possible adjustments of vessel registration fees can be established on a rational basis. Congestion pricing in harbours could be levied on operators by the infrastructure authorities, according to the same principles as in the other modes (long-run marginal costs).

1.4.7. European economies in transition

Estimates of the external costs of transport in the transition economies of central and eastern Europe are generally lower than elsewhere in ECMT countries. The single most important factor in this difference is lower levels of road passenger and freight movements. Strong growth in road traffic is expected, however. Sharp increases in accident rates since 1989 illustrate the potential for rapid changes in trends. On certain routes external costs are already severe, exacerbated by outdated technology, inadequate vehicle maintenance and bottlenecks resulting from inadequate infrastructure. The pattern of uncovered infrastructure costs in the rail sector have generally been lower than in western Europe but debt service problems are acute.

As fewer data on the external costs of transport have been collected in central and eastern Europe than in the rest of Europe, estimates of external costs are characterised by greater uncertainty and more aggregation.

The adjustment to more market oriented economies has already led to adoption of instruments suited to implementation of internalisation policies. Systems of charges for transport similar to those characteristic of western Europe have generally been adopted. Although the levels of charges are low in many of the newer ECMT Member countries, in some they are already close to levels in western Europe's largest economies. There are barriers to the use of certain instruments in some countries. Where existing charges are very low, it may take longer to reach levels required for internalisation, although a transition to high levels was accomplished rapidly in a number of countries. Considerations of competence to administer taxes and charges between local and central government may limit the use of some locally targeted instruments, but no country is immune to such complications.

Initiating internalisation now would have the major advantage of containing external costs during a period of rapid projected growth in road and air transport services. Central and eastern European countries' current transport policies take no real account of the external costs of transport and there are few incentives for internalisation.

In theory, external costs should be estimated and valued in monetary terms, but in central and eastern Europe this is still very difficult. Defining a specific environmental target first, then applying policy measures to steer the transport sector towards this target through instruments suited to internalisation, would be a pragmatic approach that might serve as a first stage towards internalisation in the short term.

1.5. IMPLEMENTATION AND ENFORCEMENT

In discussions of implementation and enforcement of the policy options and priorities described above, questions such as who does what when must be looked at. This relates, first, to the timing and evolution of regulation; and, second, to the question of what should be regulated at local, national and European levels.

1.5.1. Timing and phasing

As has been emphasised, to avoid disruption to transport users and providers, abrupt changes in regulatory conditions must be avoided, especially with respect to monetary charges. With stepwise internalisation, changes in levels of external costs over time can be accommodated (*e.g.* reductions in air pollution following tightening of car emissions standards). Moreover, regulatory policy should take account of progress in monitoring and measuring technology. This is particularly important for technological steps leading to road pricing.[14] The following elements of an internalisation strategy can be identified.

1. Continued development of dynamic regulatory standards for vehicles and fuels, in particular bringing emissions standards for all light duty road vehicles up to the level of standards for passenger cars.
2. Fuel charges to bring use-charges more in line with marginal costs, changing some high existing fixed charges to variable charges and gradually internalising external effects until general road pricing is available.
3. Annual vehicle taxes for passenger cars and HGVs that are differentiated more closely according to air and noise emissions factors, and possibly specific fuel consumption, to complement fuel charges.

Or, for passenger cars, differentiated one-off purchase taxes to complement fuel charges (they have lower administrative costs than annual vehicle taxes and a bigger impact on personal purchase decisions); for motorcycles and other vehicles with two stroke engines this may be the only effective approach, apart from regulatory standards combined with more effective enforcement.

4. Strengthening of penal laws to improve road safety and development of preventive measures through education and policing.
5. Introduction of congestion charging to improve traffic flows.
6. Development of vehicle insurance systems or use of insurance premium surcharges to achieve more variabilisation of premiums and a closer relationship to driver safety records.
7. Development of electronic km-charges for HGVs (superseding the existing Eurovignette), given sufficient technical progress.
8. Phased increases in charges for the use of rail infrastructure.
9. Contractualisation of public service obligations and reorientation to link them to transport services rather than modes.
10. Phasing out of tax advantages for air transport.
11. Assuming continued progress in technological development and testing of electronic road pricing systems, gradual introduction of such systems in metropolitan areas (to address urban air pollution, noise and congestion) and on national/international networks (to replace less efficient instruments above); experience from pilot cities should indicate which instruments can be replaced to best advantage by such systems.

Independent of the implementation of these new internalisation policies, primary attention should be given to enforcing existing legislation. It does not make much sense to add legislation if more can be achieved by improved enforcement.

1.5.2. Level of government intervention

The principle of subsidiarity calls for government intervention at levels as low and decentralised as possible, close to the real problems. On the other hand, there are several practical arguments for international harmonisation and co-ordination and related framework regulation at the European level to address tank tourism, internal market requirements, distribution of revenues from charges on international traffic, and cross-border externalities such as global warming, acidification and ozone layer depletion. Which levels of government are most suited to developing internalisation instruments and related measures can be summarised as follows.

Local level

- parking management and charging;
- congestion pricing and urban road pricing and tolls in general, within national/international minimal guidelines and technical standards;
- reform of public service obligations to improve transparency, contractualise payments and link them to mobility services rather than transport modes (also applies at the national level).

National level

- economic incentives to stimulate early introduction of cleaner vehicles (within international guidelines);
- fuel taxes;
- incentive oriented insurance systems;
- speed limits and law enforcement;

- improvement of rail infrastructure cost coverage;
- reduction of subsidies that distort transport markets;
- as at local level, reform of public service obligations to improve transparency, contractualise payments and link them to mobility services rather than transport modes.

International level

- emissions standards;
- harmonisation of technical norms;
- support for co-ordinated reductions in transport market distortions (reducing subsidies, etc.);
- harmonised increases in minimum levels of excise duty;
- taxation of air transport.

At international level the emphasis should be on harmonising the approach to internalisation, rather than harmonising levels of charges. Determining the level of charges within an agreed framework should be left to the most decentralised level of government with sufficient competence. International policy should aim to complement national approaches rather than substitute for them. Only where there are significant net benefits from uniform instruments should national measures be replaced by international measures.

NOTES

1. This effect, however, will be offset by the positive effects of opportunities for reduced general taxation.
2. Excluding air transport.
3. These preferences result from higher incomes and demand for improved safety.
4. The estimates are based on a shadow price of ECU 50/tonne of CO_2, derived from the average avoidance cost of meeting current emissions stabilisation targets in industrialised countries.
5. See ECMT Round Table 109, *The Extent of Congestion in Europe*, forthcoming.
6. The estimated values in INFRAS/IWW,1995 were 12.4 and 23.1 respectively.
7. Case study estimates for alpine transit tunnel capacity indicate that proper congestion charges, applied to peak times only, would be high and would flatten demand peaks.
8. For example, significant differences in fuel prices between countries, leading to the well-known phenomenon of ''tank tourism'', are perceived as an equity problem between countries. International harmonization of fuel excise duties will facilitate use of fuel charges as an instrument of internalisation.
9. The degree to which these charges affect such decisions is, however, diluted by a general lack of consciousness about operational cost consequences when a car is bought.
10. On the negative side, an increase in court cases might result.
11. They thus serve as an incentive to buy quieter, low emission vehicles and are especially important for motorcycles.
12. In or above the troposphere, 8-12 km high.
13. For extreme risks, the full coverage liability and non-subsidised insurance solution is the most appropriate way to integrate externalities into market mechanisms.
14. Examples are information and telematic technologies for km-charges, for automatic toll systems and for road pricing.

Chapter 2

THE CONCEPT OF INTERNALISATION

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2.1. EXTERNAL, INTERNAL AND SOCIAL COSTS

External effects of transport are increasingly the subject of discussion by economists and decision makers. A recent example is the debate following publication of the European Commission's 1996 green paper "Towards Fair and Efficient Pricing in Transport." Discussion is centred on externalities related to growing traffic volumes (environmental effects, accidents, congestion). The call for internalisation of such effects can be justified from an economic point of view by the wish to improve the adaptive efficiency of the economic system and thus increase the welfare of society as a whole.

The process of internalising external costs can be politically difficult, however, as it may require financial sacrifices from certain user groups. Moreover, internalisation may have distributional effects if no compensation is made – *e.g.* members of different income brackets may have to spend different shares of their incomes for internalisation. Both effects can cause substantial political resistance against internalisation policies, and governments have to take resistance into account when they design such policies.

This chapter first examines the concepts, both theoretical and practical, associated with social (external and private) costs. It moves from the more general (what are social/external costs?) to the more specific. In this part of the report, an attempt is made to shed light on the theoretical issues surrounding the internalisation of external costs and resolve the arguments that have characterised recent debate in political and economic circles. The chapter explains why, how and when external costs justify government intervention for internalisation (*i.e.* market correction). In each section, the theory is explained, then the relevance for policy making is briefly discussed. In particular, the direct economic interests of the main stakeholders (*e.g.* hauliers, motorists, railway operators) are taken into account, where appropriate.

2.1.1. Definition

The social costs of transport comprise all the costs stemming from the supply of infrastructure (investment, operation and maintenance) and its use by transport activities. Part of these social costs are private (or internal) costs, which means the individual user perceives them when he or she makes decisions on how and when to use transport infrastructure. These costs can either be private from the start (*e.g.* own time costs, pre-tax fuel costs, depreciation on vehicles) or become private through pure taxation or other government intervention (*e.g.* excise duties on fuel, costs of fitting catalytic converters, mandatory third party insurance). In public transport, at the level of the consumer, such private (or internal) costs include the costs of the trip ticket or the freight/shipping fare. All social costs that are not internal according this definition (*i.e.* that are not borne by the individual user or, depending on the system boundaries, by user groups) are called external costs.

Technological external costs are imposed by one individual producer or consumer on another and make the second party worse off. Such external costs are created as a side effect of the "main" activity. The best known example is air pollution, which may lead to various types of damage (to health, to buildings, etc.). Technological external effects are passed on from (for example) the polluter to the victim without a market interface between the two. This does not mean, however, that technological external effects do not lead to changes in prices on other markets – *e.g.* local property markets, with lower prices for private property in an area exposed to excessive air pollution or noise from traffic. The important distinction is that the externality is passed on from the driver or train passenger to the owner of property without any market operating between the two parties; only in a separate, second step do price changes on the property market occur (and these should not be confused with pecuniary externalities; see below). Such information from price changes on other markets, or "surrogate markets", can be used to estimate the level of the technological external costs.[1] Technological external costs occur when a person or company uses an asset without paying for it. This results in economic inefficiency.

Economists identify a second category of externality: pecuniary external costs/benefits. The term was coined in the 19th century to describe the effect on industrial producers when one of them increases production and as a consequence demand for process inputs rises, resulting in higher prices (*e.g.* for raw material) for all of them. Later analysis concluded that the higher costs simply represented economic rent to owners of the resource, that the resulting market price paid for the resource would promote economic efficiency and there was no market failure.

The term is used today where external benefits are captured by individuals and firms, and costs external to a given group can be seen to be processed by markets if the boundaries of the group are enlarged. In such cases there is no loss of efficiency or welfare to the economy.

An example of such pecuniary external costs and benefits are the effects which follow the opening of a bypass road. This may lead to loss of turnover in some shops in the village centre, whereas shops near the bypass road will profit, *i.e.* will be able to reap a benefit. The shop owners' losses or gains are pecuniary external effects of road construction. Under perfect competition, they do not change the overall level of economic efficiency or utility for society. Consumers simply find it more convenient to shop in a new location. In the simplest case, when only two shops are involved and both belong to the same owner, it is clear that the overall level of inputs and outputs is unaffected by the new road.

Price changes and subsequent market effects stemming from pecuniary externalities can be viewed as normal competitive mechanisms for the reallocation of resources in response to changes in demand or factor supply.

Several studies show considerable macroeconomic benefits stemming from transport. For example, Wagner (1995) estimates macroeconomic benefits as the difference between the change in gross domestic output and the value added in the transport sector. Wagner identifies benefits from both road and rail transport, but with significantly higher benefits for road. He interprets these as external benefits. Such benefits do unquestionably exist, but from an efficiency point of view, they do not give rise to any need for government intervention at the user level. These effects are purely pecuniary and they do not bias the individual decision with regard to transport services.

The important characteristic of pecuniary effects which makes them clearly distinguishable from technological effects is that the induced second round allocational effects are processed by markets via changes in relative prices. Technological effects, in contrast, are characterised by the lack of a market interface to correct price signal and influence the consumption of resources. They lead immediately to allocational distortions.

Technically speaking, pecuniary externalities do not produce any divergence between private and social marginal rates of substitution and transformation, whereas technological externalities do:

- Technological externalities change the functions relating outputs (or consumers' utilities) to quantities of resource inputs. Negative technological externalities reduce the amount of output or utility an economy can produce with any given allocation of inputs.
- Pecuniary "externalities" do not change production or utility functions. It would be possible for the economy to continue producing the same outputs as in the absence of a pecuniary externality, using the same allocation of inputs as was used before.

Though pecuniary externalities do not justify government intervention in prices for the use of transport – and should not be taken into account in its policy – this is not to say, though, that they are irrelevant to the assessment of transport. All social costs and benefits should be accounted for in social cost benefit analysis to determine the value of investment projects.

2.1.2. External to what?

The term "external" remains ambiguous unless specified: external to which subsystem? From a practical policy standpoint, it is relevant to distinguish the following subsystems:

1. The individual transport user: car drivers, train or bus passengers, hauliers of freight forwarders etc.
2. A group of transport users, *e.g.* a transport subsector, perhaps all drivers of passenger cars with diesel engines up to two litres in volume; perhaps all car drivers, or all hauliers; perhaps all road, rail and airport users.
3. The entire transport sector.

The policy relevance of these categories becomes obvious when we look at the example of the external costs of congestion or accidents. In the latter case, from the point of view of the individual car driver, all costs of an accident involving any other vehicle and causing damage to this vehicle or its passengers are external to the car driver who caused the accident, except for any costs that insurance paid for.

On the other hand, looking at road transport as a whole, the accident costs external to this mode are much smaller, because all accident damage inflicted by road users on other road users (including, for example, injuries to pedestrians) remain within the road system, which means they are internal costs facing that particular group. Finally, at the level of the entire transport system, external costs become even smaller, since now they are reduced to the costs borne by non-transport users, *e.g.* government subsidies to hospitals for costs not covered by transport users.

These distinctions are relevant for policy making. If the issue is to recover costs (*e.g.* from the entire road system), then "external" means "external to the road system", and the average external cost should be factored into the policy decision. However, if policy makers are concerned with incentives for efficiency, one should look at individuals, or at least small, homogeneous user groups (*e.g.* male motorcyclists aged 18 to 25), and at the marginal costs that underlie political decisions (see section 2.4 for a more thorough treatment of this point). From the standpoint of economic efficiency, the question "external to what?" can be answered with "external to the decision maker".

2.1.3. Infrastructure provision and use

Most of the external costs mentioned so far stem from the use of existing transport infrastructure (roads, rail, airports, waterways, ports). But infrastructure provision also generates relevant external costs. Examples include the negative impacts of construction (*e.g.* surface sealing, cutting off of neighbourhoods from each other, degradation of local ecosystems, detrimental effects on landscape). These effects would, at least in part, occur even if no motor vehicle, train, etc., ever used the infrastructure.

When a decision is to be taken concerning whether to build transport infrastructure, all incremental social effects (*i.e.* both external and internal) related to the decision need to be considered. Social cost-benefit analysis is the appropriate tool to reach a balanced decision. Technological externalities must be considered in the analysis because of their effects on economic efficiency. Pecuniary externalities may or may not need to be included in the analysis, depending on their distributional effects. If the distributional effects are judged to be "unfair" (*i.e.* another income distribution is considered fairer), income streams of different people or groups of people can be given different weights to account for social imbalances and used to adjust the outcome of the social cost-benefit analysis.[2]

If the aim is to maximise welfare (through efficient resource allocation), then pecuniary effects are not relevant. Take again the case of construction of a bypass, where, for example, trade will fall at a town centre gasoline station and rise at an out-of-town one. From the efficiency point of view, we are not interested in who sells fuel, only in how much is sold. If the project does not influence this amount, then there is no need to add or subtract anything to account for pecuniary effects. Again, in the simplest case, with both stations owned by one person, as long as total trade doesn't change, that person will be indifferent about having or not having the bypass.

However, if the project analysis has added in the positive effect of increased trade for the out-of-town gasoline station, it then becomes necessary to subtract the "negative" effect of reduced trade for the town centre station to avoid mis-counting the pecuniary benefit to the out-of-town station as a net benefit of the project. If the bypass is likely to lead to increased total trade, then the fraction of the increase that is not offset by decreases elsewhere is a benefit of the project overall and should be counted as such.

2.1.4. Relevance for policy making

The points raised so far have the following implications for policy making:

- Concerning correct pricing for infrastructure use, only technological external costs (not total social costs[3]) should be the subject of government intervention.
- Concerning system boundaries ("external to what?"), the level of external costs and the political goals have to correspond.
- Concerning pricing, if incentives to increase efficiency or modify behaviour for other reasons are the goal, marginal costs are relevant. If exact cost recovery is the political objective, average costs become relevant, but exact cost recovery will be inefficient unless average costs happen to equal marginal costs (for both points see section 2.4).

2.2. EXTERNAL, INTERNAL AND SOCIAL BENEFITS

In principle, the terminology explained above for costs holds analogously for benefits of transport systems. Empirically, however, most of the significant external benefits of transport activities are, in the long-run, captured by firms or individuals or automatically processed via direct market interfaces between the party causing the external benefit and the one profiting from it. Thus most external benefits do not qualify as technological externalities and do not justify government intervention.

For example, benefits accrue to a regional economy after construction of a road because of improved access to extraregional markets. Such growth and productivity effects (*i.e.* benefits) should be considered in the decision whether to build the road (*e.g.* when a social cost-benefit analysis is carried out, as discussed above), but not in managing its use. There is an important difference between internalising an effect and accounting for it in a project appraisal.

Most economists agree that in the transport sector any technological external benefits that would justify government intervention are generally negligible. At the level of infrastructure use, benefits in terms of regional development do not warrant a transfer to the road users, since they are not technological externalities and do not bias allocational efficiency.

Moreover, for any technological benefits which did exist, "netting" external costs and benefits (in the sense of adding them up and subtracting any benefits that can be attributed to a user from taxes imposed to internalise costs) would not be justified on economic grounds, because efficiency demands that the correct pricing signals be given to each individual. Any users that did create positive externalities would not necessarily be the ones causing negative externalities. Therefore, separate responses at the level of the individual are called for to find the most efficient solution for the economy as a whole.

The treatment of external benefits has been one of the most politically sensitive issues in the context of externalities. Some motorists' and hauliers' organisations, and even some economists, sharply contest the non-existence of technological external benefits. Representatives of these groups point to the (uncontested) large economic benefits that transport creates for industrialised economies as a whole. However, as explained above, for internalisation policy, only technological externalities count.

Technological and pecuniary externalities must be distinguished; and if the distinction is respected, most external benefits claimed by motorists' and hauliers' associations turn out to be pecuniary benefits, according to the definition above (see, for example, Willeke, 1991 and 1992; Aberle and Engel, 1993; or Deutsche Strassenliga, 1992). As noted earlier, the ''netting'' of costs and benefits that is often called for is not appropriate if the aim is to increase total efficiency in the transport sector or in the economy as a whole. It would be counterproductive from an efficiency viewpoint to subsidise hauliers for any of their services which lead to economic growth in other sectors of the economy. Using the same logic, one would also have to subsidise, say, computer manufacturers, since their products make other businesses more productive than they would otherwise be. The contribution that hauliers' services yield to other businesses is reflected in the market prices for road freight services (again, the analogy to computer markets is apt). The economic benefits are not disputed, but they have already been accounted for in normal market transactions (*i.e.* via market interfaces). Government intervention would be wrong in such cases, adding to inefficiency instead of decreasing it (see W. Rothengatter in ECMT, 1993).

Table 3 summarises the types of external effects and their relevance for the design of internalisation policies.

Table 3. **Types of external effects and relevance for internalisation policy**

	Infrastructure provision	Infrastructure use
Technological external effects		
Costs	Ecological and socio-economic separation Aesthetic costs, destruction of landscapes, separation effects, etc. → relevant for cost-benefit analysis	Air pollution, noise, climate change, accidents, etc. Depletion of energy and other natural resources → **relevant for internalisation**
Benefits	Fire protection due to roads in old cities → relevant for cost-benefit analysis	No relevant effect identified
Pecuniary external effects	No growth: Distributional effects (*e.g.* bypass road) → relevant for cost-benefit analysis Growth: Productivity effects, access to remote areas → relevant for cost-benefit analysis	

Source: ECMT Task Force.

2.3. VALUATION OF EXTERNAL COSTS

In economic theory several approaches for the valuation of external costs have been developed. The aim of these methodologies is to derive monetary estimates of different types of external effects. An important distinction between the approaches relates to whether they are preference oriented. The main approaches can be summarised as follows:[4]

- The revealed or stated preference (utility) valuation technique is the approach economists usually favour on theoretical grounds because it reflects willingness to pay. It infers values for environmental goods from observed or stated behaviour of individuals with regard to the goods in question.
- In the resource approach, externalities are calculated from replacement or repair costs after environmental damage has occurred.
- In the avoidance cost approach, the value of external costs is not calculated directly on the basis of individual valuations for environmental goods or environmental costs already incurred, but depends on a target that is exogenously (*i.e.* politically) given. The avoidance cost approach

seeks to estimate the cost of necessary actions to prevent a specific effect (*e.g.* the cost of reaching a given CO_2 reduction target over time). Depending on the quality of the empirical basis underlying the target, this approach may lead to too much or too little internalisation.

- The risk approach uses the cost of risk management strategies, *e.g.* insurance premiums, as a proxy for external costs. It takes into account the fact that damage is very often hard to assess (*e.g.* when it is likely to occur in the future and the effects are of unknown magnitude, such as damage resulting from a loss of biodiversity).

The choice of an estimation approach has important implications for policy making:

- In general, the valuation technique chosen influences the estimated size of external costs.
- Because different studies use different valuation techniques and make different assumptions, results are often difficult to compare. Applying the same methodological framework to different countries facilitates international comparisons.[5]
- If the avoidance cost approach is chosen (*e.g.* for estimating damage from climate change), the strict damage oriented approach of the external cost framework is abandoned in favour of estimating what it costs to reduce a certain quantity of emissions (for example). This corresponds to basing the estimate on the criterion of cost-effectiveness rather than on the criterion of economic efficiency.

Estimates of external costs, regardless of the technique used, are rough benchmark values and not ''scientifically exact'' figures. Nevertheless, they can be used as a basis for political action, because, if the estimation procedure conforms to the best practice possible, they are accurate enough to reflect the order of magnitude of external costs and therefore to point to the direction policies should take. Despite the inherent inaccuracies, the external cost concept is particularly useful in getting the political priorities (*e.g.* across modes) approximately right.

2.4. INTERNALISATION (THROUGH GOVERNMENT INTERVENTION)[6]

2.4.1. Internalise: what?

For pricing infrastructure use, only technological externalities work against efficiency and thus only these externalities should be internalised for user tariff setting. As discussed, technological external benefits are negligible from an efficiency point of view, so we focus on external costs.

According to economic theory, externalities should be internalised to the point where marginal social costs equal marginal social benefits. Therefore, there is an optimum level, of pollution for instance, which will typically be greater than zero. This is plausible, since zero pollution would probably mean zero transport activities. It is not necessary to extinguish all the external effects of transport.

Internalisation is based on establishing shadow prices, which reflect the true marginal costs of the resources used by an activity. ''Shadow price'' refers to the marginal (social) cost of the use of a resource. The term is useful because this price can deviate from average market prices for the resource. For example, in a situation of high unemployment, the shadow price of (unemployed) labour is lower than official labour costs.

In the context of internalisation the shadow price corresponds to the valuation of the externality, *i.e.* the economically correct price for the externality. The correct valuation of shadow prices is based on the economic concept of opportunity costs – the costs that arise because a decision for one option implies giving up the benefits of the next best alternative. The value of the forgone benefits determines the level of the opportunity costs. Only the external part of the shadow price of resource consumption matters for internalisation. For example, the effects of reduced air quality or noise due to transport are fully external and therefore the shadow prices of these forms of resource consumption have to be internalised in their entirety. The costs of infrastructure use, by contrast, are partly private and partly covered through taxation; only the remaining external share of the corresponding shadow price has to be internalised.

2.4.2. Incentives for internalisation *versus* cost recovery

Internalisation incentives (pricing)

For maximum efficiency, goods should be priced[7] according to their marginal costs. For efficient internalisation this implies pricing according to marginal social costs, to ensure that transport users face the right prices when they make decisions. Without government intervention, users are unlikely to take the effects of their activities on the environment into account, for the environment is frequently treated as if it were a public good for which no property rights have been defined. When individuals face correct prices (at the micro level), the sum of their individual behaviour leads to an efficient allocation of resources from the point of view of the entire economy or society (the macro level).

The term "marginal" needs some additional clarification here:

- Short-run marginal costs represent the incremental variable costs which arise when an additional unit of a good (or transport service) is demanded. The underlying assumption is that the existing infrastructure has enough capacity to absorb the additional demand (*e.g.* that it is not necessary to build a new road when transport demand increases only marginally). Where congestion exists, its costs should be included in the short-run marginal costs.
- Long-run marginal costs include short-run marginal costs, plus expected future costs that arise due to any capacity addition necessary to meet increased demand. For pricing policies, long-run marginal costs should also be considered, so that the individual transport user takes into account the influence his or her demand has on the total level of future infrastructure provided. In practice, long-run marginal pricing implies higher prices for congested than for non-congested infrastructure. The price increase is determined by the present value of the costs of future capacity expansions.

Cost recovery

Cost recovery usually focuses on infrastructure ("track") costs. It demands that, *ex post*, a group of transport users (*e.g.* within a mode) pays for all costs the group imposes. Since cost recovery is concerned with costs incurred in the past, any pricing policy aimed at cost recovery will be based on average historical costs. In the case of infrastructure costs, this ensures that investments are paid back within a reasonable period by the people who use the infrastructure.

Pricing for efficiency and for cost recovery do not necessarily lead to the same result. In fact, they lead to similar results only when investment costs remain constant over time. When average historical cost pricing is used (aimed at cost recovery), a deficit will result in situations where incremental costs lie above average costs.

In practice, "second-best" pricing policies can be used to bridge the gap between the two approaches. Such policies use price structures which are oriented to marginal costs, but where the level of prices is adjusted so that full cost coverage can be achieved with the least loss in efficiency (Ramsey, 1927). This requires making specific and sufficient allowance for system expansion and depreciation of capital goods.

2.4.3. Internalise: how?

External costs can be internalised using a variety of instruments. In theory, external costs should be estimated, valued in monetary terms and internalised step by step. This ideal procedure is often overly ambitious, mainly because some external costs cannot be easily quantified.

It is often easier, and more transparent, to first define a specific environmental target (*e.g.* emissions levels), and then apply policy measures intended to steer the transport sector towards this target at least cost. However, it should be noted that this approach[8] is inherently inefficient, since it focuses on only one aspect of economic efficiency (cost-effectiveness), rather than on the broader problem of equating marginal social costs and marginal social benefits. As a result, the approach entails a risk of over- or underresponding to a given environmental problem.

On the other hand, it should be noted that this approach leads to the internalisation of at least some of the external costs of transport activities into the cost functions of transport users. It is therefore practical, but only approximately compatible with the principle of economic efficiency.

2.4.4. Internalise: in which cases?

Internalisation of external costs to the transport sector itself is worthwhile only when: *a)* the external costs can be reasonably attributed to transport (cause-effect); *b)* the externalities are found to be significant and the transaction costs for internalising them are well below the efficiency gains achieved by the internalisation; *c)* there are enough reliable data so that levels of external costs can be determined; and *d)* based on these data, reasonable estimates of the levels have been made.

There are as yet no generally accepted guidelines for the criterion of "significance". However, a large body of studies on environmental externalities suggests that, at least for air pollution and noise, internalisation policies do seem warranted from an efficiency point of view as long as cost-efficient instruments can be found.

Before new taxes are imposed to internalise external costs attributed to the transport user, the existing tax burden should be considered. The estimated sum of all marginal external costs, including infrastructure costs, costs from accidents and environmental costs, should be compared to the taxes already levied at the margin.

2.4.5. Internalise: which effects?

- Road transport (cars, vans, lorries, motorcycles) causes several different types of environmental externality related to air pollution and noise, traffic accidents and damage to ecosystems. Whereas the external costs of accidents, of air pollution's effects on buildings, and of noise are comparatively well researched and accepted, effects on health and costs related to climate change are more difficult to value and are contested in the political context.
- When effects are expressed in monetary units per passenger- or tonne-kilometre, rail tends to generate fewer external accident and environmental costs[9] than road transport but significantly higher uncovered infrastructure costs.
- Air traffic may entail significant external environmental costs (noise, climate change, air pollution) but some of these costs (in particular those associated with climate change) are difficult to assess. No large scale attempts at internalisation have taken place so far. Noise dependent landing charges have been introduced in a number of countries, and Sweden has a NO_x tax for domestic flights.
- Inland waterways and coastal shipping generate external costs in the form of water and air pollution and climate change impacts. However, the level of these costs is lower (at least for local pollution) than in other modes, since transport of this type is usually not carried out in densely populated areas.

2.4.6. Internalise: at which level of government?

Internalisation of externalities should be carried out by the most appropriate level of government. This may be a local or regional authority (for purely local/regional externalities), a national government, or an international or supranational body, such as the EU, in cases where externalities spill over from one country to others. From an economic point of view, there are good reasons to apply the principle of subsidiarity whenever possible, since subsidiarity allows differences in preferences for environmental quality or safety requirements to be reflected. Moreover, the assimilative capacity of the environment may differ from place to place. On the other hand, a number of environmental externalities from transport are transnational (*e.g.* air pollution) or even global (*e.g.* CO_2 emissions). In such cases, international co-operation or internalisation at the supranational level may be warranted for effective and efficient policy making. In freight transport, international co-operation and harmonisation of internalisation policies helps ease hauliers' fears of a loss in international competitiveness.

2.4.7. Internalisation: how to use revenues?

Internalising external costs through price based instruments generates revenues. Most public finance theorists maintain that these revenues should be used for the most efficient projects that are available to an economy. In other words, government revenues and government expenses should be optimised separately. Therefore, revenues from environmental incentive charges should, in general, not be hypothecated (earmarked) for a particular use, but should flow into the general budget or, to maximise economic efficiency; be used to lower other, distortionary taxes (*e.g.* on labour or capital);[10] or they should be redistributed to households and/or companies on a lump sum basis to avoid undesired distributional effects.

However, earmarking may, under certain conditions, be attractive:

- Efficiency considerations may lead to part of the revenues from incentive charges being allocated for programmes to stimulate innovation. Such financial supports must be limited in time and/or to defined programmes so that they do not degenerate into permanent and inefficient subsidies. The objective of this kind of earmarking must be to accelerate and increase the leverage and impact of incentive charges. The trade-off consists of ''buying'' increased dynamic efficiency at the price of somewhat higher administrative costs and some free rider effects – both of which should be kept to a minimum.
- Other reasons for earmarking may arise when efficiency is only one of several policy objectives. In such situations some of the efficiency potential may be sacrificed to gain on other objectives, such as fairness and transparency, that contribute to political acceptance. Cost recovery requirements, for instance, may mean the level of earmarked infrastructure charges being designed so that, over the long-run, past investment costs are paid by the club of users. This is considered a fairness criterion from the standpoint of those not belonging to the club of users.[11] And congestion charges, as another example, may find better acceptance if revenues are recycled to a club of users to finance investments for capacity expansion. Environmental charges may be more acceptable if part of their revenues are used to meet abatement costs, even though other allocations might be more efficient. These are fairness considerations only from the standpoint of the members of the club of users and polluters.

Finally, it must be pointed out that overall dynamic economic efficiency may require incentive charges which significantly exceed the level of full recovery of infrastructure cost, even if this latter part is earmarked.

2.5. CONGESTION COSTS

Congestion costs occur because transport users (*e.g.* car drivers) take only the costs of their own trips into account (time costs and other costs) but neglect the costs they impose on other users of the network – *i.e.* the external costs of their activities (Newbery, 1990).

Congestion costs occur only on a fraction of the network, at least for road, rail and shipping, and vary significantly by time of use. Therefore, they necessitate additional, focused policy measures. These may be price based measures (road pricing) and/or technological measures (telematics).

In classifying congestion costs as external costs, some clarification is required. The concept of economic efficiency demands that ''external'' be defined as external to the individual transport user or decision maker. Consequently, external congestion costs are true external costs from a pure efficiency point of view and should be treated like any other externality (*e.g.* environmental externalities or externalities from accidents).

Although most external congestion costs usually remain entirely within a transport subsystem (in the case of road congestion, among road users[12]), factoring in these costs increases the operating efficiency of the subsystem. This is because efficiency is maximised when scarce resources (*e.g.* road space) are used by those individuals who are willing, at the margin, to pay the highest price for using them. Internalising external congestion costs helps ensure that existing road space is used more efficiently. A second motive for charging for congestion costs is that road congestion generally leads to higher fuel consumption and more emissions per kilometre driven, both for passenger vehicles and lorries.[13] However, some further technical research is needed before quantitative conclusions on such relationships can be drawn.

On the other hand, most congestion externalities are special in that they do not spill over to the rest of the economy as technological externalities, unlike environmental or accident externalities, where the general public bears a part of the costs. Since external congestion costs are internal to a transport subsystem, it can be argued, from a fairness point of view, that revenues from congestion pricing should remain within the same subsystem. This argument is based on the notion that transport infrastructure is a ''club good'' consumed by clearly defined clubs of users. Three ways of using such revenues are compatible with this argument:

- expanding road capacity (as long as this remains efficient after all environmental externalities are taken into account);
- lowering other road charges (*e.g.* vehicle taxes);
- returning the charges as lump sum payments to drivers.

Recycling money back into the mode from which it was extracted may seem politically difficult to justify when environmental effectiveness is the main policy objective. This may be one reason why improving public transport facilities is often chosen as an alternative, although this is in theory only a ''second-best'' approach, if the club good philosophy is followed. From an efficiency perspective, earmarking revenues from congestion pricing for investment in further measures to relieve congestion is a more valid argument that also satisfies concerns of fairness.

If environmental externalities are properly taken into account and it is assumed that public transport (particularly rail) is more environmentally friendly than private transport, subsidising public transport using road congestion charges may even be a ''first-best'' option under certain conditions – even more so when policy goals other than efficiency (*e.g.* social policy) are being pursued. Again, clear distinction among policy goals is helpful.

2.6. PROPERTY RIGHTS

In some situations, property rights ensure that users of a resource can negotiate on their own behalf when externalities arise, in which case government intervention is not required. This holds when property rights are clearly defined and enforced, and when only a very few individuals are involved, so that the transaction costs are low. If these conditions are met, if reasonably adequate information is available and if markets are not excessively concentrated, the bargaining process leads, at least in theory, to an optimum solution, in the sense that no one's well-being can be improved without harming someone else's (''Pareto efficiency'').

In many cases, however, the conditions are not all met and government intervention is warranted. This is particularly the case with environmental externalities involving many pollution sources (*e.g.* cars, buses, lorries, trains), and when traffic accident victims are involved. Negotiating a solution among many individuals or groups is practically impossible and the transaction costs would exceed all potential benefits; government intervention is then the most efficient approach.

When governments intervene, they can use a number of instruments. One of these, marketable permits, ''imitates'' property rights by assuming that absorption capacity (of the atmosphere, for example) is limited, and that only a set quantity of emissions is acceptable. This quantity is divided into small ''portions'' and a permit is issued for each portion. The permits are given away or auctioned to individual transport users. If they are auctioned, or freely traded later on, the market price for a permit will correspond to the optimum tax which could be levied for the same quantity of emissions. Hence, pollution taxes and marketable permits are exact complements, in theory. In political practice, their respective advantages and disadvantages matter. The main advantage of permits is that the environmental target can be met with some precision, usually at lower cost. They are also immune to the effects of inflation. The main advantage of a tax is that the resulting price changes and the marginal economic cost of the policy to the user are known in advance. Which instrument is favoured depends on political priorities.

2.7. EFFICIENCY *VERSUS* EQUITY

Internalisation of external effects (both costs and benefits) increases the efficiency of the economic system. Environmental effectiveness and economic efficiency are the main policy objectives being served. However, these are not the only policy objectives that may be at work. Other goals, such as achieving a certain income distribution (within a country or between countries), may help define the most desirable policy outcome.

Equity[14] is often used as an argument for public transport subsidies, making fares affordable to as many people as possible. Such policies are undertaken when the current income distribution is perceived not to be "fair", even though these policies may conflict with the "efficient" outcome. It is always important to separate efficiency from equity arguments and to state clearly which equity objectives matter most in individual transport policies.

The term "equity" is also often used when the effects of specific instruments are being discussed. Policy instruments, especially taxes, that are imposed with the aim of increasing efficiency may affect the existing income distribution of the population. Depending on the exact design (in particular, the use of the revenues), a tax may be regressive, with lower income groups having to pay a higher share of their income than richer households do; or, it may be progressive, leading to improvement in the relative position of low income groups. Such equity effects can become major arguments in the political debate. They can lend support to an inherent reluctance to pay taxes, outweighing arguments based on efficiency criteria which consider the current income distribution to be a given. There are, however, ways of reconciling efficiency and equity objectives. One is to return tax revenues in lump sum payments to some of the people who have paid them; lump sums do not distort markets as they do not affect marginal costs at the point of decision.

In a wider sense, "equity" also has a geographical dimension, both domestically and internationally. The internalisation of environmental externalities may be questioned by economically less developed regions or countries on the grounds that the primary concern in these regions or countries is economic development. However, from an economic point of view, equity arguments should not prevent the internalisation of external environmental costs, so long as other policy instruments can be applied that serve the goals of development or enable income transfers from more developed to less developed regions or countries.

2.8. PUBLIC SERVICE OBLIGATIONS

Market forces alone would not generate certain transport services in which it would be impossible to make a profit or even to cover all production costs – for example some public transport services to remote, sparsely populated areas. There may nevertheless be valid reasons to encourage the supply of a basic service, usually by subsidising the company that offers such a service.[15] For example, maintaining basic services to remote areas creates an incentive for decentralised housing and business patterns. Such services can also be justified by the special social needs of people in low income brackets, or elderly people, or those unable to drive a car.

Payments of compensation from the public purse for such public services must be targeted carefully if they are to avoid creating incentives to mix up profitable with unprofitable services. One possible long term effect is the creation of deficits which the taxpayer has to cover *ex post*, without ever having agreed to a public service obligation. To avoid this problem, public service obligations should be explicitly and transparently defined, negotiated, budgeted and paid in full by the relevant authority.

Although public service obligations are typical of railways, the concept should not be unbiased with respect to mode. For example, there are cases where subsidising the use of taxis may be more efficient than subsidising the use of a large bus, even when the environment is given due weight in the policy evaluation.

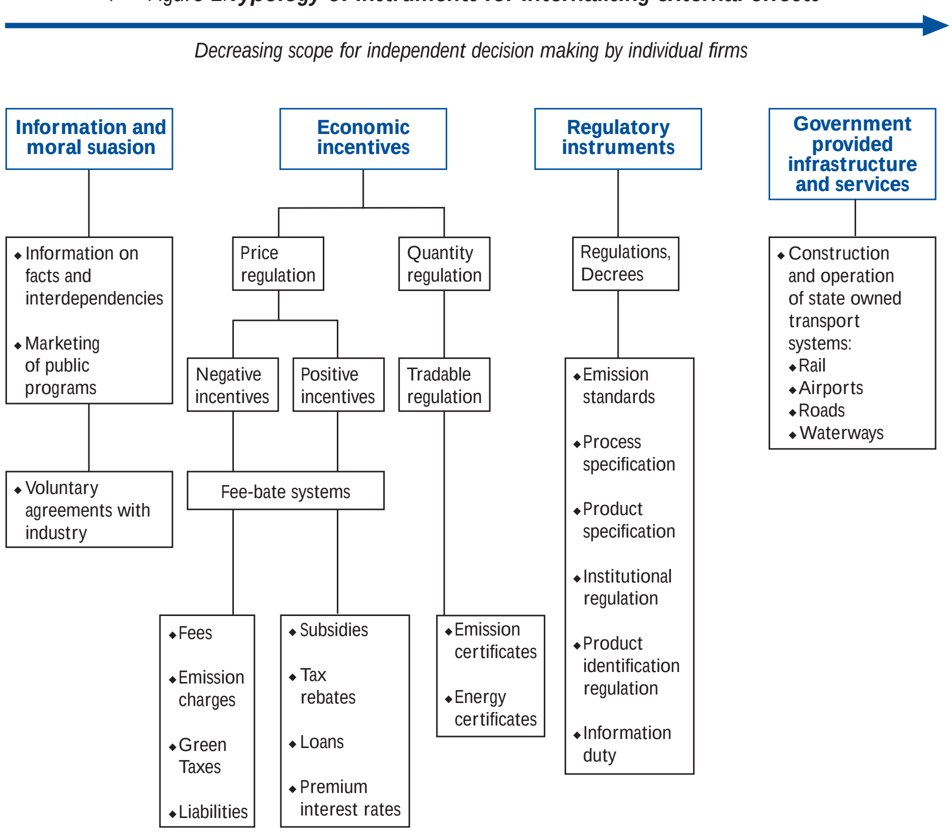
Analytically, public service obligations should be kept separate from pecuniary external benefits. The former are defined politically, whereas the latter are market phenomena.

2.9. INSTRUMENTS FOR INTERNALISATION

All instruments listed in Figure 2 can contribute to the internalisation of external costs.

Economic theory suggests that taxes are preferable to subsidies to internalise external costs.[16] In practice, however, subsidies are often used as "second-best" solutions, paid to a comparatively less polluting mode when taxing the external costs of the more polluting mode is difficult. Following this reasoning one might argue for rail subsidies in place of taxes on road transport. However, subsidies to rail may be inefficient in themselves, inducing too much use of rail or perhaps too much transport activity overall, the net result being very little environmental improvement (people may still use their cars even though rail services are available at lower cost). In any case, the main objective is to steer the market towards lower levels of externalities.

◆ Figure 2. ***Typology of instruments for internalising external effects***



Source: INFRAS/IWW (1995)

If reducing pollution is of primary concern, environmental effectiveness is the main test for policies. Given this primary condition, individual instruments can then be evaluated according to the following criteria:[17]

- Economic efficiency: Instruments should be sized and targeted so that economic efficiency (including payment for all major environmental externalities) is increased. Instruments should be as cost-effective as possible: the target should be reached at minimum cost. This usually can best be achieved using economic instruments, although a mix with other types of instrument is often feasible, depending on the circumstances. In a dynamic sense, any instruments chosen should encourage (or at least not discourage) further reductions of external costs (*e.g.* by technological innovation). It is often argued that economic instruments are well suited to this goal because they create a constant financial incentive to reduce externalities.
- Low administrative costs: This follows from the efficiency criterion. In practice, administrative costs can be kept low if: *a)* existing institutional structures can be used; *b)* new administrative schemes can be minimised; *c)* a small number of far-reaching instruments can be selected; and *d)* the policy mix does not leave too many loopholes requiring additional administration or policing to prevent erosion of the policy's effectiveness.
- Low negative side effects: The most important negative side effects are undesirable distributive effects (*e.g.* for low income groups in remote areas, when a fuel tax is introduced or increased). Such effects can be compensated by ''flanking'' policies (*e.g.* targeted subsidies for use of public transport), so long as these do not generate excessive additional costs and thus jeopardise the efficiency of the instrument.

NOTES

1. For example in the hedonic pricing method.

2. However from a theoretical point of view, it is more efficient to tackle distributional issues through the tax-benefit-system than within cost-benefit analysis.

3. Often the terms ''social'' and ''external'' are – mistakenly – used interchangeably.

4. See Annex A for a full discussion of the subject.

5. Of course, natural differences between countries still prevail. Whether economic disparities (*e.g.* different levels of GDP) should be corrected for depends on the purpose of the analysis; it is a normative question.

6. Some authors extend the term ''internalisation'' to the process wherein market forces ''internalise'' external pecuniary externalities. This report, however, does not use the term in this way.

7. ''Pricing'' here does not necessarily imply a rise in prices, but rather is used in its economics sense to mean ''reflecting the value'' of a good or service.

8. This procedure is sometimes referred to as the ''charges and standards'' approach.

9. The amount depends on whether the locomotives are diesel powered or electric. In the latter case, the type of power plant used is what matters.

10. The benefit generated by such a policy approach is called the ''double dividend'' because it may lead to both reduced unemployment and reduced environmental costs.

11. Some economists argue that full cost recovery is efficient and fair because any other source for financing infrastructure costs (*e.g.* by general income taxes) would lead to larger distortions to the economy.

12. Increased pollution due to congestion spills over to society, however.

13. An exception is NO_x emissions from cars; see Buwal (1995).

14. Sometimes, ''equity'' is used to mean a desired state of income distribution, as opposed to an actual state of income distribution or distributive consequences of policies aiming at efficiency.

15. These public service obligation payments help guarantee a certain level of a public good.

16. This is because subsidies, when paid to the ''polluter'' for refraining from polluting, are effective at the level of the individual, but not for a whole sector. They create an undesirable incentive and lead more firms/individuals to enter the market (Baumol & Oates, 1988). Another drawback is that subsidies create economic dependence and are hard to remove.

17. For a more detailed list of criteria, see Chapter 4.

Chapter 3

ESTIMATES OF EXTERNAL COSTS

TABLE OF CONTENTS

3.1. METHODOLOGICAL APPROACH

This chapter presents an overview of estimates of the external costs of transport and discusses the selection of appropriate indicators for use in policy making. The valuation of external costs is not an exact science: assumptions have to be made to simplify the calculations, and choices made among methodologies and results. Annexes B and C give details of how the estimates summarised in this chapter were calculated. Some evaluation techniques are more appropriate than others for each class of externality and Annex A examines these techniques and makes some recommendations on their use. As far as possible, studies based on the most appropriate techniques were used as the basis for the estimates presented here.

A conservative approach was adopted in selecting results for use in designing internalisation policies. Extreme outlying results from surveys of the theoretical literature were discarded and where explicit political decisions, such as emissions targets, exist these were given precedence as a basis for estimating external costs over theoretical work that results in higher valuations. The reason for introducing this bias was to develop lower bound estimates that are very unlikely to exaggerate external costs, reducing potential controversy over the quantitative aspects of the policy recommendations elsewhere in this report.

3.1.1. Shadow prices for externalities

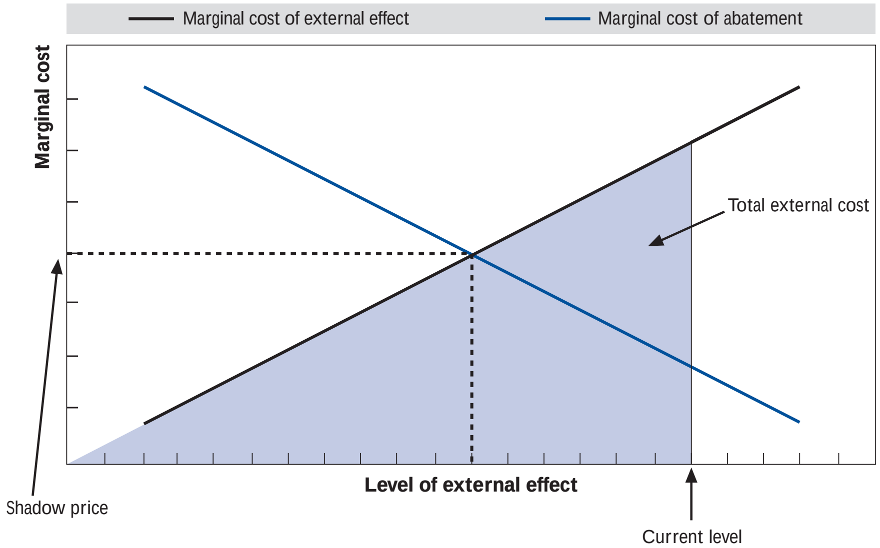
Because no markets exist for pollution or accidents, no market prices have been established for their social costs and shadow prices have to be estimated as a basis for designing internalisation policies. The core of the exercise is to establish what the price would be if a market existed. There is a large body of economic literature on theoretical and empirical approaches to estimating shadow prices. The object is to simulate markets for external effects, with the shadow price corresponding to the intersection of estimated marginal demand and supply curves, as in Figure 3. The graph plots the cost of avoiding or abating an external effect against the economic cost of the damage done by it. (Annex A discusses the preferred techniques for measuring damage in monetary terms; Annex B presents the calculations made to estimate shadow prices.)

In most cases, insufficient data is available to estimate both curves. Some assumptions then have to be made to arrive at shadow prices; two approaches are followed in this report. The first assumes the impact of an external effect is constant at the margin. Each traffic fatality, for example, can be assumed to have the same social cost (see Figure 4). The shadow price for traffic fatalities then corresponds with this single value, and the need to calculate an avoidance cost curve is bypassed.

The second approach replaces individual preferences for environmental quality with explicit collective decisions about the desirable level of environmental protection, as in official government targets for the reduction of certain pollutants. The intersection of the pollution reduction target with the avoidance cost curve can be taken as the effective shadow price (see Figure 5). This approach is followed where data on individual preferences for a clean environment are inadequate due to insufficient estimates of physical damage and lack of accurate stated preference studies.

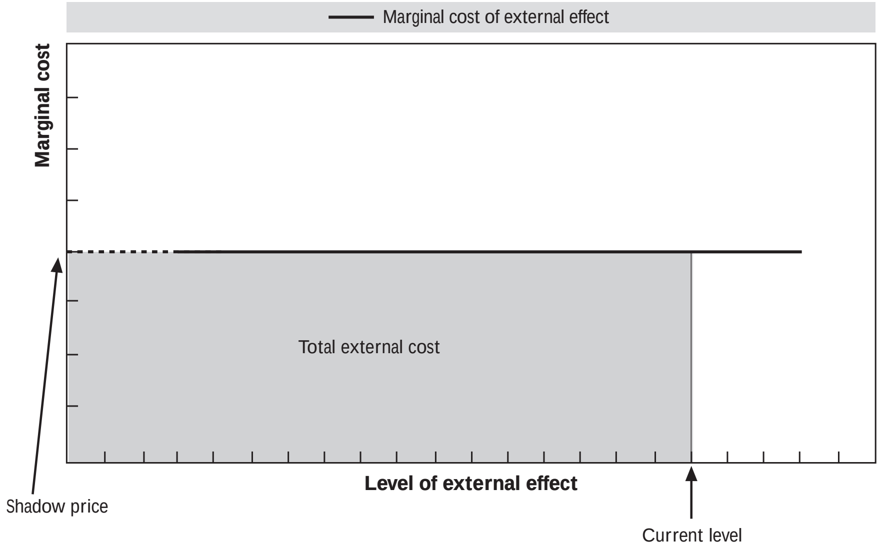
This may be the only acceptable approach in cases where estimates of damage are particularly uncertain, and has the advantage for policy making of being based on explicitly agreed political consensus. From a purely theoretical point of view the approach is not fully satisfactory, as a political

◆ Figure 3. ***Theoretical calculation of total external costs and shadow prices***



Source: ECMT Task Force.

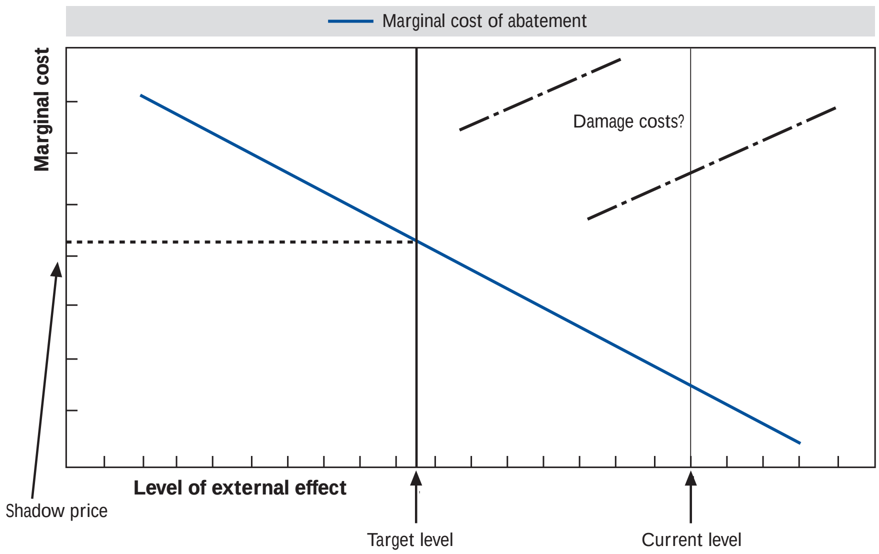
◆ Figure 4.***Shadow price estimation when marginal costs can be assumed to be constant***
(e.g. *for accidents)*



*Source:*ECMT Task Force.

target substitutes for the estimation of an optimal level of externality (where the costs of reducing an external effect balance its marginal damage costs). In consequence, researchers may not agree that the target is set at the right level.

◆ Figure 5.***Shadow prices based on pollution reduction targets***



Source: ECMT Task Force.

There are important dynamic aspects to the estimation of both damage and avoidance costs. Damage estimates improve over time and avoidance costs are in large measure a function of technological development. These aspects are dealt with in Chapter 4 on policy options.

3.1.2. Data

A review of recent literature on the estimation of transport externalities was undertaken for Europe (see Annex B). The studies examined can be divided into two broad groups, the first calculating actual damage costs and the second the costs of meeting established reduction targets. For some external effects calculating actual damage is relatively straightforward. For others, notably environmental externalities, a number of problems arise. Damage cost estimates are complicated to perform, with several dimensions of uncertainty. Many different valuation techniques have been used in deriving estimates and many of the studies reported in the literature do not appear to meet the best practice criteria set out in Annex A. The range of damage estimates for environmental externalities tends to be relatively broad and divergence in methodological approaches makes results from different studies difficult to compare. Damage cost estimates generally tend to be characterised by underestimation; only a limited number of the multiple impacts of environmental externalities are examined in any one study. The results yielded by damage cost studies can in this respect be regarded as conservative. While further research into actual environmental damage costs is expected to yield better estimates for air pollution and noise, for climate change no reasonable alternative to basing estimates on political reduction targets is foreseen in the medium term.

The damage and avoidance cost estimates used in this report are based on the estimates judged most appropriate from the data reviewed. The design of optimal policies ideally requires information on marginal external costs. Most of the literature is concerned with estimating total external costs rather than marginal costs, although for most categories of externality at least one authoritative study taking a marginal approach was also available. The most common way unit costs have been approximated (and the method followed here) is to employ a 'top-down' approach, with total cost estimates for the transport sector split among modes, and so on, down to costs per vehicle- or passenger-kilometre. The resulting estimates are of course average costs, however, not marginal costs. Where studies taking a marginal approach are available, they are compared with those from the rest of the literature. Every effort has been made to render explicit the conclusions as to the appropriate values to be retained for policy making.

3.1.3. Results

The total costs of the key transport externalities – accidents, noise, air pollution and climate change – are reviewed in turn. Uncovered infrastructure costs are also assessed. Based on the literature, two indicators are derived: *a)* estimates of total external costs in terms of percentage of GDP and *b)* shadow prices, in terms of ECU per unit of impact. From these, average unit costs are calculated, in terms of ECU per passenger- or tonne-kilometre, by apportioning costs among transport services.

This report does not cover all the external effects that could be identified. The reasons for omission vary. Some effects are not suitable for generalisation; an example is land-take, where the opportunity cost of land used for transport infrastructure is specific to each case. Others have been little researched, either because they are likely to be relatively minor effects (*e.g.* animal deaths) or because their valuation poses significant problems (*e.g.* water pollution from road run-off). Research is expanding, however, and understanding of these little-studied effects is likely to improve markedly. While their omission means evaluation of transport impacts will be incomplete, the effects that are covered represent a large proportion of the damage from transport. Factoring them into transport markets should be a significant step towards achieving more efficient and sustainable patterns of supply and demand for transport services.

3.2. ACCIDENTS

Many studies have been undertaken on the valuation of accidents and many governments have adopted official estimates for the cost of traffic accident fatalities. In deriving cost estimates, a crucial choice is whether to include non-material damage such as the intrinsic value of a life lost and the suffering that results for friends and relatives. A number of official government estimates include non-material damage, but the majority do not. Putting a price on life is a sensitive issue, but such a price may be approximated as what society is willing to pay to save lives. Estimates for non-material damage based on stated preference evaluations for risk avoidance are the basis for evaluating accident costs in this report.

Non-material and most material damage costs can be assumed to be constant, regardless of the number of accidents (the statistical value of life applied to the first accident is identical to that applied to the thousandth accident). Thus marginal accident costs are taken to be equal to average accident costs.

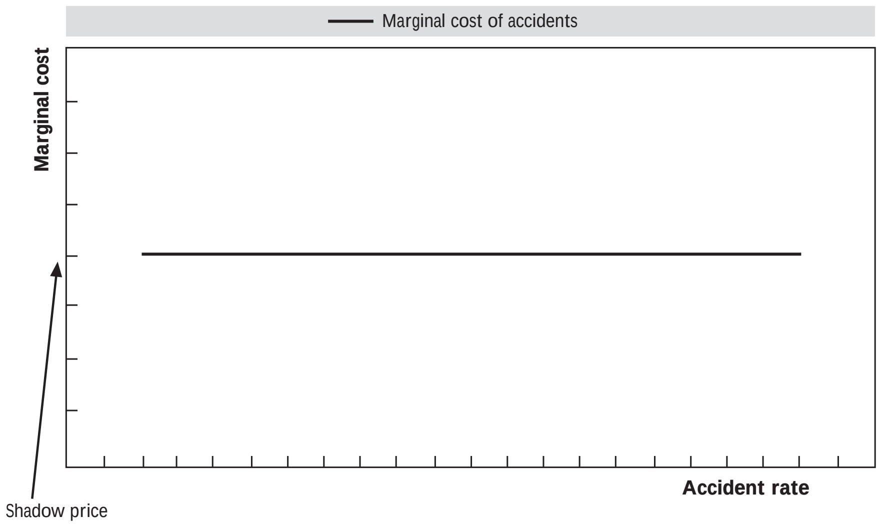
The analysis presented in Annex B yields shadow prices of, on average, ECU 1.5 million per fatality (and ECU 0.2 million per serious injury). Though somewhat below the average statistical value of life derived by the most thorough theoretical work (ECU 2.5 million) this figure was retained as it is in line with the official values adopted in the five European countries where non-material damage is included in costs.

Total road and rail accident costs are estimated to account for 2.5% of GDP in Europe, with 99% of the costs attributable to road accidents. Specific costs were calculated by distributing total costs country by country between modes and services.

Table 4. **Specific accident costs**

Cars	ECU 33/1 000 p-km
Passenger rail	ECU 3/1 000 p-km
Road freight	ECU 21/1 000 t-km
Rail freight	ECU 1/1 000 t-km

◆ Figure 6.***Graphic representation of assumptions regarding accident costs***



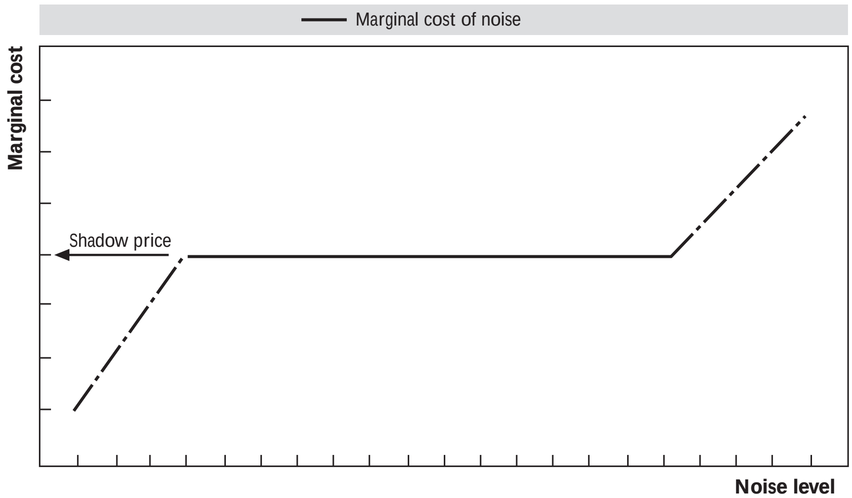
Source: ECMT Task Force.

3.3. NOISE

Most studies of transport noise measure the nuisance from road traffic only. Estimates of the external costs of road noise retained from the literature reviewed range from 0.06 to 0.75% of GDP, with a mean value of 0.3% of GDP. Most estimates of the cost of noise nuisance are based on the revealed preference approach, measuring the reduction in market value of housing exposed to noise compared with similar housing in quieter areas. Other studies, based on stated preferences, yield estimates generally towards the upper end of the range. Studies of prevention costs, based on expenditure on programmes to reduce noise impact, generally yield estimates at the lower end of the range (see Annex B, as well as the discussion of appropriate evaluation techniques in Annex A). Research by the Frauenhofer Institute in Karlsruhe, concluding that road traffic accounts for 64% of total transport noise, rail traffic 10% and air traffic 26%, would suggest that total transport noise nuisance costs might represent close to 0.5% of GDP.

The limited evidence available on the marginal costs of noise suggests that, for moderate noise levels, the valuation of noise costs is little affected by absolute noise level. The calculations made in this report assume marginal noise costs equate to average costs. These were estimated to be ECU 21 per year per dB(A) per person exposed (this estimate is not likely to be relevant for assessment of exposure to extreme levels of traffic noise; see Figure 7). The shadow price was used to calculate total costs on the basis of data on the number of people exposed to different levels of traffic noise in a selection of countries in Europe. The calculation is highly sensitive to the noise threshold assumed below which no damage is recorded. A threshold slightly over 55 dB(A) would produce a result that coincides with the average total road noise cost estimate from the literature of 0.3% of GDP (estimates in the literature surveyed were based on thresholds of 55 dB and over).

◆ Figure 7.***Graphic representation of assumptions regarding noise costs***



Source: ECMT Task Force.

Unit costs were derived as follows by distributing total costs among sources of noise :

Table 5. **Specific noise costs**

Cars	ECU 3/1 000 p-km
Passenger Rail	ECU 11/1 000 p-km
Road freight	ECU 8/1 000 t-km
Rail freight	ECU 16/1 000 t-km

3.4. AIR POLLUTION

The cost estimates surveyed for air pollution show a broad range. This reflects in part the complexity of the valuation of damage costs, which must link emissions to impacts through models of dispersion, ambient concentration and dose-response relations; in addition, financial valuations must be attached to impacts. Utility valuation techniques (stated or revealed preference) are of limited use for assessing air pollution. Pollution is too dispersed to be reflected in property values and few people sufficiently understand the chemistry and dose-response relations involved to make informed statements of preference.

In all the damage cost estimates reviewed, the authors cautioned that they were unable to cover all the effects relevant to the total costs of air pollution. The damage cost estimates reviewed place the cost of air pollution at 0.25-1.1% of GDP (one study lay outside this range at 0.03-0.11%). Studies of prevention costs (i.e. the costs of meeting predetermined emissions targets) yield estimates in a similar range. The few examples of utility valuations examined provide estimates from the upper end of the range of damage cost estimates, up to 3% of GDP.

The damage and prevention cost estimates, 0.25-1.1% of GDP with a mean value of 0.6%, were retained for deriving shadow prices and unit values. An average shadow price for pollution from NO_x and VOCs together was calculated at ECU 4-6 per kg emitted on the basis of avoidance cost estimates, calibrated with average damage cost estimates. For emissions of particulates a shadow price of ECU 70 per kilogram of PM_{10} was retained on the basis of prevention costs to meet fuel quality and emissions limit proposals made by the European Commission in June 1996.[1] This figure is applied to emissions in urban areas, with a shadow price of zero for emissions of particulars in rural areas.

None of the primary studies reviewed attempted to define marginal cost curves. Analysis of data on costs related to emissions of particulate matter as a proxy for overall air pollution, however, provided a linear marginal cost function over a limited range of emissions levels of ECU 15 per year per person exposed per μgm^{-3} fall in ambient PM_{10} concentration.

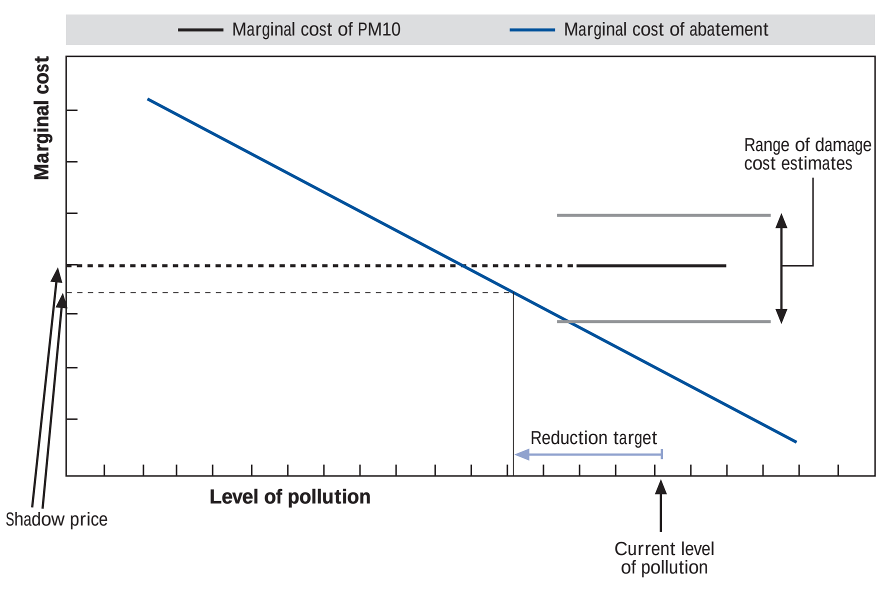
Unit costs were derived from the shadow prices for NO_x and VOCs and particulates by multiplying the shadow price by characteristic emissions factors (see Annex B) as follows:

Table 6. **Specific air pollution costs**

Gasoline cars	ECU 7/1 000 p-km
Diesel cars	ECU 5/1 000 p-km
Trucks	ECU 20/1 000 t-km
Road freight average	ECU 23/1 000 t-km

For rail, INFRAS/IWW (1995) calculated ECU 0.6-3.5 / 1 000 p-km and 0.2-1.2 / 1 000 t-km on the basis of similar shadow prices, UCPTE data on power generation, OECD data on emissions characteristics and ECMT statistics on rail freight and passenger traffic, using their own assumptions as to the ratio of diesel to electric locomotives in use.

◆ Figure 8.***Graphic representation of data on the costs of air pollution***



Source: ECMT Task Force.

3.5. CLIMATE CHANGE

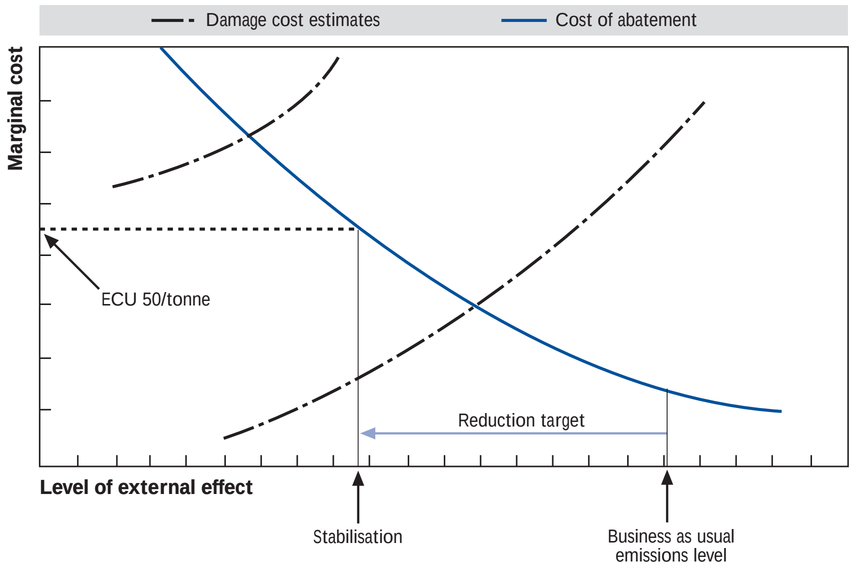
CO_2 is the main greenhouse gas emitted by the transport sector. It is difficult to predict what CO_2 emissions from fossil fuel combustion will actually do to climate, as there may well be multiplier or contrary effects still insufficiently understood, and the significance of CO_2 emissions in comparison to other forces driving climate change remains unclear. Many scientists agree that the major consequences of climate change would be changes in precipitation, adverse effects on agriculture through desertification and aridification, an increase in extreme meteorological conditions, such as cyclones, and a rise in sea level. Most damage estimates have been made for the US economy and involve a benchmark of a doubling of pre-industrial-era atmospheric CO_2 concentrations. The results mostly suggest damage amounting to around 1-2% of GDP. Assuming that on average in OECD countries transport is currently responsible for 30% of CO_2 emissions from fossil fuel combustion, transport emissions might imply damage of around 0.3 to 0.6% of GDP.

Aggregate estimates of damage for the world economy lie close to the estimates for the US due to the weight of GDP in the developed economies in comparison with the economic output of other countries. Obvious ethical concerns arise because many poorer countries stand to suffer heavily, with estimates of up to 8 or 9% of GDP in parts of South Asia and Africa.

There are two principal problems in moving from total damage estimates to a shadow value. First, since the expected damage will occur many years in the future, the choice of discount rate is crucial to the final result. Second, average and marginal damage is not likely to be the same – the severity of total damage may rise exponentially with the increase in greenhouse gas concentrations. Estimates from the studies surveyed that have attempted to calculate the marginal damage from CO_2 emissions, either at the current level of emissions or at some future optimum level, average ECU 2-11 / tonne of CO_2.

These studies tend to be conservative in the face of uncertainty, an effect compounded by the fact that some low probability scenarios of catastrophic damage are commonly ignored and in each study there are several omissions in the categories of damage considered. The precautionary principle would favour using an approach that poses a risk of abating too much rather than too little. This indeed seems

◆ Figure 9. ***Graphic representation of the costs of CO_2 emissions***



Source: ECMT Task Force.

to be the approach adopted by European governments: countries are committed in the medium term to reductions in CO_2 emissions below a future business-as-usual baseline. The marginal cost of meeting the European Union's target at the time of writing (stabilisation at 1990 emissions levels[2]) is estimated at ECU 50 per tonne of CO_2 (ECU 184 per tonne of carbon) for measures implemented within the Union. In this report, ECU 50 per tonne is taken to represent the shadow price of emissions because of the problems noted for damage cost estimates and because this figure is consistent with current government policies. (Meeting the target proposed by EU Environment Ministers in 1997 – an overall cut of 15% in emissions by 2010 – would roughly double this shadow price.)

Based on a shadow price of ECU 50 per tonne and on average emissions coefficients for road and rail services, specific costs for CO_2 emissions were calculated as shown in Table 7:

Table 7. **Specific climate change costs**

Cars	ECU 6/1 000 p-km
Road freight	ECU 10/1 000 t-km
Rail	ECU 3/1 000 p-km
	ECU 1.1/1 000 t-km

3.6. INFRASTRUCTURE AND CONGESTION COSTS

Although infrastructure costs are not external in the same sense as environmental or accident effects, relating infrastructure pricing more closely to the structure of costs could increase the efficiency of infrastructure provision and use. Uncovered infrastructure costs distort intermodal competition and can have a significant bearing on the effectiveness of use-charges introduced for the internalisation of environmental and accident costs. The policy options discussed in Chapter 4 take a comprehensive view and incorporate infrastructure costs into the analysis.

A broad definition of infrastructure costs is used, including not only costs of maintenance and investment in expanded capacity but also costs of policing, administration and traffic management. Cost estimates are based mainly on data for annual expenditure with a correction factor introduced to account for the difference between annual cash flow and economic value in terms of opportunity cost, making allowance for depreciation (see Annex C for details). On the revenue side, road and vehicle taxes, fuel taxes and tolls are treated as hypothecated (including in countries where treasury policy does not allow for earmarking). For rail services, revenues related to public service obligations are added to income from ticket sales.

Uncovered rail and road infrastructure costs amount to an estimated 0.15% of GDP in the countries of the EU plus Switzerland and Norway; 95% are accounted for by railways, amounting to some ECU 8 billion per year. Table 8 summarises average European costs per kilometre. For roads, assigning

Table 8. **Specific infrastructure costs for road and rail transport**

	Road		Rail	
	Passenger ECU/1 000 p-km	Freight ECU/1 000 t-km	Passenger ECU/1 000 p-km	Freight ECU/1 000 t-km
LRMC	25	35	40	40
SRMC	12	14	20	20
Uncovered costs	–4	8	12	23

Source: ECMT Task Force estimates.

costs between users is rather uncertain. The work of INFRAS/IWW (see Annex C) suggests that there are cross-subsidies between cars and freight in many countries but that overall, and for Europe as a whole, road related revenues and long term costs are roughly in balance.

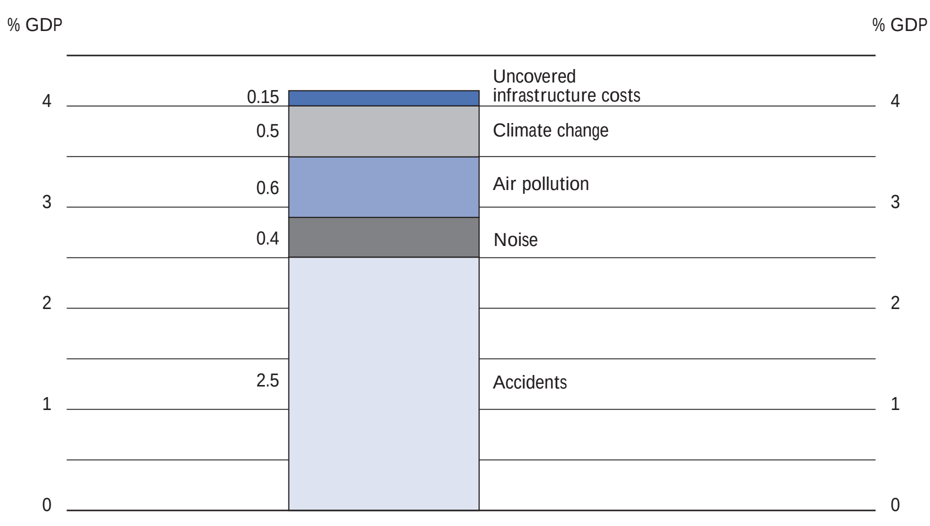
From a policy point of view, short-run marginal costs (SRMC) are of interest as they represent the lower bound for the infrastructure costs that should be covered by use-charges. It is important to distinguish between infrastructure with congestion problems and infrastructure with spare capacity. Efficient pricing requires that long-run marginal social costs – including future discounted capacity costs – should be charged for users of congested infrastructure. When capacity is far from fully utilised and capacity costs are zero, however, only short-run marginal costs should be charged.

This report treats congestion as a localised, mainly urban phenomenon, as is thought to be the situation in the majority of ECMT Member countries.[3] Congestion charges are recommended as a means of addressing chronic congestion, compensated by an equivalent reduction in fixed infrastructure charges. As the net change in charges is zero, converting estimates of total congestion costs into specific charges is not necessary here.

3.7. SUMMARY OF EUROPEAN AVERAGE ESTIMATES OF EXTERNAL COSTS OF TRANSPORT

Figures 1 and 10 and the following tables summarise the data presented in this chapter and used in later chapters as the basis for policy options. Figure 10 summarises estimates for the total external costs of road and rail transport. These are averages of the estimates examined. The data do not permit the calculation of confidence intervals.

◆ Figure 10. ***Average estimates of total external costs of road and rail transport***



Source: ECMT Task Force.

Table 9. **Unit costs for external effects**

Accidents	ECU 1.5 million per fatality. ECU 0.2 million per serious injury (ECU 0.03 million per injury).
Noise	ECU 21 per dB (A) per person exposed, 55 dB(A) threshold.
Air pollution	ECU 15 per year per person per μgm^{-3} ambient PM_{10} concentration, as a proxy for all pollution; or ECU 5 per kg NO_x plus ECU 5 per kg VOCs emitted, plus, in cities, ECU 70 per kg of particulates emitted.
Climate change	ECU 50 per tonne CO_2 emitted.

Source: ECMT Task Force estimates.

Table 10. **Specific costs for road transport**

ECU/1 000 v-km	Cars	Freight
Accidents	60	60
Noise	5	23
Air pollution	13	66
Climate change	10	28
Uncovered infrastructure costs	–7	23

Source: ECMT Task Force estimates.

Table 11. **Specific costs for roads and railways**

	ECU/1 000 p-km		ECU/1 000 t-km	
	Cars	Rail	Road Freight Average	Rail
Accidents	33	3	21	1
Noise	3	4	8	6
Air pollution	7	2	23	1
Climate change	6	3	10	1
Uncovered infrastructure costs	–4	12	8	23

Source: ECMT Task Force estimates.

NOTES

1. These proposals have since been reviewed and made more strict, but had not been approved in Council at the time of writing.
2. The Third Conference of the Parties under the UN Framework Convention on Climate Change tightened the target to a reduction in emissions of 8% in relation to 1990 by 2008-12.
3. The extent and cost of congestion in Europe was the subject of ECMT Round Table 109 in March 1998, forthcoming.

Chapter 4

POLICY OPTIONS

TABLE OF CONTENTS

4.1. FROM EXTERNAL COSTS TOWARDS POLICY

4.1.1. Introduction

This chapter discusses policy proposals which can come close to achieving internalisation of transport externalities. The starting points are Chapters 2 and 3. Chapter 2 clarified the aims of internalisation: if those who decide to make a trip or transport goods are confronted with all the consequences of their decision, the result will be efficient decisions and a fair allocation of costs. Chapter 3 discussed the current level of transport externalities, expressed in money value. Here, these values are used to set priorities for the choice of policy instruments and, where price incentives are considered as a policy response, to indicate charge levels.

Internalisation is *not,* as so often assumed, a synonym for pricing policy. In theory, setting correct prices might generate the desired result, but the practice is less simple, for two main reasons. First, only if the market mechanism is perfect are prices ''ideal'' instruments; as this is seldom the case, other policy instruments might be preferred. Second, the ''perfect'' price instrument is often not available in practice, so second – and third – best instruments are used. Moreover, undesired side effects may need to be corrected with supplementary policy instruments, which usually are not price incentives.

For these reasons, all types of policy instruments will be considered for internalisation policy. Section 4.1.2 presents an overview of the main categories of policy instruments to be used in environmental and transport policy. Section 4.1.3 reviews the main criteria for the selection of policy instruments. Both sections provide the background for the rest of the chapter.

Because the externalities of road transport are relatively high and the choice of related policy instruments is complicated, more space is given to road transport than to other modes. Section 4.2. discusses the pros and cons of available policy instruments by cost item and goes on to develop an integrated approach for packages of instruments for internalisation. Sections 4.3-5 cover rail, water and air transport.

4.1.2. Overview of policy instruments

Below are descriptions of the main categories of policy instruments which might be used for internalisation.

Communication

Communication is used in both environmental and transport policy to influence individual behaviour. Traffic signals are a very common example. Driver education also belongs to this category. A distinction can be made between education, information and awareness raising, all of which fall in this area.

Government regulation

The ''command and control'' type of instrument is commonly used in environmental policy. Governments can set rules, prescribe or prohibit behaviour and require certain activities to be licensed. Vehicle emissions and safety standards belong to this category. Traffic management and infrastructure policy can also be regarded as direct government intervention.

Voluntary agreements

Voluntary agreements (*e.g.* on environmental issues) can be made between governments and branches of industry. A given industry might commit itself to reduce its pollution, for example, while the government agrees to abstain to some extent from direct intervention in the industry's operations. This type of agreement can be used to encourage improved fuel efficiency of new vehicles, for instance.

Economic instruments

Economic instruments, used to influence behaviour, can be divided into: *a)* market creation; *b)* subsidies; and *c)* taxes and charges. Systems of tradable emissions permits and the privatisation of infrastructure are examples of market creation. Such measures expand the scope of market mechanisms and thus, in theory, generate proper prices. Subsidies are commonly used for public transport but are also applied to the development and implementation of clean technology. Examples of taxes and charges (pricing policy) in the transport sector include fuel and vehicle taxes, the Eurovignette[1] and airport and harbour fees.

4.1.3. Criteria for selecting policy instruments

A number of criteria are relevant for the selection of policy instruments to internalise transport externalities and meet the overall goal of achieving an economically efficient outcome. There exists a large body of scientific literature on criteria for the choice of policy instruments, which it is beyond the scope of this report to discuss in detail. The 1996 European Commission green paper, "Towards Fair and Efficient Pricing in Transport", presents a short overview. The following sections are based on that overview, with the addition of three further criteria: enforcement, implementation period and legal obstacles.

Effectiveness

Clearly, any policy instrument should achieve its intended objectives: here, the internalisation of transport externalities. Hence, instruments should create a situation in which users of transport facilities are confronted with all the consequences of their decisions.

Cost-effectiveness

Another key criterion is that an instrument should reach a predefined target at least cost, including administrative and transaction costs. To give an example with respect to air pollution charges: a charge on vehicle emissions measured during travel would be the most effective, but in-use emissions measurements are so expensive that this option is not cost-effective.

Distributional equity

Considerations of fairness should play a major role in devising policies. Approaches such as the user pays and polluter pays principles are widely accepted. Additional policy measures are sometimes needed to correct unintended and undesired distributional effects of environmental policy. Of particular interest is the distribution of costs and benefits of transport among countries. The approach generally regarded as fairest is that the country which bears the costs of traffic should be compensated by the charge revenues.

Transparency

To ensure that intervention is justified, understood and accepted, it is important for measures to be transparent to the public. Simple instruments should be favoured. A cumulation of different policy instruments does not generally lend itself to transparency. Furthermore, it is important for the use of the revenues also to be transparent.

Side effects

Certain policy instruments can have unintended side effects, both positive and negative. An example is the distributional effects of taxes.

Enforcement

It is important for measures to be both enforceable and enforced. A well known problem in this respect is the difficulty in enforcing speed limits for road traffic. The enforcement criterion goes hand in hand with the effectiveness criterion. A speed limit, or any other measure, that cannot be enforced sufficiently will not be effective in achieving its stated goals.

Implementation period

Another criterion involves the length of time needed for implementation of a policy instrument. General road pricing, for instance, may be an effective instrument, but its implementation is probably feasible only in the long run, so other policy instruments are likely to be needed in the meantime.

Legal obstacles

Ideally, policy instruments should be acceptable under current law. It is of course possible to change current law if it conflicts with the introduction of an attractive policy instrument, but in most cases this will not be easy.

Note that the criteria can conflict somewhat and do not always point in the same policy directions. Choices should be made and priorities set.

4.2. ROAD TRANSPORT

4.2.1. Instruments by cost component

The following section discusses the advantages and disadvantages of available policy instruments for each separate type of transport externality, or cost component. All the types of policy instruments discussed in section 4.1.2 may be considered, but for practicality's sake the discussion will be limited to the most promising policy instruments for each component.

Table 12. **Policy instruments, by cost component**

Infrastructure	Use-charges[1] Fixed charges
Congestion	Congestion charges (= specific urban use-charges) Traffic management
Accidents	Road safety policy (standards, traffic management, education) Risk related insurance premiums or charges (= specific use-charges)
Climate change	Fuel charges (= specific use-charges)
Air pollution	Standards (vehicle, fuel) Specific urban policy (*e.g.* parking policy, restricted access) Traffic management (*e.g.* speed limits) Use-charges
Noise nuisance	Standards Specific urban policy Use-charges

1. In this report, "use charges" are all types of charges related directly to the actual use of a vehicle. Use-charges are variable charges, while vehicle and sales taxes are fixed charges.

Source: ECMT Task Force.

The aim of an internalisation policy for road transport is to confront drivers as directly as possible with all the effects they generate with each trip. That is why the different factors determining these external costs are distinguished: the ideal mix of policy instruments creates a proper incentive for each different factor. The magnitude of the externality also has some influence on the mix of instrument. It is more important to internalise large externalities than to reduce relatively small ones.

4.2.2. Infrastructure and congestion

Infrastructure costs

In this report infrastructure costs are considered in a broad sense: not only road investments and maintenance costs, but also costs for traffic police, judicial costs, traffic management costs and administrative costs.

Price incentives

The main policy instruments for internalisation of infrastructure costs involve proper pricing. Because roads are built to be used, it does not make sense to discourage or prevent traffic flows through communication or direct government intervention. When congestion exists, however, drivers might be persuaded through capacity management to change to uncongested periods or to other modes.

Efficient pricing in uncongested circumstances

To achieve economic efficiency, the level of use-charges for uncongested roads should correspond closely with marginal infrastructure costs – *i.e.* the road user should pay, for every part of a trip, the additional costs incurred. On average, roughly half of infrastructure costs relate directly to actual use of the road. The level of use-charges should be set accordingly – to reflect the actual costs of use.

The other half of infrastructure costs can be considered fixed and not dependent on road use. The interest on invested capital, for instance, has to be paid whether the road is used or not. It is not efficient to make road users pay for fixed costs via use-charges. To achieve full coverage of infrastructure costs it is better to use fixed charges or a lump sum charge such as a vehicle tax. A fixed charge can be regarded as a ticket to enter the road network.

Thus, in general, a combination of use-charges and fixed charges is needed to achieve both economic efficiency and a fair allocation of costs. In most countries the split between use-charges and fixed charges does not reflect the ratio between the two types of costs. The level of use-charges generally is too low and does not cover marginal infrastructure costs. Conversely, the level of fixed charges is often too high, at least where road traffic pays fully for infrastructure costs. A shift away from fixed charges towards use-charges is generally required. Such a shift, often called variabilisation, will increase the efficiency of use of the available road infrastructure.

Efficient pricing in congested circumstances

The arguments presented above are for uncongested roads. In many urban areas of Europe, however, congestion has become a structural phenomenon. Congestion requires an even stronger emphasis on use-charges, because each extra trip results not only in additional infrastructure costs, but also in time losses for other road users. Efficient pricing means incorporating these congestion costs in the use-charges to achieve efficient use of the road capacity. On the other hand, congestion is not an argument for making road users pay more than the full infrastructure costs, so congestion pricing should be combined with a reduction of fixed charges. It might be efficient in congested areas to abolish fixed charges totally and make road users pay the full infrastructure costs via use-charges. While this would result in substantially higher use-charges than are currently applied, the total tax burden on road traffic would not increase.

Use-charges

Several policy instruments in the category of use-charges are currently employed for road traffic and additional instruments might become available in the near future. The options discussed here are:

- general road pricing;
- urban road pricing;
- variable tolls;
- electronic km-tax for HGVs;
- fuel taxes.

The extra infrastructure and congestion costs caused by a trip depend on (among other factors): *a)* road type, including geographical circumstances (*e.g.* soil, terrain, climate); *b)* vehicle type (*e.g.* weight, number of axles); *c)* distance driven; and *d)* level of congestion. The ideal policy instrument allows tariffs to be differentiated according to these four factors.

General road pricing

A system of electronic road pricing covering all roads would come very close to being the perfect policy instrument. The number of kilometres driven on each road type would be registered and the tariff per kilometre could differ by road type, vehicle type and degree of congestion. The revenues could easily be allocated to the owners of the infrastructure (*e.g.* countries and municipalities).

The introduction of electronic road pricing would require both a technological and an administrative effort. Two different technical routes are now being explored. The first uses a roadside electronic beacon which communicates with a receiver in the passing vehicle. With a specific price per kilometre for that section of the road network and time of day, a bill for use of the road can be calculated. At present it would be too expensive to introduce a system based on roadside beacons for the entire road network. A variation on this idea involving an odometer in the vehicle, requiring fewer beacons, might be more promising.

A second system uses satellite signals rather than roadside beacons to determine the geographical position of a vehicle. Called the Global Positioning System (GPS), it is used for ship navigation and in international truck fleet management. GPS is not yet accurate enough to determine exactly on which road a vehicle is driving. Further technical improvements would be needed before GPS could be used for general road pricing.

An important advantage of a GPS based electronic road pricing system is that it would not require expensive roadside beacons. GPS signals combined with an odometer in the vehicle would enable registration of kilometres driven on each road segment, each with a specific price.

Besides the development of registration techniques, electronic road pricing requires an efficient billing system. Rather than sending all road users a monthly invoice, payment could be made directly from the vehicle with a prepaid card. For each beacon passed or kilometre driven, a set amount of credit would be subtracted from the value of the card. At gasoline stations or other sites the card could be recredited. Drivers without sufficient credit on their cards would be detected (preferably electronically) and fined.

It is important to ensure that the technique used for road pricing allows for international interoperability so that vehicles crossing borders would need only to be equipped with one monitoring system and costs could be minimised. Interoperability will require the setting of international technical standards.

Because of the technological developments required, general electronic road pricing is a long run option. Existing international agreements related to the Eurovignette, and perhaps also to vehicle taxes, would need some adjustment to allow for a gradual introduction of road pricing.

Once these issues were resolved, stepwise implementation could start; the urban road pricing proposal and an electronic km-tax for HGVs, discussed below, could be the first steps.

A related issue is whether all roads should be subject to road pricing, or only main roads. Installing electronic equipment alongside all roads could prove prohibitively expensive, yet if some roads are not included there would probably be an undesired shift from main roads to "free" local roads. Use-charges for the unpriced roads would have to be collected through other policy instruments, which would result in a combination of electronic road pricing on some roads and general use-charges for all roads. The advantage of such a combined approach is that the price difference between roads with and without road pricing could be relatively modest, reducing the incentive to shift to unpriced routes. Another advantage is that the costs of the system might be more acceptable.

Urban road pricing

As long as a general system of road pricing is not yet available, urban road pricing might be an attractive policy instrument. Part of the marginal costs of road traffic – such as congestion, air pollution and noise – are concentrated in urban areas, so higher use-charges are needed for urban areas than for rural ones. This would result in a combination of general use-charges based on the marginal cost of road traffic in rural areas, and urban road pricing reflecting the additional, specifically urban marginal costs. The main aim of higher urban use-charges would be to reduce congestion.

Most urban road pricing schemes envisage one or more corridor rings in or around the city and automatic payment equipment for each vehicle crossing any corridor ring. This system does not register distance driven, but approximates the distance roughly via the number of crossings. It is important for the tariff at each crossing to be variable from day to night and from workdays to weekends. If higher tariffs are set during peak congestion hours, it creates an incentive to make more efficient use of the road capacity and reduce time losses caused by congestion. It is also feasible to differentiate tariffs with respect to vehicle type (based on vehicle weight, number of axles and vehicle size). This makes it possible to set tariffs corresponding with marginal infrastructure and congestion costs for each vehicle type. On the other hand, with urban road pricing different tariffs cannot be set for different road types.

Urban road pricing is certainly less than perfect compared with general road pricing but it offers good opportunities for incentives that help in managing specific urban problems such as congestion. As urban road pricing by definition does not affect rural traffic, a combination of urban road pricing with other use-charges is needed, as outlined above. A potential disadvantage is that urban road pricing might result in a spatial shift of economic activities towards locations outside urban areas. However, congestion is already having this effect; a combination of reduced congestion and higher urban traffic charges might not increase this risk, on balance.

Variable tolls

The purpose of existing motorway tolls is usually to finance infrastructure investment. In some countries, variable tolls that aim to spread demand on heavily used sections have recently been introduced to manage congestion. This can be viewed as an early application of road pricing. Its impact on traffic should yield valuable information for the development of road pricing elsewhere.

Electronic km-tax for HGVs

Until such time as a general system of road pricing becomes available, an electronic km-tax for HGVs would have major advantages.[2] It would make it possible to charge HGVs by kilometres driven, with tariffs differing according to vehicle type. Charge rates would differ by vehicle weight and number of axles, and thus approach marginal infrastructure costs by vehicle type. Such close correspondence with marginal costs cannot be realised with fuel charges and is only partly reached with urban road pricing (only for urban traffic).

A km-tax for HGVs was applied in some Scandinavian countries and in Austria, but abolished prior to their EU accession. These were simple systems based on sealed odometers in trucks. The number of kilometres driven was registered during the trip (at border crossings, by customs officials) and the charge imposed later. There would be problems introducing such a system widely in Europe because of the very large number of border crossings involved.

New electronic systems could avoid such administrative problems at borders. With currently available GPS technology, a "black box" in each truck can give an electronic signal identifying the country the truck is driving in, and equipment within the truck can register the numbers of kilometres driven per country. The haulier could later be charged for each country according to the number of kilometres driven there. The tariff per kilometre would differ by truck type (weight, number of axles and environmental characteristics) and by country.

This system does not require international harmonisation of tariffs, leaving the determination of charge levels to national governments. With such an electronic km-tax for HGVs it might be possible to set special tariffs for environmentally sensitive corridors, *e.g.* through the Alps. Whether this is feasible depends on the accuracy of the GPS technology.

An electronic km-tax for HGVs is a very flexible policy instrument and could replace the Eurovignette, part of existing vehicle taxes and possibly special policy measures for sensitive corridors. An important advantage over policy instruments such as the Eurovignette and vehicle taxes is that the km-tax is a use-charge while the others are fixed charges. Furthermore, it would be very easy for new countries to join a system of electronic km-taxes, because no negations would be needed on the distribution of the revenues, unlike with the Eurovignette. Of course, effective enforcement and administration would be essential.

Fuel charges

Charges on fuel are now the most widespread use-charge for road traffic. Their main advantage is that they are easy and cheap to implement and enforce. Their main disadvantage is that fuel consumption is not perfectly related to marginal infrastructure costs. For cars and vans the link is acceptable, but for trucks it is poor (see *e.g.* Oftedal, 1993). It would improve the situation to combine fuel charges with an electronic km-tax for HGVs. Fuel charges will remain an element of use-charges at least until general road pricing is available (for possible combinations of use-charges, see Table 19).

Because fuel consumption and marginal infrastructure costs are only roughly correlated, it might be supposed that a vehicle tax is a better policy instrument for internalisation of marginal infrastructure costs. Yet a vehicle tax does not depend on distance driven and so is even less related to marginal infrastructure costs than is fuel consumption. The second-best policy is therefore to combine a fuel charge with a differentiated vehicle tax. The level of the fuel charge should correspond with the marginal infrastructure costs per litre of fuel for the average vehicle. The vehicle tax should reflect differences in marginal infrastructure costs by vehicle type, for the average distance driven. This combination gives incentives according to both mileage and vehicle type. No better approach is achievable in the absence of the new policy instruments discussed above.

Another drawback of fuel charges is that revenues do not necessarily go to the country where the driving is done. Indeed, in some border regions a substantial amount of "tank tourism" exists, providing a convincing argument for neighbouring countries to harmonise their fuel prices to some extent. The differential should be limited, say to ECU 0.20/litre. This is one reason to specify minimum excise duties for fuel in Europe.

Allocation of fuel charge revenues is even more important for trucks, which can cross half of Europe before having to refill their tanks; revenues from fuel charges might go to any country on the route. Transit countries have particular reason to fear that revenues from fuel charges will go to other countries. Although international transport is only a small part of total transport volume, the allocation issue is a strong argument for an electronic km-tax for HGVs, with driving distance registered in each country separately. It was this international distributional issue that resulted in the introduction of the Eurovignette. The disadvantage of the Eurovignette is that it is a fixed charge, not a use-charge like a km-tax. The Eurovignette could be fully replaced by an electronic km-tax for HGVs.

Fixed charges

The fixed charges currently most applied for road traffic are sales taxes, annual vehicle taxes and the Eurovignette. In general, these are good instruments with which to allocate fixed infrastructure costs. The main problem with sales and vehicle taxes is that they are levied in the country of registration or sale, which might not be where the vehicle is mainly used. With the introduction of the Eurovignette in five European countries, the allocation of revenues among countries has been somewhat improved.

4.2.3. Accidents

Accident costs

The large number of road accidents in Europe causes both financial and non-financial damage to the persons involved and their families and associates. The main effects are:

- hospital or other medical costs;
- lost production;
- material costs (*e.g.* vehicle repair);
- handling costs (police or fire services, legal administration, etc.);
- prevention costs (vehicle safety features, road design and surfacing, driver education, etc.);
- non-material damage (personal distress of victims, relatives and friends);
- individual death and injury.

A substantial part of these costs is internalised in most countries, directly or indirectly paid by those who cause the accidents. Material costs are generally covered by vehicle insurance or the owner directly. Prevention costs are paid either by the vehicle owner, or by the government as part of infrastructure costs. Medical costs are partly covered by insurance.

The remainder of the medical costs and the other cost components are considered external costs. These are currently not properly allocated to those causing the traffic accidents. A recent Dutch estimate (Muizelaar *et al.*, 1995) is that this external portion amounts to 15-25% of the total accident costs – excluding non-material damage.

Three types of policy instrument to deal with accidents are discussed below. All three aim at reducing the number of accidents, reducing costs per accident and fully covering accident costs. The first category falls under traditional road safety policy and includes safety standards, traffic management and driver education. The second instrument is vehicle insurance, which already internalises a large part of accident costs. Third, additional financial incentives are discussed.

Road safety policy

For years now, many governments at various levels have sought to bring down the number of road accidents, especially those producing fatalities and severe injuries. Many initiatives have been taken, and public and political awareness about road safety has long been high. This is not the place to discuss road safety policy in depth, but a few remarks can be made regarding internalisation of transport externalities.

Road safety policy involves many different instruments. Vehicle and road safety standards have reduced the numbers of accidents and fatalities substantially and will continue to be important. Traffic management – speed limits, speed control, traffic signals and guidance of traffic flows – also has an impact on road safety and the potential to reduce accident rates even further. Strict enforcement of speed limits on a Dutch motorway, for instance, reduced the number of accidents by 15-25%. Finally, driver education is historically a focal point of road safety policy. The combination of these policy instruments has achieved a dramatic improvement of road safety, especially in the number of fatalities, even as traffic volumes have grown. ECMT statistics show that the number of road trans-port fatalities per vehicle-kilometre was reduced by an average of 5% per year over 1970-94.

Making road users pay the costs of road safety policy – preferably in relation to the risks – it is an attractive way of internalising. The number of accidents and thus the externalities will probably be reduced in coming years, though an increase in costs per accidents could offset this decrease, as Dutch experience for 1983-93 shows: both total accident costs and external costs increased for the period, while the number of fatalities and injuries fell by 30% (Muizelaar *et al.*, 1995).

Other policy instruments are needed to achieve full internalisation, further reducing accident rates and confronting drivers with the social costs then remaining. Furthermore, it should be noted that road safety policy cannot generate incentives on all risk factors. Both yearly distance driven and the choice of ''risky'' *versus* ''safe'' roads determine accident risk to some extent, and are not influenced by traditional road safety policy; additional policy instruments are required to incorporate them.

Vehicle insurance and liability

Vehicle insurance covers most of the legal liability for accident costs, both material damage to others and some medical costs. Legal liability differs by country. One option for further internalisation is to increase the liability for accident costs. This would be straightforward for total medical costs, simply requiring legislation stating that vehicle insurance should cover all medical costs related to traffic accidents. Vehicle insurance premiums would rise, but premiums for health insurance should go down, along with government subsidies for health care. It would also seem feasible to expand liability to cover the costs incurred by public services as a result of traffic accidents. In Germany, for instance, drivers causing an accident are charged for police handling costs.

A further step might be to expand liability to cover social security costs – *e.g.* unemployment and disability payments, and widows' and orphans' pensions – would be covered by vehicle insurance, to the degree that they stem from traffic accidents. Some international harmonisation of social security legislation might be required, which would be harder to achieve.

Finally, liability might be expanded to loss of production related to fatalities, and to non-material damage. This would require leg islation fixing a sum per fatality, which would have to be paid through vehicle insurance coverage to the relatives and/or to the government. A potential disadvantage of increased liability is that the number of court cases and associated legal costs might rise dramatically, given the large sums that would be involved. Hence, a combination of expanded liability and general charges, to be discussed later, might be preferable.

Another issue with respect to vehicle insurance is the relationship of the premium level with the actual accident risk. To achieve both a fair allocation of costs and the best incentive to reduce accidents, the insurance premium should be linked as closely as possible to the degree of accident risk. The accident risk and the related costs depend on many factors, such as vehicle characteristics, road design, road type, driver characteristics, driving behaviour, vehicle speed, distance driven, traffic conditions and weather.

The ideal system for setting insurance premiums would incorporate all these factors. In practice, most insurance companies charge a fixed premium and a flexible surcharge related to the vehicle owner's accident history (the so-called *bonus/malus* or *malus* system). The premium also depends on vehicle type and economic value. Though this approach appears reasonable to the insurance companies, it does not produce adequate incentives on all risk factors. Just as some companies differentiate premiums geographically (*e.g.* urban *versus* rural), it would seem feasible to incorporate vehicle safety characteristics, etc., into a differentiated premium. Some legislation is probably needed to improve the system of premium setting for vehicle insurance so as to achieve proper incentives to reduce accidents. However, there would remain a risk of drivers not providing proper information so as to avoid paying higher premiums, thus limiting the degree to which the structure of the vehicle insurance premium could be improved.

It would likely be difficult to incorporate incentives into the insurance rates with respect to driving behaviour (*e.g.* speeding), road type and annual distance driven. Price incentives (discussed below) might also be desirable, and indeed might be required, to achieve full cost coverage. Finally, it should be noted that the fixed part of the insurance premium does not generate a proper incentive, because it is vehicle use, not vehicle ownership, that leads to accident risks.

Price incentives

The main price instruments available were discussed in the section on infrastructure costs. Now we consider their potential with respect to accident costs.

General road pricing would make it possible to differentiate tariffs for safe and unsafe roads, which might direct traffic towards safer routes. Furthermore, the distance component of accident risk could be integrated. Urban road pricing might include an accident surcharge for higher accident risks in urban areas. Both general and urban road pricing could be differentiated by vehicle type.

The electronic km-tax for HGVs offers an opportunity to include an accident charge, depending on distance driven and vehicle type, but only for HGVs.

Fuel charges have some link to the distance driven, to vehicle type and to driving behaviour (*e.g.* speeding or aggressive driving, both of which mean increased accident risks). Fuel charges probably have less potential to generate strong incentives to reduce traffic accidents than do road pricing and the electronic km-tax. On the other hand, they would be more effective in this respect than vehicle taxes or any other fixed taxes. So, if vehicle insurance does not cover full accident costs, and if a km-tax or road pricing is not available, fuel charges are a third-best option for allocating accident costs. At least they would enable some link to be established between the price incentive and the accident risk – whether related to speeding or other driving behaviour, or distance driven – and full cost coverage would be achieved. A fuel charge for accident costs could be combined with a differentiated vehicle tax to correct for differences in accident risk per vehicle type. Fuel charges have a disadvantage with respect to international distribution of the revenues, however, as discussed above.

Another possible price incentive mechanism is a tax or charge on the insurance premium. This would create an opportunity to achieve full cost coverage while avoiding some of the disadvantages of expanded liability discussed above. This approach, however, would widen the mismatch between price incentives and accident risk in the insurance premium structure. Probably a combination of the insurance premium (without specific taxes) and other use-charges would generate price incentives better related to accident risk than would the insurance premium combined with a specific tax or charge.

4.2.4. Climate change

Emissions

The enhanced greenhouse effect is mainly caused by emissions of CO_2, NO_x, CH_4 and CO. This report focuses only on CO_2 emissions from the transport sector. The amount of CO_2 emitted is directly related to the amount of fuel burned, per fuel type. Each litre of gasoline results in 2.34 g of CO_2. For diesel fuel and LPG the respective emissions factors are 2.62 g and 1.62 g. CO_2 emissions per vehicle depend mainly on: *a)* vehicle type; *b)* distance driven; *c)* speed; and *d)* driving style.

Fuel charges

Theoretically, fuel charges provide the optimal incentive to reduce CO_2 emissions from road traffic. Fuel savings result directly in a CO_2 emissions reduction. The savings can be achieved through technical improvements, changes in driving behaviour and reduced mobility. Assuming a ''price'' of ECU 50/tonne of CO_2 (Chapter 3 and Annex B), the corresponding fuel charges (per litre) are as shown in Table 13.

Table 13. **Fuel Charges per litre for CO_2**

Gasoline	ECU 0.12
Diesel	ECU 0.13
LPG	ECU 0.08

These levels are rather low relative to existing excise duties in most countries; hence, no other policy instruments need be considered for this effect. If the total level of fuel charges were to become unacceptably high, *e.g.* related to the international distribution of the revenues, it would be more appropriate to search for other instruments to incorporate infrastructure and accident costs rather than climate change costs.

Government regulation

If a CO_2 fuel charge generates insufficient incentive for industry and consumers to develop and buy fuel-efficient vehicles, it might be well to consider a differentiated vehicle tax related to specific CO_2 emissions, and/or fuel efficiency standards (such as a more flexible version of the corporate average fuel efficiency or CAFE standards applied in the US). Any such regulations should be additional to fuel charges and not replace them but annual vehicle taxes would need adjusting to avoid double charging.

4.2.5. Air pollution

Emissions and impact

Air pollution refers to several forms of environmental impact. The emphasis in this report is on human health effects from particulates, ground level ozone (mainly from NO_x and VOCs) and acidification (mainly from NO_x and SO_2). It is important to distinguish between emissions in urban and rural areas, as emissions generally have a stronger impact in urban areas.

Standards

Fuel quality standards and vehicle emissions standards constitute the main policy instrument to reduce air pollution from road traffic. This type of direct government regulation, which forced the introduction of catalytic converters on gasoline cars, has been very effective in recent years. Specific emissions have been reduced by around 80%. The EU is expected to tighten its emissions standards, with a further reduction in air pollution as a consequence. To illustrate, Table 14 compares the 1994 fleet average emissions factors for NO_x and VOCs in the Netherlands with those expected for new vehicles in 2000. (The penetration of catalytic converters was around 50% in 1994; the proportion varies by country.)

Table 14. **Dutch fleet average emissions factors for NO_x and VOCs, 1994 and expected for 2000**

(g/v-km)

	Fleet average, 1994	New vehicles, 2000
Gasoline car	2.6	0.35
Diesel car	0.9	0.5
LPG car	1.6	0.35
Diesel van	1.4	0.8
Diesel truck	18	8

Source: CBS Statistics (1994) and CE estimates (2000).

As Table 14 indicates, the amount of air pollution per vehicle-kilometre will likely be reduced drastically in the coming decade. Even further reduction is technically feasible, but would require stricter emissions standards than those currently foreseen in the EU. Challenging standards form an effective way to force technical improvements.

Standards for vehicle emissions and fuel quality also constitute an effective internalisation instrument. They make vehicle owners and fuel users pay for their cleaner fuels and vehicles, and reduce the environmental damage caused to others. The economic value of the remaining emissions will be rather low. Using the values for air pollution from Annex B (ECU 5/kg of NO_x and VOCs; ECU 70/kg of particulates[3] emitted in cities) the corresponding fuel charges per litre are as shown in Table 15.

Table 15. **Fuel charges per litre for air pollution**

Gasoline car	ECU 0.02
Diesel car	ECU 0.06
LPG car	ECU 0.02
Diesel van	ECU 0.08
Diesel truck	ECU 0.14

These data are presented only to give an impression of magnitude; the intent is not to suggest that fuel charges are the best policy instrument to cover the remaining costs of air pollution (see discussion hereafter).

Traffic management

Traffic management can also help reduce air pollution. The main approach is to set and enforce proper speed limits, but road design (traffic calming measures) can also help. Lower speeds and more even traffic flow will reduce the level of NO_x emissions (which generally increase with engine temperature).

Price incentives

The ideal way to internalise remaining air pollution costs, as a complement to tighter standards, is to measure actual emissions in use and charge the driver accordingly. However, this method is still too costly. To identify second-best price incentives, it is necessary to distinguish the main influences on emissions levels:

- vehicle type, including engine characteristics and fuel evaporation;
- fuel quality;
- engine temperature (cold: low NO_x, high VOCs; hot: high NO_x, low VOCs) and driving behaviour;
- distance driven.

A use-charge, differentiated by vehicle type, would be a reasonable approximation of the perfect price incentive. It could be applied through a system of general road pricing or an electronic km-tax for HGVs. If these policy instruments are not available, the remaining option is to incorporate driving distance through a fuel charge whose level should correspond with emissions per litre for the average vehicle. Furthermore, a differentiated vehicle tax should complement this fuel charge, with the differentiation based on annual emissions for the average distance driven by a given vehicle type. This combination is only a third-best approach, but is better than using the vehicle tax without any form of use-charge (which would enable full cost coverage but would not generate a proper incentive on driving distance). It should be noted, however, that technical improvements to vehicles will result in much lower emissions in the future and the corresponding air pollution component of a fuel charge would be rather small.

Policy instruments for urban areas

It is important to note that urban emissions have a greater impact on the environment and on human health than do the same emissions in rural areas. First, more people are exposed in cities;

second, the concentration of pollutants in the air is higher in urban areas, and the impact often rises more than proportionately to the concentration of emissions. Hence, the values attached to some pollutants ought to be higher in urban areas than in rural ones. Accordingly, the ''price'' per kilogram of (for instance) NO_x emitted in cities is ECU 8, or twice the level in rural areas. Furthermore, for particulates only an urban price is estimated: ECU 70/kg (in rural areas the price is assumed to be zero).

Specifically urban forms of air pollution can be internalised only through urban policy instruments. Urban road pricing is discussed in section 4.2.2. Cities might also be allowed to set emissions standards that are stricter than the general standards, requiring (for instance) use of so-called ''city diesel''; another option is allowing only cleaner vehicles in the city centre. The stricter standards should ideally correspond with general standards to come into force in the near future, so as to avoid a proliferation of different standards. Another possibility is to tighten general emissions standards for vehicles driven mainly in urban areas, such as vans.

4.2.6. Noise

Impact

Traffic noise can have a negative impact on human health and cause nuisance to individuals, resulting in consequences such as reduced property values in noisy areas or lower perceived attractiveness of recreational areas affected by noise nuisance.

Government regulation

Several forms of direct government intervention can reduce noise nuisance. One is setting proper vehicle emissions standards. Measures affecting roads can also be taken, such as ''quiet'' road surfacing, noise screens and road systems designed to maintain constant traffic flow. Traffic management can reduce noise nuisance, too: constant traffic flow and lower speeds both result in lower noise levels. Another option is to create bypasses around noise-sensitive areas such as city centres.

Price incentives

The above options, however, will not reduce noise nuisance to the optimum and therefore will not result in full internalisation. Price incentives will need to be used as well. To discuss different price incentives it is useful to distinguish the main factors influencing the magnitude of noise nuisance:

- vehicle type;
- speed;
- driving behaviour;
- driving distance;
- time of day;
- surroundings;
- road type and construction;
- traffic flow and intensity.

General road pricing can generate incentives on many of these factors. Speed and driving behaviour are probably exceptions, but fuel charges will have at least some correlation with these two factors. If general road pricing is not introduced, second- or third-best price incentives will be needed. The electronic km-tax for HGVs can be differentiated by vehicle type and driving distance. For cars and vans a combination of fuel charges and a differentiated vehicle tax can be used (see section 4.2.5 for details). This combination can also be applied to trucks if a km-tax is not introduced.

Urban policy instruments

Once again, a distinction needs to be made between urban and rural areas, as noise nuisance from road traffic is concentrated in urban areas. Following the assumption in Kågeson (1993), the economic value of noise emissions in rural areas may be half the average, and in urban areas it may be 2.5 times the average; hence it is essential to concentrate the internalisation policy on urban areas. One possibility is allowing only quieter vehicles in cities, especially at night. Local traffic management can also diminish urban noise nuisance. And urban road pricing can incorporate the extra nuisance that noise poses in urban areas, relative to rural areas.

4.2.7. Other costs

Sections 4.2.2-6 do not cover all the costs generated by road traffic. The main externalities not dealt with in this report are:

- visual intrusion of roads and road traffic (impact on towns and landscapes);
- barrier effects, dividing roadside communities;
- fragmentation of ecosystems by roads;
- deaths of animals in road traffic;
- soil and water pollution.

In general, differentiated use-charges could take account of these externalities, in combination with measures such as crossings for animals and underground roads.

4.2.8. Transport charges and taxes

In determining charges for internalisation, existing charges must be taken into account. It should be stressed that road traffic already generates large amounts of revenue in specific charges and taxes. The suggested price incentives should be compared with current levels of taxes and charges; increases and reductions in some current taxes will be needed, depending on what new policy instruments are introduced. For instance, introduction of general road pricing might be combined with abolition of the annual vehicle tax and a substantial reduction in fuel charges. An electronic km-tax for HGVs would probably replace the Eurovignette.

In addition to the total charge level, it is important to examine the split between use dependent charges and fixed charges. On average in Europe, both kinds need to be raised. In some countries, however, fixed charges are currently high and could be lowered to partially compensate higher use-charges.

By some rough estimates, current traffic taxes and charges equal current infrastructure costs in Europe. However, for individual countries the balance may be rather different. In some countries car traffic pays more than the infrastructure costs it imposes, while in other countries taxes and charges are not sufficient to cover these costs. Probably in no European country is overall road traffic charged more than the total costs it generates.

4.2.9. Policy mix and priorities

This section uses the results of sections 4.2.1-8 to draw up recommendations for the main policy instruments for internalisation. The mix of instruments has to cover all cost components, but it is of course attractive to use instruments which generate incentives in respect of several components at once. Section 4.2.10 discusses in detail the choice of instruments to increase the level of use-charges for road traffic. One of the main recommendations based on the analysis in this report is to raise use-charges, but implementation poses practical problems.

Table 12 presented an overview of the most relevant instruments by cost component. From this overview, four main types of policy instruments can be identified: *a)* standards; *b)* use-charges; *c)* specific urban policy; and *d)* traffic management. A combination of these policy instruments can come close to adequate internalisation of the externalities of road traffic.

Standards

Direct government regulation has helped reduce externalities of road traffic substantially and continues to be very promising. The setting of tight standards for vehicles, fuels and roads translates into direct regulation of a number of externalities at source. Enforcing such standards is relative easy.

Vehicle standards can determine specific emissions[4] of air pollution and noise, limit damage to roads and influence road safety. Fuel quality standards can reduce air pollution. Standards for road construction influence accident risk. All these types of standards are currently applied, and a further tightening of the limit values would suffice to internalise part of the current external costs. An additional vehicle standard for specific fuel consumption could also be considered.

A disadvantage of standards is that they only set an upper limit, and no incentive is created to do even better. Hence, standards rarely stimulate the development of new technology, unless they are explicitly technology forcing, with stricter limits set for the future than can currently be met, thus forcing industry to develop better technologies. Current practice could be improved by setting two levels for standards: the lower value would be legally binding for all vehicles, and the upper would apply in particular circumstances, *e.g.* using financial incentives to promote the introduction of vehicles meeting the tighter standards, or allowing only the cleanest vehicles to enter city centres. Countries and cities would decide individually whether to introduce such policies. Heavily polluted areas, for example, could follow a stricter environmental policy than the European minimum standards. A second important advantage of ''two tier'' standards is that the dynamic process of technological improvement is stimulated. Although industry has to deal with two different standards at once, this might prove a small disadvantage compared with the benefits for environmental policy.

Note that standards do not provide an incentive for proper *use* of vehicles and roads. Distance driven, for instance, is not affected by any standard. Because use largely determines the magnitude of externalities, standards need to be combined with the other mechanisms discussed below.

Use-charges

Use-charges give companies or individuals a price incentive which should correspond with the full consequences of their own decisions. This results in ''better'' decisions, reducing externalities to some extent and allocating costs – *e.g.* road or accident costs – more directly to the users causing the costs, which is generally considered fair. The revenues of use-charges can be applied (directly or indirectly) to paying the costs involved. It is important for the use-charges for a given trip to be related as closely as possible to the extra costs of that trip, but this is not easy in practice. Second – and third-best policy instruments might be the only options available.

When discussing the required level of use-charges, it is helpful to anticipate developments in the volume of externalities per vehicle-kilometre where measures have already been adopted. Tighter standards or speed limits, for instance, should be elements of an internalisation policy and will bring the accident rate down along with pollution per vehicle-kilometre. In determining the policy mix to achieve internalisation, it is better to base the estimates of use-charges on expected future emissions factors, accident rates and so on. This ''dynamic approach'' is the one followed in this report.[5] For air pollution, for example, use-charges could be based on emissions factors according to standards that have already been decided and will come into force in the future. As new and stricter standards are adopted later, use-charges are further reduced.

In following a dynamic approach it is important to use assumptions that are realistic and that are supported whatever policy decisions are required for their realisation.

Table 16 presents estimates of the average use-charges required for internalisation, based on the shadow prices for the externalities established in Annex B. A dynamic approach is followed (see Annex D for details); its main elements are:

- Road infrastructure costs per vehicle-kilometre are assumed to be unchanged; road building, maintenance and traffic management costs are expected to rise, but this effect is assumed to be offset by expected growth in road use intensity.

Table 16. **Estimates of average use-charges[a] corresponding with expected future marginal costs (excluding congestion)**

ECU/v-km

Cost component	Passenger car			Freight (truck, van)
	Gasoline	Diesel	LPG	Diesel
Infrastructure	0.023	0.023	0.023	0.041
Congestion	–	–	–	–
Accidents	0.028	0.028	0.028	0.028
Climate change	0.009	0.009	0.008	0.025
Air pollution	0.002	0.004	0.002	0.024
Noise nuisance	0.005	0.005	0.005	0.023
Total	**0.066**	**0.067**	**0.065**	**0.142**
Average fuel charge in EU countries, January 1996	0.041	0.022	n.a.	0.067

a) Assuming the non-pricing instruments described are also implemented.
Source: ECMT Task Force estimates; see Annex D for main assumptions.

- The accident rate (number of persons killed and injured per vehicle-kilometre) used in the calculations is roughly half the current level in Europe, anticipating progress in road safety. Furthermore, the shadow price for fatalities and injuries is expected to be unchanged. This probably is a conservative assumption; several studies (*e.g.* Muizelaar *et al.*, 1995) indicate the shadow price will increase with time.
- Charge levels are based on emissions forecasts for new vehicles sold in 2000. Specific air emissions from vehicles are assumed to decrease by roughly 75% for cars and 50% for vans and trucks (see Table 14). The shadow prices for air pollution are assumed to be unchanged in coming years (this may be a conservative assumption, given emerging epidemiological evidence on the impact of particulate emissions).
- The fuel efficiency of vehicles is expected to improve by 5-15% from the current fleet average over ten years. The shadow price for greenhouse gas emissions is assumed to be unchanged (a conservative assumption given the decision of the UN-FCCC conference in Kyoto to reduce target emissions of CO_2).
- The shadow prices for noise nuisance per vehicle-kilometre are assumed to stay level because, while vehicles and roads are expected to become less noisy, a larger portion of traffic will be in urban areas and the shadow price per dB(A) will probably go up in response to growing income and resulting increased aspirations regarding quality of life.
- The average load factor for trucks (over 3.5 tonnes) is expected to improve from 6 tonnes to 8 tonnes as a result of improvements to logistic systems currently penetrating the market. This raises the average load factor for all road freight from 2.8 tonnes to 4 tonnes.

Using these and some other assumptions (see Annex D) the required average use-charges for road traffic are estimated. Table 16 presents the results and compares them with the current average excise duty in the EU.

Table 16 shows that current excise duties[6] are only about half as high as the use-charges expected to be required. It is therefore recommended that efforts be made to increase use-charges for road traffic (for policy instruments to achieve this, see section 4.2.10).

For cars, two cost components determine the total user cost to a large extent: infrastructure (35%) and accident costs (40%). The use-charge for air pollution is very low because of expected reductions in vehicle emissions. For freight transport, all five types of costs are substantial. Infrastructure costs represent the largest share: 30%.

Specific urban policy

Externalities of road traffic are concentrated in urban areas. Section 4.2 discussed several specific urban issues: congestion is mainly an urban phenomenon; the impact on human health of 1 kg of air pollutant is much larger in urban areas than in rural areas because more people are exposed; and the noise nuisance of a vehicle-kilometre in a build-up area is generally larger than it is outside.

For these reasons, a policy aiming at internalisation should distinguish between urban and rural areas. For instance, the average use-charge in Table 16 would overcharge rural traffic and undercharge urban traffic. Vehicle standards should be stricter for city traffic as well. Table 17 indicates the difference in use-charges between urban and rural areas for the use charges required to cover anticipated levels of external costs.

Table 17. **Anticipated difference between expected urban and rural use-charges**

ECU/v-km

Cost component	Car (gasoline)			Truck/Van (diesel)		
	Rural	Urban	Difference	Rural	Urban	Difference
Infrastructure	0.023	0.023	–	0.041	0.041	–
Congestion	–	0.022	0.022	–	0.060	0.060
Accidents	0.028	0.028	–	0.028	0.028	–
Climate change	0.009	0.009	–	0.025	0.025	–
Air pollution	0.001	0.003	0.002	0.016	0.044	0.028
Noise nuisance	0.005	0.013	0.013	0.012	0.058	0.046
Total	0.063	0.098	0.035 (+55%)	0.122	0.256	0.134 (+110%)

Source: ECMT Task Force estimates; see Annex D for main assumptions.

Table 17 shows that use-charges in urban areas need to be 50-100% higher than those in rural areas so as to incorporate congestion, thus covering infrastructure costs fully and resulting in better, economically efficient traffic flow. At the same time the fixed charges for infrastructure would be reduced, so the charge related to congestion would not represent a price increase but only a shift in the price structure. Differences in costs associated with air pollution and noise nuisance are also important.

Policy instruments to internalise specific urban externalities, especially congestion, are thus needed. Section 4.2.2 discussed a system of urban road pricing which could generate incentives to reduce congestion and intensify the use of the available road capacity. It mentioned that revenues from congestion charges should be recycled to the road sector, for instance by reducing fixed charges. Congestion pricing is simply a tool for managing traffic flows better.

Other specific urban policy instruments might also be considered. It is well known that parking capacity and parking tariffs affect traffic flows to a city. There are advantages to strict emissions standards for vans because vans drive mainly in urban areas. City centres could be open only to cleaner vehicles (which should meet emissions standards not yet generally in force, but already adopted for the future; this would not only improve urban air quality but would also stimulate introduction of vehicles meeting the future standards).

It is important for specific urban policy measures to be co-ordinated with policy for rural areas; urban traffic should not simply be charged double. Furthermore, urban and rural policy should be carefully integrated to avoid undesired shifts of economic activities and traffic to the countryside.

Traffic management

Improved traffic management can reduce externalities substantially. Three directions in particular may be pointed out:

- Setting and enforcing proper speed limits. Lower driving speeds result in reduced congestion, fuel consumption and air pollution, and improved road safety. Lower speed limits seem to be a very cost-effective way to help reduce road traffic externalities.
- Congestion management. This involves, for example, allowing vehicles to enter a full motorway only gradually, *i.e.* making vehicles wait at the entrance.
- Traffic flow management. By giving proper information to drivers and managing traffic signals intelligently, vehicles can be directed towards roads with available capacity and a steady flow can sometimes be achieved, instead of repeated acceleration and stopping.

Traffic management can reduce congestion, improve road safety and reduce noise levels as well as emissions of CO_2 and air pollutants.

4.2.10. Instruments for increasing use-charges

One recommendation in the previous section was to increase use-charges for road traffic to roughly twice the current European averages. The question is whether appropriate policy instruments are available to achieve such an increase. As Section 4.2.2 showed, all policy instruments have their pros and cons.

Table 18 summarises the discussion about the choice of policy instruments to increase use-charges. The top part of the table shows for each price instruments how good a linkage with use dependent or marginal costs can be established. As this report has often stated, such linkage is required for economic efficiency to be achieved. The use-charge should depend on four main factors: driving distance, vehicle type, road type and time of day/week. These factors strongly influence use dependent costs. Table 18 also shows which price instruments are suitable to cover the fixed infrastructure costs. The bottom part of the table assesses price instruments with respect to the criteria for the choice of policy instruments as presented in section 4.1.3.

It should be stressed that the table presents only a rough assessment of the policy instruments that can be employed to increase the level of use-charges. This is sufficient, however, for an overview of the main advantages and disadvantages of these instruments.

A general system of electronic *road pricing*, covering at least all main roads, appears theoretically to be the best instrument for internalisation, except in relation to climate change, where fuel charges fit best. The charge level can differ by distance driven, vehicle type, road type and degree of congestion. This comes close to the perfect charge, corresponding with the marginal costs of each trip. In addition to road pricing, there is a need for a fixed tax (*e.g.* vehicle tax) to cover the full infrastructure costs, in so far as these are not covered by use-charges. The disadvantage of such a system of general road pricing is that it is probably rather costly. Furthermore, technical constraints mean it is unlikely to be implemented in the coming decade.

Some of the advantages of general road pricing can be achieved through a similar instrument: *urban road pricing*. This allows congestion to be incorporated in the use-charges, which is the main advantage over the policy instruments discussed below. Some form of urban road pricing can probably be introduced on a substantial scale in the next few years.[7]

Part of the advantages of general road pricing can also be achieved through variabilisation of existing motorway tolls, particularly in regard to managing congestion. Such variable tolls can be introduced rapidly on routes already tolled. New electronic drive-by tolling systems may make congestion tolls cost-effective on existing untolled routes in the future.

An *electronic km-tax* for HGVs allows for a reasonable cost allocation to freight transport. Damage to roads can be charged per kilometre driven and the tariff can differ by vehicle weight and number of axles. This is a much better allocation than achievable with the current combination of fuel taxes,

Table 18. **Comparison of policy instruments for use-charges**

	General road pricing	Urban road pricing	Electronic km-tax for HGVs	Extended insurance liability/ surcharge	Fuel charge	Differen-tiated Vehicle Tax	Euro-vignette variants
Application	General	Urban	Trucks	Accidents	General	General	Trucks
Linkage to:							
Distance driven	++	+	++	–	+	––	––
Vehicle type	++	++	++	++	0	++	++
Road type	++	–	––	–	–	––	––
Time	++	++	––	–	––	––	––
Fixed costs	–	–	–	n.a.	–	++	++
++ good link							
+ reasonable link							
0 poor link							
– very weak link							
–– no link							
Potential effectiveness of incentives created *re:*							
Accidents	++	+	+	+	+	0	0
Air pollution and noise	++	++	+	0	+	+	+
Climate change	+	+	+	0	++	+	+
Infrastructure	++	+	++	0	+	+	+
Congestion	++	++	0	0	0	0	0
Practical merits							
Short term availability	––	+	+	–	++	++	++
Acceptability of implementation costs	––	–	0	0	++	+	+
International distribution of revenues	++	++	++	0	–	–	+
Transparency	++	++	++	+	0	0	0
Ease of enforcement and fraud prevention	+	+	0	+	++	+	+
Absence of legal obstacles or legislative burden	0	+	0	–	++	+	+
++ good							
+ positive							
0 neutral							
– negative							
–– bad							

Sources: ECMT Task Force.

vehicle taxes and the Eurovignette. Another important advantage is that the km-tax achieves a proper international distribution of revenues. The country where the road is used receives the revenues, which is not always the case with fuel charges. An electronic km-tax for HGVs can probably be implemented within a few years and is not costly. Some Scandinavian countries and Austria have recent experience with km-taxes for road freight transport, though they did not employ electronic systems (see section 4.2.2).

The *insurance premium* should be related as closely as possible to the accident risk (see section 4.2.3). Because accident risk is related to vehicle use, the ideal premium takes the form of a use-charge (not a fixed charge or lump sum). The current structure of the insurance premium does not come very close to this ideal; section 4.2.3 discussed ways to improve the tariff structure and expand liability to costs which are currently external. No obvious conclusions can be drawn about the potential for improving the insurance premium as regards these two issues. If vehicle insurance does not approach the desired premium structure or enlarged liability, other use-charges may be needed to compensate and to achieve full coverage of accident costs. Although a fuel charge is not closely related to accident risk, it generates a better incentive than fixed charges such as vehicle taxes.

Fuel charges, currently the most widely applied use-charge, do not generate optimal incentives. Congestion cannot be incorporated, and the link with infrastructure and accident costs is not strong; nor is the link with pollution, except for CO_2. Another disadvantage is that not all revenues of fuel charges go to the country where the costs are incurred. Differences in charge levels lead to "tank tourism" and consequent losses of revenue, although the share of international traffic is modest compared with domestic transport in most countries. The main advantages of fuel charges are that they generate a better incentive to internalise marginal costs than do fixed charges, and that they are simple and cheap to implement; this is why they are used so widely. Furthermore, they are the only form of use-charge with some linkage to speed and driving style.

The relationships among these different options now need to be explored, as only general road pricing (GRP, as opposed to urban road pricing or URP) and fuel charges are appropriate for all vehicle types and in both urban and rural areas. The other instruments offer only partial solutions and have to be combined with other use-charges. Table 19 presents possible combinations of use-charges.

Table 19. **All the possible combinations of the four kinds of use-charges considered**

	Rural		Urban	
	Cars/vans	Trucks	Cars/vans	Trucks
1	Fuel	Fuel	Fuel	Fuel
2	Fuel	Km-tax	Fuel	Km-tax
3	Fuel	Fuel	URP	URP
4	Fuel	Km-tax	URP	URP + Km-tax
5	GRP	GRP	GRP	GRP

GRP = General road pricing.
URP = Urban road pricing.
Source: ECMT Task Force.

For cars and vans in rural areas, the required increase in use-charges can be achieved only through general road pricing or fuel charges. As this kind of road transport accounts for roughly half the total social costs of transport it should not be ignored. Thus fuel charges will likely remain an important element of internalisation policy, at least until general road pricing becomes available. In the meantime combining fuel charges with urban road pricing and an electronic km-tax for HGVs offers a package of instruments that is reasonably complete in its coverage. It avoids the main drawbacks involved in using fuel charges alone, and will be available before general road pricing.

Table 20 presents a rough estimate of the level of fuel charges required. The data refer to rural traffic, which generates lower costs than urban traffic. It is assumed that half of anticipated external accident costs will be internalised via the vehicle insurance premium and half via fuel charges. A dynamic approach is followed, including assumptions for reductions in accident rates, specific fuel consumption and air emissions (see Annex D and text above for details).

According to the calculations summarised in Table 20 the average fuel tax in Europe (excluding VAT) will be close to doubled if use-charges for road traffic are increased via fuel charges in the period before general road pricing is introduced. It is not practical to introduce two charge levels on diesel, one for cars and another for trucks. The weighted average of the required diesel charges is around ECU 0.59/litre. Using this average means trucks are overcharged and vans together with diesel cars undercharged. This can be partly corrected by imposing an additional surcharge on the vehicle tax for diesel cars and vans and allowing a similar reduction for trucks.

Table 20. **Estimated average fuel charges for rural traffic for internalisation, in combination with vehicle standards and insurance**

ECU/litre

Cost component	Passenger car			Freight (truck, van)
	Gasoline	Diesel	LPG	Diesel
Infrastructure	0.28	0.35	0.22	0.22
Congestion	–	–	–	–
Accidents	0.17	0.21	0.14	0.07
Climate change	0.12	0.13	0.08	0.13
Air pollution	0.02	0.03	0.01	0.09
Noise nuisance	0.03	0.04	0.02	0.06
Total	**0.62**	**0.76**	**0.48**	**0.57**
Memo items:				
Average excise duty in EU, January 1996	0.48 [a]	0.32	n.a.	0.32
EU minimum excise duty	0.287 [a]	0.245		0.245

a) Unleaded gasoline.
Source: ECMT Task Force estimates; see Annex D for details and for results in terms of ECU per v-km.

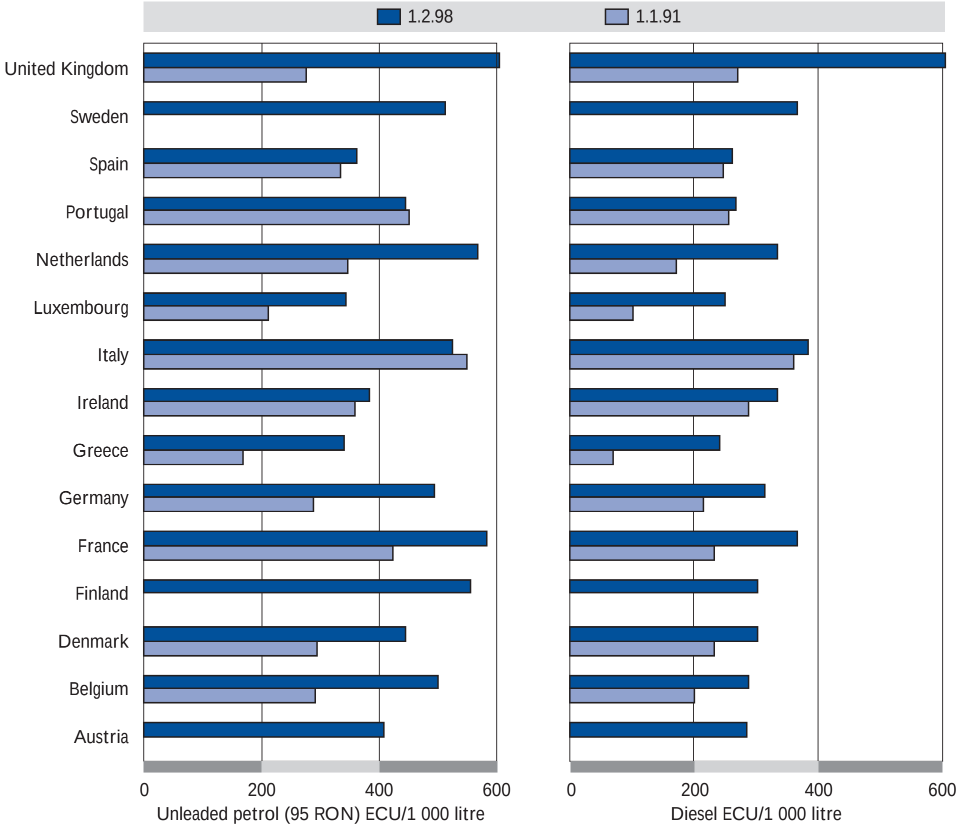
Even though fuel charges are not the perfect way to achieve the required increase in use-charges, this appears to be the only feasible approach which can be implemented within a decade. To avoid some of the disadvantages, fuel charges need to be supplemented with other policy measures, particularly to ensure that urban traffic pays its full costs. A differentiated vehicle tax is required to generate better incentives per vehicle type and the vehicle tax itself is needed to achieve full cost coverage. Furthermore, standards for vehicles and fuels as well as traffic management are important in the mix of policy instruments. Such a package can be introduced in the short term and would certainly be an important step forward, compared with current policies. Some of the drawbacks can be eliminated with additional instruments. The electronic km-tax for HGVs is important to realise a fair international distribution of the use-charges paid by trucks. An additional advantage is that the allocation of costs to HGVs will be better than with a fuel charge. This is important, because the link between fuel consumption and total costs is better for cars and vans than for trucks. Urban road pricing can be added to the estimated fuel charges since the latter are based on rural costs.

The improved structure of the insurance premium is also compatible with the suggested fuel charges, though if the increased liability for accident costs were to exceed half the existing external part, the estimated fuel charges would need to be lowered accordingly.

A number of factors should be borne in mind when comparing the figures in Table 20 with the national levels of excise duty (Figure 11). First the charges in Table 20 are averages for Europe, based on a review of the literature for estimates made mainly for western Europe. The size of estimated costs varies significantly with country as can be seen in the tables in Annex B. Many of the countries with higher than average existing levels of excise duty on fuel are also characterised by higher than average valuations of external costs – although this is not always the case – which would result in a higher recommended level of fuel charge for internalisation than the average if the exercise were to be repeated on a country specific basis. Some adjustment for inflation would also have to be made for detailed comparisons. It should also not be overlooked that the total figures in Table 20 would have to be increased from 10 to 30% if all accident costs were to be internalised via a fuel charge rather than partly through insurance cover. Finally, it should be noted that Finance Ministries are likely to levy taxes on fuel for purely revenue raising purposes on top of any charges designed specifically for internalisation – the purpose of existing fuel charges has not been made explicit in most countries in either fiscal or transport policy.

◆ Figure 11. ***Excise duties on unleaded petrol and diesel in the European Union 1991 and 1998***

Current prices and exchange rates



Source: 1991: Centre for Energy Conservation and Environmental Technology, Delft; 1998: European Commission – Directorate General for Energy, in CPDP (1998)

4.3. RAIL TRANSPORT

The general approach for internalising the externalities of rail transport and other modes is the same as for road traffic. The implementation, however, is less complicated because the current level of administration of railways is higher than in road traffic and the number of vehicles and tracks is much lower.

Infrastructure

As with road transport, the marginal costs of rail infrastructure should be covered by use-charges. In situations where capacity is not congested marginal costs are roughly 50% of total infrastructure costs. The other half are fixed costs, which need to be paid whether the railway is used or not. To achieve full coverage of infrastructure costs a lump sum or fixed charge is thus needed, additional to the use-charge. This can be regarded as payment for a ''licence to operate''. British experience shows it is possible, although not easy, to allocate fixed infrastructure costs to different operators.

A system of track pricing can be used to make rail service operators pay the marginal infrastructure costs for each trip. The level of the use-charge can differ from one track to another and can of course depend on the distance travelled and the capacity used (few or many stops). The fixed infrastructure costs might be covered by an annual lump sum charge.

Accidents

Rail has a good safety record, mainly because safety standards for trains, tracks and operational procedures are very high in most countries. Moreover, some further improvements can be expected. For the remaining accidents, the same approach can be followed as for road traffic: *a)* expanded liability; and *b)* price incentives related as closely as possible to the risk. The price incentives can be incorporated into track pricing in the case of rail service operating companies.

Although the same ''prices'' apply to fatalities and injuries whether caused by road or rail traffic, the level of the price incentive calculated for rail is probably less than 10% of that for road, given rail's better safety performance.

Climate change

As the environmental impact of one kg of CO_2 is the same for all transport modes, the ''price'' of one kg of CO_2 is also the same for rail as for road use. Because a relatively small number of operators run trains, voluntary agreements between national governments and rail operators for energy efficiency improvements seem attractive. Standards for diesel engines and power plants could perhaps be used as well.

Remaining CO_2 emissions should be charged as for road traffic. It would likely be simple and efficient to charge both the diesel fuel and the electricity used. The level of the charge on diesel would be ECU 0.13/litre. For electricity the level would depend on the generation method. In the Netherlands, for instance, 630 g of CO_2 is emitted for the production of 1 kWh. The corresponding charge would be ECU 0.03/kWh. Countries that use a lot of coal would need a higher charge, while for those with considerable hydro and/or nuclear power a lower CO_2 charge would apply (such non-fossil generation also has environmental impacts and risks, however, which should be incorporated in the price incentive).

Air pollution

Air pollution from trains is caused either directly by diesel locomotives or indirectly in the power plants where the electricity is generated. In both cases, emissions standards are useful. Tighter emissions standards for diesel engines and fuel would lead to substantial and fairly cheap emissions reductions.

Additional, operational measures might reduce emissions further. Such measures could be incorporated in voluntary agreements. Remaining emissions could be internalised through price incentives; surcharges on diesel fuel and electricity are attractive options. The level of the diesel charge should be around ECU 0.17 /litre, assuming that technical improvements reduce emissions per litre by roughly 20%. Finally, specific urban externalities caused by air pollution from trains can be incorporated in track pricing.

Noise

The noise nuisance caused by trains can be reduced by imposing tighter standards for rolling stock and by building screens beside tracks through sensitive areas. The remainder can be internalised via use-charges incorporated in track pricing.

Overview

Table 21 summarises the main policy options to internalise the externalities of rail transport. The main instruments are standards, voluntary agreements and use-charges (track access charges and fuel charges).

Table 21. **Policy options per cost component: rail**

Infrastructure	Track access charges Fixed charges
Congestion	Track access charges
Accidents	Rail safety policy Risk related insurance premium Track access charges
Climate change	Voluntary agreements Electricity and diesel charges
Air pollution	Standards Voluntary agreements Electricity and diesel charges
Noise nuisance	Standards Voluntary agreements Track access charges

Source: ECMT Task Force.

Use-charges

As is the case for road traffic, internalisation will result in higher use-charges for rail transport. It is not possible in the framework of this report to estimate accurately the required price increase. Differences among countries are probably large. By a rough guess, however, the price increase for rail transport might be of the same order of magnitude as that for road, mainly because the current level of use-charges is modest compared with the infrastructure and operational costs. Two important factors might reduce the expected level of price increase: first, there appears to be considerable scope for efficiency improvements in the rail mode, and second, public authorities will probably contract some public transport services under public service obligations, which will keep the fares down on specific routes.

It can be expected that railway operators will adapt to higher use-charges by attempting to increase their average load factor, thus generating a financial gain and reducing pollution per passenger- and tonne-kilometre. Through such operational changes the initial price increase might be compensated to a large extent, but the service level will be reduced somewhat, possibly implying both less frequent service and closure of some remote lines.

Public transport

It is often argued that public transport companies fulfil a public service. In so far as this is the case, it seems more efficient and transparent to contract and pay for the desired public services than to grant general subsidies to public transport companies.

4.4. WATER TRANSPORT

Infrastructure

The marginal costs of waterway and harbour infrastructure should be covered by use-charges and the fixed infrastructure costs via lump sum charges. Harbour and lock fees appear to be suitable instruments for marginal infrastructure costs. Additional lump sum charges might be needed for certain inland waterways.

Accidents

Accident costs can be internalised mainly through safety policy measures and expanded insurance liability. Environmental damage caused by accidents (*e.g.* oil spills) should be included. In addition a use-charge might be considered; the level will probably be negligible compared with that for road traffic.

Climate change

CO_2 emissions from shipping can be reduced by operational measures and changes to vessels. In general, larger vessels of improved shape are more fuel efficient. Sailing at optimal speed can also reduce fuel consumption and related CO_2 emissions. Standards or other forms of direct government intervention seem inappropriate for promoting fuel efficiency in shipping, but voluntary agreements with shipping companies may offer some opportunity. A fuel charge would generate a good incentive for technical and operational improvements; the level should be ECU 0.13/litre, equal to that for trucks and diesel trains.

Air pollution

As engine emissions standards and fuel quality standards can reduce air pollution from ships substantially, at rather low costs, they represent a cost-effective way to internalise these externalities. Remaining air pollution can be internalised via price incentives; a fuel surcharge is a suitable policy instrument to achieve this. Assuming that standards and operational changes reduce emissions per tonne-kilometre by 25%, the level of the required charge should be around ECU 0.17/litre of diesel fuel.

Water pollution

Better enforcement of existing legislation, and possibly tighter safety standards, can reduce water pollution. Pollution caused by accidents should be covered by insurance.

Noise

Noise nuisance does not seem to be a consideration in shipping.

Overview

Table 22, summarising the main policy options, shows that standards and use-charges are the chief policy instruments for internalisation.

Table 22. **Policy options per cost component: shipping**

Infrastructure	Harbour and lock fees Fixed charges
Congestion	Harbour and lock fees
Accidents	Water safety policy Expanded insurance liability
Climate change	Fuel charges
Air pollution	Standards Fuel charges
Water pollution	Standards and better enforcement
Noise nuisance	–

Source: ECMT Task Force.

Use-charges

Within the framework of this report it is not possible to evaluate whether current harbour and lock charges sufficiently cover the marginal infrastructure costs.

The suggested fuel charges for climate change and air pollution amount to roughly ECU 0.30/litre of diesel, equivalent to a price increase of more than 200% (the current averages are ECU 0.13 for inland shipping and ECU 0.08 for maritime shipping). Costs of freight transport by inland waterway will as a consequence rise by around 20%. In ECU per tonne-kilometre this is, however, a smaller increase than that for road transport.

4.5. AIR TRANSPORT

Infrastructure

Marginal infrastructure costs for air transport should be covered by use-charges. Because many main airports have capacity problems, use-charges are likely also to cover the full infrastructure costs. The current airport fees for air traffic control are adequate instruments for internalising infrastructure costs. Government subsidies, mainly to small regional airports, should end or be replaced by transparent payments for public services.

Accidents

Safety is a crucial issue for the aviation industry. The many measures taken to reduce accident risks give aviation a good safety record compared with road transport. Efforts to minimise risks should be continued and might even be intensified. In addition, liability for accident costs could be expanded. The remaining accident costs of aviation might be covered by an instrument such as airport charges, or even be neglected (these externalities are probably very small).

Climate change

CO_2 emissions from aviation have the same impact on climate change as emissions from other sources. In addition, NO_x emissions at cruising altitude may contribute to climate change, at about the same order of magnitude as aviation CO_2 emissions, though much uncertainty on this issue exists. The impact on NO_x emissions at high altitude may be substantially higher, but is uncertain; no adjustment was made for high altitude emissions.

Many measures can help reduce CO_2 and NO_x emissions. Technical and operational improvements are important. Operational changes relate to load factor, aircraft size, flight path and optimal speed. Emissions standards can be applied for NO_x at cruising altitude. CO_2 emissions are directly related to fuel consumption and can probably not be reduced by direct government intervention. The process of optimising the many operations of the aviation industry is so complex that regulation would probably not lead to efficient solutions, and could easily distort competition. Voluntary agreements between the airline industry and governments, with respect to energy efficiency improvements, appear to be a more attractive route.

Remaining emissions of greenhouse gases would be charged, just as in other modes, generating an extra incentive to increase fuel efficiency. Fuel charges, route-charges or environmental surcharges on landing fees might be attractive instruments. If only CO_2 emissions are considered, the charge on jet fuel should be ECU 0.12/litre. Assuming NO_x emitted at cruising altitude to have the same impact as CO_2, the fuel charge is doubled to ECU 0.24. In addition, a differentiated landing fee or registration fee is needed with respect to specific NO_x emissions per type of aircraft.

Air pollution

Aviation also causes some air pollution at ground level, mainly in the direct vicinity of airports. Although the levels are generally small compared with ground transport, an internalisation policy ought to take account of them. Both emissions standards and differentiated landing fees can reduce ground level pollution. In addition, a surcharge on landing fees, corresponding with the emissions during landing and take-off from each aircraft type, can be considered.

Noise

The noise nuisance of aviation is concentrated around airports. Many measures have been taken to reduce aircraft noise and to insulate or even remove houses. Noise standards exist for aircraft and might be tightened in the near future. Differentiated landing charges applied by some airports generate a good incentive to use and develop quieter aircraft, and to schedule landing and take-off for less sensitive times of day as regards noise nuisance.

Overview

Table 23 presents an overview of the main policy options to internalise aviation externalities.

Table 23. **Policy options per cost component: aviation**

Infrastructure	Landing charges Air traffic control fees
Congestion	Landing charges
Accidents	Aviation safety policy
Climate change	Voluntary agreements Standards (NO_x) Fuel charges or landing/route charges
Air pollution	Standards Differentiated landing charges
Noise nuisance	Standards Insulation of buildings Differentiated landing charges

Source: ECMT Task Force.

Use-charges

The suggested use-charges might double or triple the current fuel price, initially increasing air fares by 15-30%. Many technical and operational improvements, however, will increase aircraft fuel efficiency and thus greatly reduce the cost increase.

Intermodal distortion

Equal treatment for all transport modes will require the ending of the current VAT exemption on ticket sales at least for intra-European transport. It also suggests that tax free sales related to flights within Europe should end.

NOTES

1. A unified system of fees for heavy goods vehicles in the Benelux countries, Germany and Denmark, accompanied by a mechanism for allocation of the revenues to the participating countries.
2. Such a charge could be applied to all trucks or only to heavier vehicles, *e.g.* above 12 tonnes.
3. This shadow price is based on the marginal abatement costs of achieving air quality standards. Current damage might be higher.
4. Emissions per kilometre driven, as opposed to total emissions.
5. The dynamic approach, using data about future specific externalities, is appropriate when use-charges are estimated for the average fleet; however, when use-charges are to be determined for each individual vehicle, this approach should not be followed.
6. Average excise duties per litre in the EU: ECU 0.48 for unleaded gasoline and ECU 0.32 for diesel fuel (Dings and Bleijenberg, 1996).
7. The Dutch Government intends to introduce urban road pricing on a wide scale by 2001.

Chapter 5

ECONOMIC IMPACT

TABLE OF CONTENTS

5.1. INTRODUCTION: THE BENEFITS OF TRANSPORT

The preceding chapter developed and discussed the main options for a policy aimed at internalising transport externalities. The question now arises as to the economic impact of such a policy, for it is evident that transport fulfils an essential function in the economy, which should not be unnecessarily impaired by an internalisation policy.

Transport is important for both the production and the consumption sides of the economy. Regarding consumption, transport offers the opportunity to enjoy the benefits of access to places at a distance, such as city centres, sunny beaches and attractive natural areas. It allows location of activities over a larger area, enabling a wider choice of dwelling places, workplaces, shopping centres, schools, health services, recreational activities and so on. The current trend is that the distance between main activities grows by a few percentage points each year, which translates into more mobility.

On the production side of the economy, transport can yield at least four types of benefits:

- economies of scale, by concentrating economic activities;
- specialisation of production;
- use of comparative advantage, *e.g.* grapes grow better in southern Europe than in northern Europe;
- reduction of the total logistical costs of economic production, including costs of storage.

Transport services also require the manufacturing of vehicles, building of infrastructure, maintenance and operation of vehicles and so on. And these activities generate demand for other goods and services. So the consequences for transport of internalisation may translate into impacts on many economic sectors.

A first step in the assessment of this impact is a discussion about the use of the revenues from higher use-charges for transport (section 5.2). The choices made on this issue determine to a large extent the impact of internalisation. Next, an indication is given of the changes expected in transport prices as a consequence of internalisation (section 5.3). This includes consideration of possible changes in the modal split and forms a starting point for the economic assessment in the next sections. Section 5.4 presents an overview of the main costs and benefits of internalisation, including both financial and non-financial effects on welfare. The financial consequences might influence several other economic activities, which can in combination affect the level of economic growth and employment (section 5.5).[1] Finally, section 5.6 discusses the main distributional issues. This chapter on the economic impact of internalisation is based on a review of available economic studies on the subject and is not the result of empirical research.

5.2. INTERNALISATION AND TAXATION

As has been stated before in this report, internalisation of transport externalities does not aim at increasing tax revenues for governments. However, higher use-charges, such as those suggested in chapter 4, will generate extra revenues. This section discusses how these revenues might be used to avoid an increase in the overall tax burden on the economy. The section does not aim to prescribe specific uses for revenues; rather, it explores the relevant arguments. The link between use-charges and general taxes is also reviewed, examining whether there are economic or other arguments for levying taxes on transport over and above the use-charges required for internalisation.

5.2.1. Use of revenues

First, it should be noted that in some countries part of the higher use-charges required for internalisation should be compensated by reducing fixed charges. This applies mainly to road transport. Internalisation requires to some extent a change in the price structure rather than an overall price increase (although in most countries internalisation will also result in higher overall charges for transport).

It can be argued from an equity standpoint that these revenues should be used to compensate those who suffer from the externalities caused by transport,[2] and this approach is followed here.

Revenues from increases in charges to cover infrastructure costs need to go to those providing the infrastructure – mainly governments – so that infrastructure is paid for by those using it rather than through general taxation. Revenues from price increases to cover accident costs should benefit governments (in respect of medical and welfare costs), companies (for loss of production) and individuals (for loss of income and non-material damage). Revenues from charge increases in respect of environmental costs can compensate those being exposed to pollution, etc., mainly citizens and to some extent companies (*e.g.* farmers).

The revenues accruing to governments can be used for any purpose. No specific purpose follows from internalisation policy, so the most reasonable assumption is that the rates of general taxes, such as income and labour taxes, VAT and company taxes, will be reduced. There is no reason to combine internalisation with any particular form of extra government expenditure.

Next the question arises of how individuals and companies should be compensated financially. It does not appear to be feasible to identify each firm and person suffering from transport effects and to allocate funds proportional to their inconvenience and damage. A more practical approach is to use the existing tax system to achieve a more general compensation. This allows for differentiated tax reductions for individuals (through lower income taxes) and economic sectors. Agriculture, for instance, could be compensated more than industry, to account for damage to crops caused by air pollution. Individuals should benefit most from such tax cuts because they suffer most of the damage.

The conclusion is that higher use-charges for transport should preferably be compensated partly through lower fixed taxes in the transport sector (at least in many countries) and partly through lower rates of general taxation. This approach has the political advantage of making it clear that internalisation has nothing to do with increasing the overall tax burden.

5.2.2. General taxes

The perfect tax system does not, in theory, distort economic allocation,[3] but in practice few non-distorting taxes exist. In general it is preferable from an economic point of view to tax activities, property, goods and services which have low price elasticities. In such cases taxes will not influence economic behaviour as much as where elasticities are high.

The tax burden in most European countries is heavy on labour, modest on capital and low on pollution and on natural resource use. The high taxes on labour are seen as one cause of high unemployment in Europe. The tax system appears to be rather far from the perfect non-distorting system. Because almost all taxes distort the economic process at least a little, it might be attractive to apply taxes with opposite, or at least different, distorting impacts. This argues for a more balanced mix of taxes on labour, capital, natural resource use and other environmental impacts than is currently applied in most countries.

Where additional taxes on transport are considered for general taxation purposes, fixed taxes seem more appropriate than use-charges since the economic distortion of fixed taxes (*e.g.* on vehicles) is less than that of use-charges.[4] It is mainly a distributional – and thus political – issue, whether it is regarded as fair that transport contributes to the general tax revenues in combination with other taxes. The analyses and recommendations in this report assume no such contribution from transport to general taxation. In any case, such taxes applied for the purpose of raising revenues for general expenditure would go on top of the use-charges discussed in Chapter 4.

5.3. TRANSPORT PRICES AND MODAL SPLIT

Internalisation of transport externalities affects the price level of transport in several ways. Price increases can be caused by both tighter standards and higher use-charges. Lower fixed charges and increased efficiency will lead in the opposite direction. Examples of cost reduction caused by increased efficiency are a reduced accident rate and higher utilisation of infrastructure capacity. It is rather complex to determine what the net effect on transport prices would be. Also, elasticities are poorly understood, as the price changes of interest are bigger than the range normally experienced in transport markets. Matters are even further complicated because this report presents no accurately defined set of policy measures but only some general policy outlines. Hence, this section only indicates the overall magnitude of price changes that could be expected from the policy options presented in Chapter 4.

5.3.1. Passenger transport

The variable costs of car traffic will increase by roughly 25% in rural areas and 60% in cities.[5] The average level of fixed charges in Europe will also rise, though the situation varies widely at national level and in some countries fixed charges could fall. Total costs for car users – fixed and variable – rise by around 15%.[6]

The cost of public transport will also increase. Covering infrastructure and external costs might increase rail tariffs 20-30%.[7] Again, the differences among countries are large. In general the tariffs for urban public transport can be expected to increase more than those for intercity rail services (similar to the differentiated price increase for car traffic). Efficiency improvements or changes in the level of compensation related to public service obligations will influence the resulting price increase.

The marginal costs of air transport will initially increase by 15-30% as a consequence of the internalisation policy outlined.[8] Several efficiency improvements, such as improved fuel efficiency and higher load factors, will reduce the impact on fare levels. The net price increase might be of the order of 10%.

The price changes expected for car traffic (use-charges) and public transport are of the same order of magnitude. No substantial shift is expected between these two modes. The price increase for air appears to be smaller than for the other modes. If, however, VAT on air tickets in Europe is introduced, the price increase for air will approach those of the other modes. Under these assumptions, no substantial changes in the modal split for passenger traffic can be expected to result from internalisation policy. The share of walking and cycling will perhaps increase a little at the expense of car traffic and public transport in urban areas.

5.3.2. Freight transport

With respect to road freight, a distinction is made between vans and trucks. Vans are driven mainly in urban areas and in many cases the transport of goods is not the only aim of the trip. A price increase for vans of ECU 0.05/v-km can be expected,[9] corresponding with roughly 10% of total costs. In trucking the price increase for freight forwarders will be roughly 18% in rural areas and around 30% in urban areas.[10]

The marginal costs of rail freight will initially increase by roughly 80% to bring about efficient pricing of infrastructure and externalities.[11] Because of efficiency improvements the resulting price increase will probably be limited. Moreover, governments are likely to contract for some services under public service obligations in the interests of regional development or to avoid capital losses that would result from line closures. It is thus impossible to estimate the impact on prices with any certainty. Internalisation might imply, however, that rail freight services will become concentrated on the main relatively long distance routes.

The marginal costs for water transport will rise by around 25% for inland waterways and 35% for short sea trips.[12] This implies that the prices for freight transport by inland waterway will increase from around ECU 0.025/t-km to ECU 0.031/t-km.

All freight transport modes will thus become more expensive. The increase for rail freight might be somewhat larger than for the two other modes. The possible impact on the modal split depends on many factors, including market segmentation. In general, rail and water have a high share of bulk goods transport while road freight is dominant with respect to mixed cargo. Containers form a segment of the market where there is fierce competition among all these modes. With these market segments in mind, and looking at the indicated price changes, the market share of road haulage cannot be expected to change substantially. The modal split between rail and water might not change much either, because in much of Europe waterways are not available. In countries with good opportunities for water transport, this mode already has a good market share compared with that of rail.

5.3.3. Transport sector overall

Although no major changes in the model split are expected as a consequence of internalisation policy, this does not mean the transport sector is not affected. Growth in traffic will be reduced somewhat in response to the general increase in transport prices. According to a rough estimate, transport volume (in tonne-kilometres and passenger-kilometres) will be 10-15% less under an internalisation policy compared with current trends in the medium term. For ten years growth slows from around 2% a year to 1%.[13] After this implementation period, growth goes back to 2% a year. A longer implementation period would result in a more gentle transition.

Somewhat reduced growth in the transport sector does not mean lower macroeconomic growth and employment overall. Section 5.5 discusses the resulting shifts in production structure and consumption patterns.

5.4. COSTS AND BENEFITS

Two kinds of costs and benefits need to be distinguished: financial and non-financial. The financial impact is fairly clear: *e.g.* higher costs for vehicles due to stricter environmental standards or reduced infrastructure costs caused by better capacity utilisation. The non-financial costs and benefits may require more examination. The main non-financial cost of internalisation is probably reduced mobility.[14] Higher use-charges, for instance, will influence behaviour: some marginal trips will not be made any more. The welfare[15] gain of a trip is equal to the utility derived from the trip – *e.g.* living in a nice neighbourhood far from the workplace or visiting a pleasant recreational site – minus the costs of the trip. If a trip is not made any more, the associated welfare gain is lost and this is the non-financial cost of internalisation. An example of a non-financial benefit is reduced personal distress caused by a reduction in traffic accidents. Welfare can thus be affected by both financial and non-financial impacts, as this section will discuss. The distinction will be made, but in the end only the impact on total welfare is relevant.

5.4.1. General

One of the main aims of internalisation is to increase economic efficiency, which relates to both financial and non-financial impacts, and any successful internalisation policy will increase welfare. Two examples illustrate this relating to environmental standards and mobility:

- Stricter environmental standards will increase the costs of vehicles and at the same time reduce environmental costs. Internalisation means tightening standards to the point where the marginal costs of abatement – the costs required to avoid the ''last'' kilogram of pollution – equal the marginal benefits.[16] This is the optimal situation: any stricter or looser standards will lead to less than optimum welfare.

- Each trip has its own social costs and benefits. A trip contributes to welfare only if the benefits are larger than the costs. Internalisation aims at a situation where all trips with a welfare gain are made and trips leading to a welfare loss are avoided. This leads to maximum welfare. In some circumstances a little less mobility can increase welfare.

So in general, internalisation of transport externalities will increase overall welfare; the benefits will be higher than the costs.

5.4.2. Government

Internalisation will reduce government expenditure on infrastructure, health care and social security. Furthermore, governments will collect the higher use-charges for transport.[17] This report assumes that the full financial gain to governments will be recycled in the economy through lowered tax rates (see also section 5.2). First, to some extent the fixed taxes for road transport need to be reduced in some countries. For the remaining part, general taxes, such as those on labour and income taxes, can be lowered.

5.4.3. Companies

The commercial sector is mainly affected in three ways by internalisation of transport externalities:

- it faces higher transport costs, resulting from higher use-charges and stricter vehicle standards;
- it may benefit from tax cuts, *e.g.* in fixed vehicle taxes, labour taxes and company taxes;
- it sees a reduction in the costs that were related to congestion and production losses following traffic accidents.

The net effect on the commercial sector can be expected to be positive, because higher use-charges are fully compensated by lower taxes, and because the sector benefits from other cost reductions. This does not mean, however, that each individual company benefits. Companies using a lot of transport for their production might experience a competitive disadvantage, while those with labour intensive production processes will benefit more from the tax cuts (see also section 5.5). This differentiated impact at firm level will probably stimulate a shift in the economy towards a less transport intensive production structure and higher labour intensity. It is expected, however, that the shift will be very small because the price increase in transport is modest (see section 5.3) and because companies will respond to this increase first by adapting their production logistics and location (see, *e.g.*, Bleijenberg, 1996).

5.4.4. Consumers

Consumers experience the main financial and non-financial impacts on welfare. Consumers are confronted with higher use-charges, which will reduce growth in mobility. This represents a welfare loss, at least in the short term before spatial patterns of organisation adapt. Higher transport prices and a little less mobility are compensated, however, by lower general taxes, lower vehicle insurance premiums in the long term and various non-financial types of welfare gain, notably: less personal distress, resulting from a reduction in transport accidents; fewer time losses from congestion; and a safer, healthier, more pleasant environment.

Consumers are expected to experience both a small financial gain and an increase in total welfare. As a consequence, reduced mobility – and thus expenditure on transport – results in extra consumption of other goods and services. In general the consumption pattern shifts a little away from travelling long distances and buying products from far away. Again, this shift is expected to be very small, because the increase in transport prices is modest.

5.5. ECONOMIC GROWTH AND EMPLOYMENT

This section discusses the impact of internalisation on GDP growth and employment, taking into account the interlinkages and dynamics of the economy. It includes examination of the economic consequences of reduced traffic growth, but excludes non-financial impacts on welfare. Hence, the outcome of the analysis should be balanced with the relevant non-financial impacts (see section 5.4).

The complexity of the economic process and the role of transport in it can be analysed with the help of macroeconomic models. Before turning to some model calculations, the impact of internalisation on the competitiveness of European industry is discussed, as the relative position of European industry compared to others is a determinant of the economic impact.

5.5.1. Competitiveness

The competitive position of European industry is affected by internalisation policy in three ways: *a)* more expensive transport resulting from stricter vehicle standards and higher use-charges; *b)* reduced general taxation; and *c)* reduced costs from congestion and less loss of production from traffic accidents.

Although the net result can be expected to be positive for business as a whole, specific subsectors might face higher costs. The question is how costs and benefits are distributed among subsectors, with the consequences for industries that compete in international markets most relevant. As no detailed analyses of the consequences for these industries are available, only some general remarks can be made:

- Transport intensive industries face both higher transport costs and lower congestion related time losses. The net effect depends on specific circumstances.
- The policy measures to be selected largely determine the distribution of costs and benefits among subsectors.
- If the competitive position of an industry is harmed by internalisation, specific compensating policy measures can be considered in the total policy package.
- End-use transport prices rise by around 20-30%, but transport costs make up only a few percent of total production costs.
- Companies will probably adapt their logistics and spatial economic organisation a little, reducing the impact on total costs in the longer term.

These general considerations lead to the conclusion that it is unlikely that European competitiveness will be harmed by internalisation of transport externalities. Some distortions require attention, though, especially differences in fuel prices among countries and the position on the European market of non-European transport companies that do not have to comply with strict vehicle standards. The gain in economic efficiency, however, seems to offer enough opportunities to remove such distortions.

In the rest of this section it is assumed that the competitiveness of the European industry is not substantially affected by an internalisation policy.

5.5.2. Economic growth and employment

An indication of the macroeconomic impact of an internalisation policy can be developed with the use of a macroeconomic model. However, hardly any model calculations have been made for transport policy in isolation from general environmental policy. Only for the Netherlands are some specific transport studies available. These and some studies on the macroeconomic impact of a more general environmental policy are discussed below.

The Central Planning Bureau (CPB), the economic institute of the Dutch government, has a long tradition in macroeconomic modelling and assessment of the economic impact of policy alternatives. In a recent report (CPB, 1996) it evaluates several transport policy packages aimed at reducing both pollution and the growth in transport volume. One package assumes a European consensus about far-reaching measures, including very strict vehicle standards, an increase in fuel taxes of around

ECU 1/litre, VAT on flights within Europe and speed limiting devices on trucks. A substantial reduction in growth of road and air traffic is expected as one result of this European policy, which has some similarities with the internalisation approach developed in this report. The revenues of the fuel tax are proportionally recycled in the economy to both households (labour taxes) and companies (employers' part of social security payments).

The main conclusion from the model calculations is that the macroeconomic impact of the policy package is small, despite the substantial shift in consumption patterns. Households shift their consumption away from car driving towards luxury goods (*e.g.* furniture and appliances) and tourism. A similar shift takes place in production: less transport, more services. As a consequence of these shifts total employment increases a little, mainly because of the reduced labour costs.

Similar results were obtained in an earlier Dutch study (Bleijenberg *et al.*, 1990). The results, presented in Table 24, show the macroeconomic impact to be almost negligible. Growth in GDP slows from roughly 25% to 24.6% over ten years. On the other hand, 0.5% more employment has been generated after ten years. There is no recurring inflationary effect; prices rise by a few tenths of a percent but only in the first few years.

Table 24. **Economic impact after ten years of a fiscal package for transport policy**

Package: Fuel tax increased by Gld 1.50/litre; Vehicle tax abolished; Income tax reduced.	Impact: Differences relative to unchanged policy
Budget balance	0.0 percentage points of Dutch GDP
Tax burden (taxes + social security)	–1.5 percentage points of Dutch GDP
Production volume	–0.4%
Employment	+0.5%
Inflation (one-off adjustment of 1.8%)	0
Labour costs	–1.9%

Source: Bleijenberg *et al.* (1990).

Next, some studies assessing the economic impact of environmental policy in general are discussed. First, model calculations by DRI are presented, evaluating two packages of environmental policy in comparison with a reference scenario, in a report prepared for the European Commission (DRI, 1994). The first package consists of policy measures ''in the pipeline'' (PIP), which can be regarded as traditional environmental policy. The second package is called an ''integrated scenario'' (INT) and is based on roughly the same approach as this report: economic efficiency is a major aim and financial instruments are used in combination with traditional command and control policies. There is no increase in the total tax burden, only some shift away from labour taxes towards taxes on natural resource use and pollution. Table 25 summarises the main results.

Table 25 shows that the impact on GDP growth is either slightly negative or positive depending on the policy measures considered. The policies evaluated cause a one-off price rise, but no recurring impact on inflation. Integrating environmental and economic policies generates extra economic growth with environmental results that are better than those of a traditional environmental policy. Extra employment can also be expected from an integrated economic and environmental policy.

Two further reports have evaluated macroeconomic research concerning the impact of such policies on employment. OECD (1996) concludes: ''Most macroeconomic studies of the link between environmental expenditures and employment also confirm the conclusion that the net employment effects (at least at the scale envisaged by these models) is actually likely to be positive over the medium term. The effect on growth is weakened as price rises work their way through the economy, but the positive

Table 25. **Economic impact of two types of environmental policy**

Summary results for EU-6 economies [a]; Difference in annual % growth from 1992 to 2010; PIP and INT *versus* reference scenario

	PIP	INT
Real GDP at factor costs	–0.03	+0.05 – +0.06
Producer prices	+0.09	+0.20 – +0.16
Wholesale prices	+0.05	+0.18 – +0.14
Nominal wages [b]	+0.07	+0.16 – +0.14
Employment	0.00	+0.07 – +0.15

a) France, Germany, Italy, Netherlands, Spain, United Kingdom.
b) Labour costs to the employer.
Source: DRI (1994).

employment effects usually remain relatively robust. However, these studies also suggest that, although the linkage is positive, it is likely to be relatively weak. Finally, a review of literature on the so-called ''double dividend'' (De Wit, 1994) concludes: ''With a very high degree of probability a shift in the burden of taxation from labour to environmental factors will have a favourable impact on employment, particularly in the shorter term, and possibly in the longer term as well.''

5.5.3. Conclusions

The main conclusions to be drawn from this section are:

- the macroeconomic impact of internalisation is likely to be very small and depends on the details of the policy package, including possible mitigating measures;
- the impact on GDP growth may be slightly positive or slightly negative;
- the impact on employment is most likely to be positive.

These conclusions are the result of opposing influences. The slight decrease in the growth in traffic volume is negative for the economy in GDP terms, but is offset by positive effects on GDP resulting from reduced general taxation. The net result is probably very small.

5.6. DISTRIBUTIONAL ISSUES

Distributional issues often play a key role in policy making. These issues relate not to the total level of costs and benefits as discussed above, but to the distribution of costs and benefits across different sectors and groups in society. Fairness is the main focal point of distributional issues.

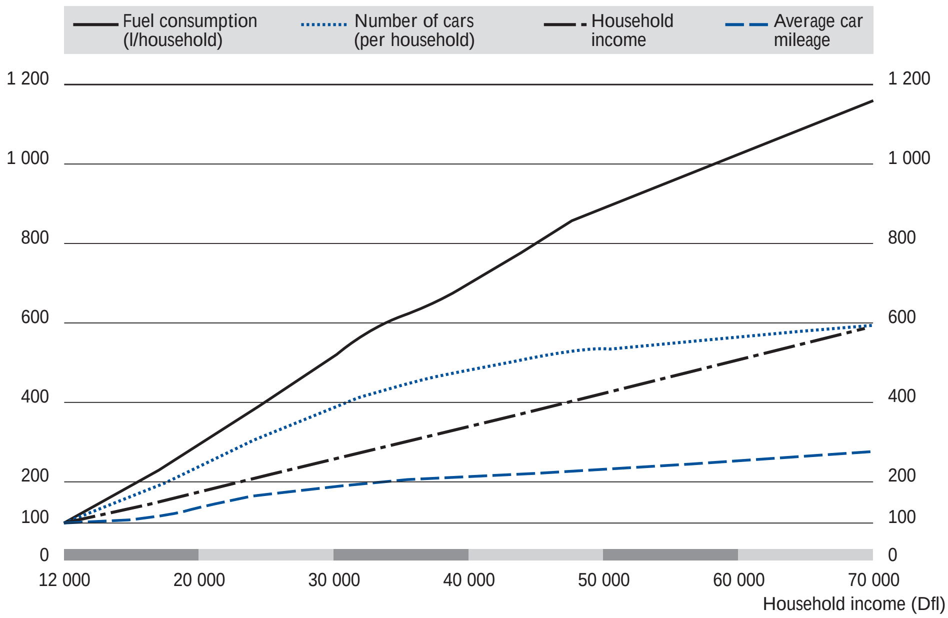
The main issues can be identified as: *a)* sectoral distribution (households, companies and governments); *b)* personal income distribution (low *versus* high income households); and *c)* distribution among countries. The first point is discussed in section 5.4. The remainder of this section considers the latter two topics.

5.6.1. Personal income distribution

A politically sensitive question is whether an internalisation policy specifically affects low or high income groups. To answer this question one must look at both the higher use-charges and the tax cuts suggested. Different taxes have different distributional impacts. For example, an increase in allowances against income tax will benefit mainly low and middle income groups, while a reduction of the top rate will benefit higher income groups. Vehicle taxes and VAT have their own specific consequences for personal income distribution. It would appear that appropriate choices in the detailed design of tax cuts to compensate charges for internalisation can yield almost any desired income distribution (or be tailored so as not to affect the distribution at all). Some data for the Netherlands illustrate this point.

Figure 12 presents the link between household income and car ownership, average mileage and fuel consumption. It shows that fuel consumption increases more than proportionally with household income up to a net income of around Gld 30 000 a year, and for higher income groups it increases proportionally with income. So fuel charges have less impact (in terms of percentage of net income) on low income groups than on middle and high income groups. If the revenues of fuel charges were to be redistributed equally to each household, low income groups would benefit from this policy package, while middle and high income groups would face increased costs.

◆ Figure 12. ***Car ownership and use related to household income, Netherlands, 1994***



Source: Davidson (1996).

Fuel charges, km-charges and annual vehicle taxes all have different impacts on income distribution. Charges per car-kilometre, not taking into account the size of the car, affect low and middle income groups more than households with higher income (in percentage of household income). Annual vehicle taxes, on the other hand, will put the largest burden on middle income groups. It should again be stressed that the tax cuts used to recycle the charge revenues will largely determine the net impact on personal income distribution.

As a further illustration, Table 26 presents the impact of two policy packages on income distribution. Both packages contain an increase in fuel charges of ECU 0.25/litre. The first assumes that the revenues are recycled through a reduction of the annual vehicle tax, while in the second the income tax is lowered via a tax credit for employed people.

Package 1 has a progressive impact on income distribution, while package 2 mainly affects middle income groups. A combination of these two packages and other tax cuts could indeed generate any politically desired income distribution.

Table 26. **Impact of two policy packages related to personal income distribution, Netherlands**

Average household income (ECU)	6 000	8 000	13 250	17 000	20 500	24 000	35 000
Change in expenditure (%)							
Package 1 fuel charge reduced vehicle taxes	–0.32%	–0.34%	–0.30%	–0.25%	–0,22%	–0.06%	+0.14%
Package 2 fuel charge reduced income tax (tax credit)	–1.50%	+0.23%	+0.44%	+0.37%	+0.10%	+0.03%	–0.10%

Source: Davidson (1996).

5.6.2. Peripheral countries and regions

Another important issue is the distribution of costs and benefits of an internalisation policy among countries. As Chapter 4 established, revenues from use-charges need to go to the country where the costs related to traffic are generated (territoriality principle). From this point of view an electronic km-tax for HGVs is preferred over a fuel charge, because the country where fuel is purchased is not necessarily the country where the fuel is used.

This section discusses another distributional issue: the position of so-called peripheral countries and regions. Higher use-charges for transport could perhaps impede the economic development of peripheral regions and prevent them from catching up with wealthier regions. Several policy responses are possible, but the matter requires close attention.

First, note that improved or cheaper transport between central and peripheral regions does not necessarily benefit the peripheral economies. It may instead strengthen the position of central regions, allowing their markets to expand and giving them even greater economies of scale. It is not easy to predict which regions benefit most from improved or cheaper transport; many factors affect the economic outcome.[18]

Assume for the time being that cheaper transport between central and peripheral regions does indeed benefit the peripheral economies. Rather than being an argument against the suggested internalisation policy, this suggests that transport between central and peripheral regions should be exempted from higher use-charges – in effect, subsidising transport from and to peripheral regions. (It should be stressed that any arguments in favour of subsidised transport to and from peripheral regions do not imply that all transport should be subsidised.) Thus, internalisation policy could accord special treatment to transport to and from peripheral regions.

Next, the question arises whether subsidised transport is the best way to counterbalance any possible negative impacts for peripheral regions. It is clear that subsidies generate distortions and result in a more than optimal amount of transport, along with related externalities. From an economic point of view less distorting income transfers to the peripheral regions would be preferable. These might also be more beneficial for the peripheral regions, reducing the advantage that central regions would reap from subsidised transport and leaving governments of peripheral countries free to use revenues from transport charges as they saw fit, redistributing them in the way best suited to the distributional needs of their country.

5.6.3. General

Some general remarks with respect to internalisation and distributional issues are appropriate here. The main aim of internalisation is to increase economic efficiency. If this were to lead to a distribution of costs and benefits which is not desired, the first step would be to search for additional policy measures to mitigate the undesired impact. This approach makes it possible to achieve both economic efficiency and the desired distribution of costs and benefits.[19] Thus additional policy measures aimed at achieving the desired income distribution might be needed in combination with an internalisation policy.

Political interest may often be focused more on the distribution of costs and benefits among countries, or groups in society, than on the overall efficiency gains which can be achieved. Therefore distributional issues must be addressed in policies for greater economic efficiency.

NOTES

1. This section deals with so-called pecuniary externalities, which are incorporated in market processes.

2. If the marginal costs of externalities are higher than the average costs, efficient prices generate more money than the total damage caused. This "producer surplus" is in fact a perfectly non-distortionary tax (see last part of this section). Other, distorting taxes can be lowered in this case.

3. Note that optimal economic allocation is the main goal of internalisation. The same starting point is now used to discuss the tax system.

4. This corresponds with observations elsewhere in the report: use-charges are mainly aimed at achieving economic efficiency and fixed charges are suggested to solve distributional issues (*e.g.* full cost coverage).

5. This relates to European averages for gasoline cars, which can be different for each country. The estimates are based on Annex D Tables D4 and D5, with the assumption that the variable costs are ECU 0.10/km.

6. Current total costs are estimated at ECU 0.25/v-km.

7. The estimated external costs amount up to around ECU 11.7 per 1000 p-km (Annex B). The uncovered infrastructure costs are estimated at ECU 12.4 (Annex C). Furthermore, it is assumed that current rail fares are on average ECU 100 per 1000 p-km. Finally, it is assumed that existing government support to the operational costs are continued under PSOs. If the latter would not be the case, rail fares would increase much more.

8. This estimate does not include the imposition of VAT or elimination of tax free sales at airports and in planes. The European Union may end these tax exemptions for flights within Europe.

9. To adjust for accident and environmental costs (see Annex D, Table D5), with no adjustment related to infrastructure costs, which are assumed to be roughly covered.

10. To adjust for accident and environmental costs (see Annex D, Tables D4 and D5) and infrastructure cost undercoverage (see Annex C). The current average price per t-km is estimated at ECU 0.13.

11. Uncovered infrastructure costs are estimated at ECU 0.023/t-km (see Annex C); external environment and accident costs are taken from Annex B; the current average for rail freight tariffs is estimated at around ECU 0.04/t-km.

12. This assumes a required fuel charge of ECU 0.30/litre (see section 4.4); current fuel prices are ECU 0.13/litre for inland waterways and ECU 0.08/litre for sea shipping; current fuel costs are estimated at 10% of total costs.

13. There exists quite a lot of uncertainty about the level of price elasticities, because the price changes are more than marginal and because long term changes are generated.

14. Mobility, however, is not necessarily a very good indicator of the benefits of transport, which are more properly determined in terms of access.

15. Welfare is the utility derived from the use of produced goods and services (financial) and other goods and services (non-financial), such as a clean environment, leisure time and health.

16. The benefits of reduced pollution are both financial (*e.g.* reduced damage to crops and forests) and non-financial (*e.g.* a more pleasant environment). Under the assumption that the same environmental targets have to be met with or without stricter standards, the benefits of reduced pollution are equal to the avoided costs of abatement measures which would otherwise have had to be taken.

17. If infrastructure is privatised both the cost of infrastructure and the use-charges will be shifted to a private company.

18. For an overview of different positions and determining factors, see (*e.g.*) Bleijenberg *et al.* (1996).

19. This is the "Rule of Tinbergen": If you want to achieve two (or n) goals, you need two (or n) policy instruments.

Chapter 6

INTERNALISATION IN TRANSITION ECONOMIES

TABLE OF CONTENTS

6.1. INTRODUCTION

This chapter addresses policy responses to the external costs of transport in transition economies, on the basis of experience in Poland and the Czech Republic, as reported by their Ministries of Transport. Like other central and eastern European countries, they are characterised by several features that have an important bearing on the development of policies towards the external costs of transport.

The establishment of market mechanisms in transport and elsewhere in the economy is not yet complete, and other significant economic and social problems inevitably take priority over transport costs in the legislative and policy-making agenda. Most transition economies, like the rest of Europe, have relatively dense road and rail networks traversing many towns and villages. The environment is polluted across large areas, though the pollution is not always related principally to transport. The share of transport in total emissions is lower than the European Union average, but as emissions from stationary sources are reduced and road traffic increases, the trends will move towards convergence.

Poland, the Czech Republic and, to varying degrees, other European transition economies are beginning to experience negative effects of transport similar to those witnessed in EU countries. Public opinion now requires the adoption of policies to substantially mitigate these effects, in particular those related to traffic accidents, congestion, air pollution, global warming and noise.

The outlook for the transport sector in transition economies largely reflects national demographic and economic developments. Table 27 summarises characteristics of Poland and the Czech Republic.

Table 27. **Economic indicators in Poland and the Czech Republic**

	Poland	Czech Republic
GDP	Estimated at US$5 000 (1994) per capita (PPP), or one quarter of the OECD average. Industrial production now growing rapidly (*e.g.* transport equipment up 23% in 1994)	Per capita GDP estimated at 40% of OECD average. GDP down to 78% of 1989 level in 1993; grew thereafter to 85% in 1995.
Population	Constant	Constant
Inflation	585% in 1990, 35% in 1994, 22% in 1995	8.8% in 1996
Unemployment	16% at the end of 1994.	Over 4% (for first time).
Private sector share of GDP	31% in 1990, 55% in 1994.	

Source: Ministry of Transport and Maritime Economy, Poland; Ministry of Transport and Communications, Czech Republic.

In both countries the volume of rail traffic is falling, though the modal share for rail is higher than the EU average. The shares of air and inland waterway traffic are low. Road traffic is increasing, from a relatively low base. The volume of road haulage has risen in step with GDP. Passenger car traffic has grown considerably.

In Poland in 1980 the number of passenger cars per thousand inhabitants was only 61, but it more than doubled over the period 1990-92, to 167. Forecasts suggest the figure will be 269 by 2000 and 397 by 2010. In the Czech Republic car ownership increased from 220 per thousand in 1989 to 302 in 1995 and is forecast to rise to 420 by 2000. Though the average age of the car fleets in these countries is higher than in the European Union, the structure is slowly improving in favour of new cars equipped with catalytic converters.

Table 28. **Share of western technology vehicles less than 6 years old in Polish fleet, 1990**

	Number of vehicles (thousands)		
	Passenger cars		Trucks
	Gasoline	Diesel	
Total	4 998	263	483
Western technology vehicles < 6 years old	240	13	17

Source: Ministry of Transport and Maritime Economy of Poland.

Many used cars from western Europe, often repaired after accidents, are sold in Poland and some other countries in central and eastern Europe. This influences safety on the roads. It also explains the difference between the large share of western cars in Poland's total passenger car fleet – 20% – and the relatively low share of western cars less than six years old: about 7%.

With the growth in road haulage and in the number of cars in central and eastern Europe, the negative impact on the natural environment will almost inevitably intensify. Average annual mileage of motor vehicles in Poland in 1990 was assessed at 6 500 km for gasoline cars, 15 000 km for diesel cars, 24 000 km for trucks and 39 000 km for buses. Except for trucks, annual average mileage has declined, but it is assumed that in the next few years it will grow again.

6.2. VALUATION OF ENVIRONMENTAL EXTERNALITIES

To obtain accurate, reliable data on external effects, the choice of methodologies is important. Most of the evaluation methods examined in this report have not been applied so far in central and eastern European countries.

The relatively low level of theoretical and practical knowledge in estimating externalities in most of central and eastern Europe, and the lack of the complex databases required, has far-reaching implications. For instance, it is difficult even to specify the number of new vehicles in Poland, since such statistics were not traditionally kept. There is no experience in analysing the transport market in relation to stated preferences.

In most cases air pollution from mobile sources has been measured only sporadically. Most measurements have involved just one kind of pollution or have had a limited time dimension (*e.g.* half-hourly measurements over a short period or measurements taken over a number of years only once a year). However, the results of even these examinations highlight the problem of CO and NO_x emissions in urban areas. It has been estimated that in the biggest cities in Poland, 70-80% of all pollution results from car emissions.

In Poland, monetary valuation of the external costs of transport is not advanced and most valuations are based inappropriately on existing ecological and infrastructure charges. These estimates are thought to be five to ten times lower then actual costs because the current very small charges are inadequate compared to actual levels of nuisance. In a few cases the hedonic price method has been partly applied, *e.g.* to estimate the relationship between house prices and noise levels.

As an example of the difficulties of estimating externalities with insufficient data, the case of the number of dwellings in Poland exposed to different levels of noise is revealing. So far no regular measurements of the intensity or growth of transport noise have been made. According to research done between 1987 and 1989, 21% of the land area of Poland is affected by noise at a level of 60 dB(A) Leq or more, but it is impossible to make direct comparisons with EU countries. The first difficulty is in setting a threshold below which no significant damage is assumed to occur. In Poland the threshold for external noise (outside a building), beyond which noise disturbance and its negative influence on health and psychology grows quickly, is usually taken to be 69 dB(A), while governments in EU countries consider the appropriate level to be 55 dB(A).

Figures 13 and 14 show results of recent research at the University of Gdansk, based on interpolation of data from other countries using: the known level of transport noise in Denmark, the Netherlands, Germany and Switzerland; the amount and intensity of vehicle traffic in Poland; and estimated noise indexes of Polish vehicles in relation to German vehicles. A value of 55 dB(A) Leq was taken as the threshold noise level, corrected for subjective differences in perception of the same noise levels. Lack of data prevented differentiation by night and day.

Figure 13 shows the share of dwellings exposed to different levels of noise in Poland. At almost all levels, road traffic noise annoyance predominates. The number of dwellings exposed to aviation noise is relatively slight.

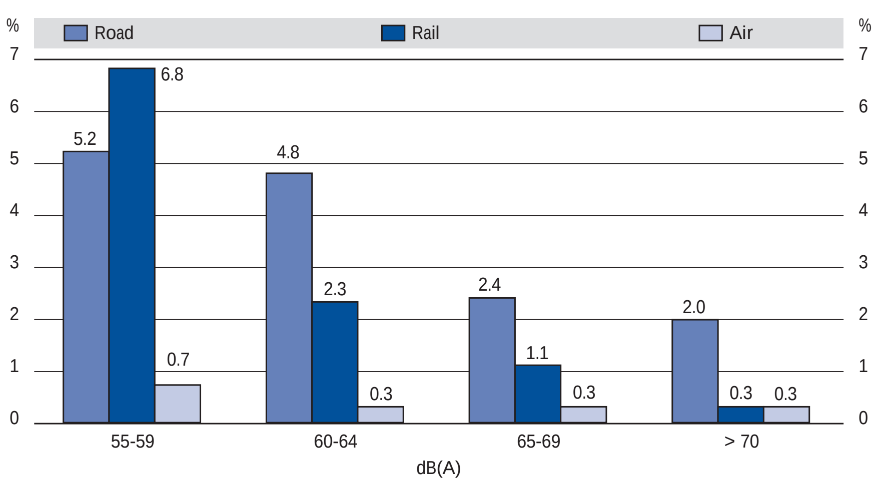
Figure 14 shows the share of dwellings exposed to more than 55 dB(A) in Poland and three other European countries. Swiss dwellings are exposed to the worst road traffic noise. In Poland a significant share of dwellings are exposed to railway noise. Tables 29 and 30 present equivalent data for the Czech Republic.

The only available estimate for total exposure to aircraft noise in the Czech Republic is around 9 000 people, 0.1% of the population, exposed to noise levels above 85 dB(A).

No noise avoidance cost estimates have been determined in Poland and the majority of the proposed solutions for reducing noise nuisance have not been implemented to any great degree. The same is probably true of many other central and eastern European countries.

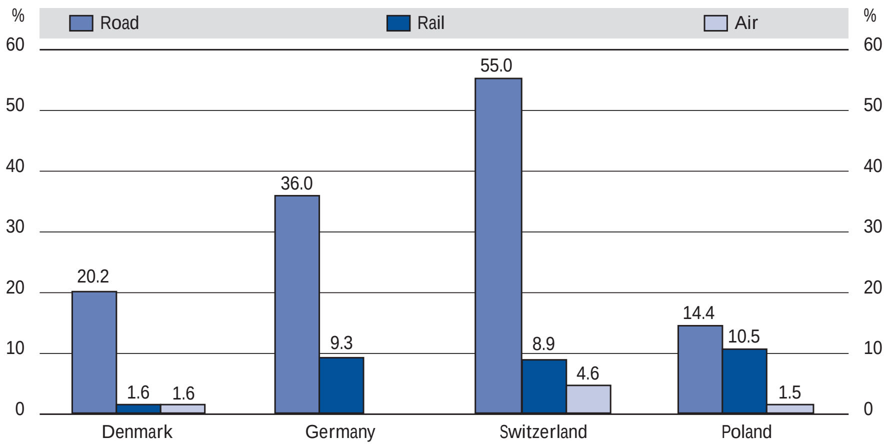
In Poland, as in most other central and eastern European countries, shadow prices for transport externalities have not been estimated, or where partial valuations have been made, they are not reliable because of data insufficiencies like those described above for noise nuisance.

◆ Figure 13. ***The share of dwellings in Poland exposed to more than 55 dB(A) noise***



Source: University of Gdansk; Ministry of Transport and Maritime Economy, Poland.

◆ Figure 14. ***The share of dwellings exposed to more than 55 dB(A) noise***



Source: University of Gdansk; Ministry of Transport and Maritime Economy Poland.

Table 29. **Exposure to road transport noise in the Czech Republic**

Zone (noise level)	Number of people exposed	Proportion of population exposed
Total above 65 dB(A)	1 395 000	13.5%
of which: 65-69.9 dB(A)	591 000	5.7%
70-74.9 dB(A)	711 000	6.9%
75-79 dB(A)	93 000	0.9%

Source: Ministry of Transport and Communications, Czech Republic.

Table 30. **Exposure to rail transport noise in the Czech Republic**

Zone (noise level)	Number of people exposed	Proportion of population exposed
Total above 65 dB(A)	120 000	1.2%
of which: 65-69.9 dB(A)	57 000	0.6%
70-74.9 dB(A)	55 000	0.6%
75-79 dB(A)	8 000	0.1%

Source: Ministry of Transport and Communications, Czech Republic.

6.3. ESTIMATES OF THE SIZE OF TRANSPORT EXTERNALITIES IN RELATION TO GDP

In most central and eastern European countries, total external costs for transport either have not been estimated or the results of valuation are not reliable for the reasons discussed above. Wronka *et al.* (1995) estimated external costs for Poland in terms of percentage of GDP (Table 31), on the basis of the following ecological and infrastructure charges:

- air pollution costs – charge system for polluting the environment;
- water and soil pollution and land-take costs – charge system for using water and land;

Table 31. **External costs of road and rail transport as a percentage of GDP in Poland**

Externality	Road transport (% of GDP)	Rail transport (% of GDP)
Air pollution	0.33	0.003
Water and soil pollution	0.05	0.004
Noise	0.09	0.01
Accidents	1.0	0.002
Land-take	0.25	0.04

Source: Wronka *et al.* (1995).

- noise costs – decrease in house values;
- accidents – estimated uncovered costs of accidents (fragmentary application of WTP method).

See the previous section for comments on the inadequacies of the methodology. The resulting estimate of total external costs, below 2% of GDP, can be treated as a minimum value.

In the Czech Republic, although the methodology for quantifying the external costs of transport is not yet mature enough for application, the Ministry of Transport and Communications is reviewing the various approaches treated in Annex A to determine their applicability to the transport sector. In particular transposition of physical effects into financial terms is under examination.

While comprehensive quantification of the external costs of transport is lacking for the Czech Republic, the Ministry of Transport and Communications believes the values presented in the Executive Summary of this report are an appropriate first approximation. In the view of the Ministry it is reasonable to assume that transport externalities are likely to show a similar relation to GDP in countries with at least partially similar economies; on this basis, external costs in the Czech Republic can be estimated as shown in Table 32.

Table 32. **External costs of transport in the Czech Republic**

Type of externality	Size (% of GDP)
Accidents	1.25-2.50%
Noise	0.20-0.65%
Air pollution	0.25-0.65%
Global warming	0.5-2%
Congestion	up to 2%
Infrastructure	*
Total	2.2-7%
Central value	4-5%

* For rail transport, about ECU 10/p-km and ECU 20/t-km remain uncovered; for road transport, charges exceed costs, notably for passenger transport.
Source: Ministry of Transport and Communications, Czech Republic.

6.4. POLICY DIRECTIONS

Although the internalisation of transport externalities is not the primary objective of transport policy, some direction and aims concerning the reduction of the negative aspects of transport are evident in transport and environment policies in central and eastern Europe.

Czech government policies

The government applies principles set out in the document "Transport Policies of the Czech Republic for the 1990s" in regard to reducing the environmental load caused by traffic. The document is being revised with the intent of ensuring implementation of international obligations, notably the UN Framework Convention on Climate Change and related ECMT Resolutions.

To ascertain the burden for which transport is responsible, forecasts of transport demand are under way, together with a range of research activities. The following sections describe the main projects.

Harmonisation of economic conditions in transport markets, including externalities

The project, scheduled for 1996-98, includes:

- analysis of Czech transport policy in relation to the European Union;
- analysis of state budgetary expenditure on transport infrastructure in comparison to taxes levied on carriers, by transport mode;
- analysis of the externalities engendered by each mode of transport;
- proposals for the regulation of economic conditions to ensure harmonisation with conditions in the European Union, including the incorporation of external effects;
- incorporation of externalities into quantitative economic and ecological evaluations;
- proposals for administrative and organisational measures.

Stabilisation and gradual lowering of the environmental load caused by transport

This project, completed in 1995, was based on a comprehensive analysis of current and future developments in transport activity and its environmental impact. The objective was to suggest measures to ensure optimum regulation of transport operations. The proposed regulatory package also takes account of international commitments and foreseeable developments, including the UN/ECE Regional Conference on Transport and the Environment of 1997, the ECMT-industry Joint Declaration on reducing CO_2 emissions from new passenger cars and the ECMT report on CO_2 emissions from transport. The current package comprises 19 general measures and 32 mode-specific measures. The following measures aimed at reducing CO_2 emissions form a basic part of the package:

- optimisation of traffic on selected road routes, together with enforcement of speed limits;
- tariff measures to favour public road transport, urban mass transit and railway passenger traffic;
- preference for the development of electric traction;
- support for the development of integrated passenger transport systems;
- support for the development of trans-shipment centres for combined freight transport;
- bilateral international agreements for regulating international road haulage;
- preferential treatment for carriers providing public passenger transport;
- support for the use of alternative drive systems and fuels;
- support for educational activities focused on improving the efficiency of transport.

Tax System Act

This Act, not yet implemented, introduces taxes aimed at improving environmental protection. It concerns all branches of the economy. More generally, favourable VAT and road tax rates are applied to environmentally friendly modes of transport – electric vehicles, combined transport and some public road passenger transport, including urban public transport.

New transport policy strategy

Application of the principle of internalising externalities is to be considered in this strategy. Such application should lead to a gradual transformation of the charging system for transport, creating incentives to reduce external costs. It is believed that application of the polluter pays principle can be achieved only in steps. Internalisation is considered a key to harmonising competitive conditions between transport modes.

Polish government policies

Environmental policy

Substantial progress in environmental protection hinges on restructuring of the economic areas that pose particularly great threats to the environment (*e.g.* energy production, industry, transport), as well as wider application of ecological development principles in economic areas that are directly involved in exploiting such natural resources as water, minerals and soil. The Polish Ministry of Environmental Protection and Natural Resources, in the July 1992 document "Polish Environmental Policy", presented the principles of ecological policy and the priorities of environmental protection in Poland.

The following elements are regarded as essential:

- consideration of the results of detailed ecological analysis in transport policy to facilitate appropriate distribution of projects for road, rail, sea and air transport, as well as public and private passenger transport;
- development of transport systems that cause the least possible harm to the natural environment;
- a system of incentives for ecologically sound initiatives in transport;
- introduction of environmentally friendly fuels;
- introduction of regulatory laws concerning pollution and noise from combustion engines, in congruence with UN/ECE regulations and with the regulations of its committee on environmental protection that Poland has ratified;
- organisation and implementation of roadside inspections to guarantee that vehicles comply with environmental protection requirements.

Considering the degree of neglect in the area of environmental protection and the limits on funding available for ecological initiatives in the immediate future, it is important to determine priorities when formulating objectives and financing projects. High priority short term projects (*i.e.* to be realised in three to four years) should redress shortcomings and hazards that pose a direct threat to health, life and the country's most valuable natural resources. Short term priorities with regard to transport include: initiation of a programme to restrict the detrimental environment effects of passenger and freight transport; and introduction of universal vibro-acoustic test standards for transport machinery, vehicles and exhaust systems.

Medium term priorities (within ten years) include projects aimed at limiting ongoing environmental degradation. Their realisation should allow Poland to approach EU environmental protection standards. With regard to transport, medium term priorities include: reducing emissions of SO_2 by 30%, NO_x by 10% and dust by 50%, along with reductions in emissions of VOCs; and implementing anti-noise and anti-vibration initiatives, including purchases of new rolling stock for urban passenger rail, wide application of noise barriers, better management of air traffic, and insulation requirements for buildings.

Long term objectives are those that will take 25-30 years to realise. Long term priorities relating to transport include: use of catalytic converters on all cars, reduction of SO_2 and NO_x emissions by 80% and reduction of CO_2 emissions to a level agreed upon by the international community.

Energy policy

The executive branch of the Ministry of Industry and Trade deals with the difficult questions of Polish energy policy. The results of its work are two fundamental documents: ''Industrial Policy Assumptions Implementation Program 1993-1995'' and ''Assumptions of Poland's Energy Policy: an outline of the program to the year 2010''. The main industrial policy strategy concerning environmental protection involves rebuilding the industrial subsectors that represent the greatest ecological threats. An important area for this policy is energy production. Objectives for the restructuring of the fuel and energy industries include ensuring:

- efficient use of fuel and energy;
- minimisation of the negative effects of energy production and use on the natural environment;
- safeguards on the competitive power of the Polish oil refining industry as well as fuel quality that meets environmental norms.

Transport policy

The Ministry of Transport and Maritime Economy, in its document ''Transport policy'' (June 1995), sets forth the main goals of transport policy, including initiatives that produce socio-economic effectiveness, increase safety, improve the financial situation of Polish transport firms and facilitate solutions to the most pressing ecological problems (*e.g.* by reducing exhaust and noise). Ecological threats and poor traffic safety are forcing public officials to take action.

6.5. ECONOMIC IMPLICATIONS

In Poland, as in most central and eastern European countries, no research on the economic implications of internalisation instruments has been undertaken. Some studies in Poland simply warn against increasing the fiscal burden on Polish road transport companies and suggest that implementing internalisation policies will reduce the competitiveness of Polish transport firms in the European market. At least in the short term, any assumption that an increase in use-charges can be offset by a decrease in fixed taxes is not realistic because of current Polish conditions, with the Finance Ministry having a policy of limiting reductions in fixed taxes.

The Czech Ministry of Transport believes that internalisation is in the interest of the national economy and thus taxes and charges must be reformed to provide the necessary incentives to reduce external costs while avoiding a substantial increase in the overall burden of taxation for transport users or an increase in charges that would restrict mobility. The Ministry stresses the need to balance conditions for domestic and foreign transport operators so that the competitiveness of domestic carriers does not decline. It may also consider limited use of targeted subsidies to the transport sector, while respecting EU regulations such as the Guidelines on State Aid for Environmental Protection.

6.6. EXISTING NATIONAL INSTRUMENTS FOR INTERNALISING EXTERNAL COSTS

All countries in central and eastern Europe have regulatory and fiscal instruments that provide, or could provide, incentives for internalisation of transport's external costs. The current period of change, of which tax reform is an important part, provides a significant opportunity to incorporate incentives in tax instruments. Examples are given below for the Czech Republic and Poland.

Czech Republic

Several instruments, mainly of a fiscal character, are available to support a downward trend in the adverse impact of transport in general and road transport in particular. Further opportunities are apparent as well: for example, the current tax system results in a price differential that favours leaded over unleaded gasoline.

The existing *annual road tax* is differentiated according to vehicle categories defined in law. The difference between the charges for heavy goods vehicles and for passenger cars takes fully into account the greater impact of the former in terms of carriageway wear and environmental damage. The lowest tax rate (vehicles up to 1 tonne) is Kc 1 800 per year; the highest (vehicles over 36 tonnes) is Kc 44 100 per year. For vehicles that meet strict environmental protection criteria (passenger cars with three way catalytic converters, for example), the tax is forgiven or reduced under a regulation in effect at least to the end of 1998.

A *charge for the use of motorways and restricted-access roads* has been introduced. Once paid (indicated by car stickers), this charge provides no incentive with regard to the decision to travel. It may also have a negative impact by diverting traffic off motorways. The annual charge is Kc 400 for vehicles up to 3.5 tonnes gross laden weight, Kc 1 000 for 3.5 to 12 tonnes and Kc 2 000 for cars over 12 tonnes. Changes to the levels of the charge and to institute congestion management are under consideration.

The *excise tax* on hydrocarbon fuels and lubricants amounts to about 50% of the retail price. As it is applied equally to all kinds of gasoline, it leads to higher prices for unleaded than for leaded petrol, an unfortunate effect, overcome by oil suppliers through a voluntary price agreement initiated by the Ministry of Industry and Commerce.

Value added tax is levied at 22% or 5%, depending on mode of transport.

Applying *conditions to the import of used cars* has been considered but so far postponed.

Restriction of heavy freight traffic on roads is in effect for weekends and holidays. A number of exemptions apply, *e.g.* for the transport of perishable goods.

Transit of cars through the centres of larger cities is restricted and there are charges for parking. These regulations, mainly affecting Prague, should help reduce the number of cars in city centres.

Potential future instruments for the internalisation of external costs are under consideration. These include not only economic but also regulatory instruments. They also cover better enforcement of existing regulatory requirements and the targeted application of subsidies.

Poland

Only a few instruments in effect in Poland can be regarded as leading to reduction of negative transport externalities. These are mostly reductions of or exemptions to fiscal charges.

Annual vehicle tax rates are set by the Finance Ministry. They depend on the capacity of trucks and engine displacement of passenger cars. The revenue from this tax goes to municipal budgets. Municipal authorities have the right to reduce the rates. In most municipalities substantial reductions are given for LPG-fuelled cars (20-30%) and for vehicles not more than four years old (10-20%).

Poland, like most countries in Europe, levies *excise duties on motor fuels* at a fixed amount per litre. The level of tax has risen in recent years. Again as in most other European countries, the excise tax on diesel fuel is lower than that on gasoline. There are no special taxes, such as environmental damage taxes, on motor fuels. All fuels are also subject to VAT at the basic rate of 22%, except for LPG, to which a reduced rate of 7% is applied.

Heavy goods traffic on roads is restricted, as in many European countries. A prohibition on trucks exceeding 16 tonnes was introduced for national holidays by a decree of the Minister of Transport in September 1996.

Incentives for the purchase of new vehicles have been introduced: an increase of the import duty on old cars, and a prohibition of imports of vehicles more than ten years old.

Future developments being considered that could reduce the negative effects of transport are:

- shifting the balance of taxation in transport towards use-charges rather than fixed taxes, and a possibility of incorporating the vehicle tax in the price of fuel;
- restricting HGV traffic on weekends, which was to be introduced in the second half of 1998 but was delayed because of infrastructure deficiencies, especially a lack of parking;

- changes in the system of sales taxes on new motor vehicles, especially in regard to excise tax. Current sales taxes alter consumer behaviour by discouraging the replacement of old and less environmentally friendly vehicles with new ones. Consumers have to pay a registration fee, customs duty if they buy an imported vehicle and excise tax or luxury car duty if the car's price exceeds ECU 7 000, at a rate of 10% for domestically produced and 15% for imported cars. In this system, cars equipped with ABS or an airbag are much more expensive.
- introducing road use-charges and tolls to finance the extensive motorway construction programme.

6.7. MAIN OBSTACLES TO INTERNALISATION OF EXTERNALITIES

Current transport policies in central and eastern European countries take no real account of the external costs of transport. There are no specific policies for the creation of incentives for consumers to change decisions in ways that could reduce environmental costs. Generally, road transport demand is sharply rising, leading to growth in negative external effects.

In theory, external costs should be estimated and valued in monetary terms so that they can be brought into the market mechanism. But in practice obtaining such estimates is extremely difficult in central and eastern European countries. It is easier to define environmental targets without reference to absolute costs and apply policy measures intended to steer the transport sector towards these targets. At least in the short term, this will continue to be the preferred approach.

The obstacles to use of internalisation instruments can be divided into the following categories.

Political obstacles

The negative impact of transport is a sensitive issue in most countries of the region, but is not yet a critical issue. In populations used to a standard of living lower than that in EU countries, ecological awareness is less developed. Hence internalisation policies will be politically more difficult to put across in central and eastern Europe.

Relatively low purchasing power makes the impact of some measures (*e.g.* restrictions on used car imports) harder on consumers, undermining support for environmental protection policies.

The generally prevailing opinion within government administrations is that the economy does not yet generate sufficient financial resources to allow expenditure on environmental protection.

Administrative institutions have insufficient knowledge about reliable estimation of external costs and how to implement internalising instruments efficiently.

Differences of interest among local, regional and central authorities are significant. In Poland, for example, road transport charges fund local as well as central government budgets and special earmarked funds. Any change in the flow of fiscal resources meets strong local opposition. Plans to incorporate vehicle tax in the fuel price in Poland are highly controversial because the vehicle tax currently funds local budgets while all fuel tax revenue goes to the central budget. In the past it has proved extremely difficult for local government to recover financial resources supplied to the central budget.

In some countries, including the Czech Republic, treasury policy rules out the creation of earmarked taxes despite their attractiveness in gaining acceptance for specific taxes.

Social issues

Because of the relatively low purchasing power, there is more need to avoid abrupt increases in charges, such as fuel taxes that would result in a considerable restriction of passenger car use.

In a period of rapidly increasing access to private motor cars, from a relatively low base, central and eastern European societies generally choose not to be concerned with the need to contain the external costs of transport, despite the extent to which they are affected by these costs.

Economic barriers

State budgets in central and eastern Europe, even where balanced, are tight, without substantial reserves. Thus experiments with and alterations to the tax system that could have unpredictable macroeconomic consequences are difficult to entertain.

It is extremely important for increased transport use-charges to be offset by reductions in taxes elsewhere if consumers and the economy as a whole are not to suffer. Uncertainty about ensuring this balance makes increased use-charges extremely difficult to reconcile with policies to contain inflation. Deregulation of prices in other areas, such as power and housing, takes precedence and has already put strains on inflation as measured by consumer price indexes.

In western Europe, revenue from road transport is generally roughly in balance with government expenditure on roads while expenditure on railways generally exceeds revenue in that sector. In central and eastern Europe, the balance is sometimes very different. For example, in Poland only one-fourth of transport tax revenue is reinvested in the transport sector; the rest supports national expenditure on items such as health and education.

Technological obstacles

Technological barriers are most significant in the case of advanced instruments, *e.g.* mileage tax or electronic road pricing. The introduction of such charges would make sense only if applied throughout all of Europe. At this stage, expecting application in Poland alone, for example, is not realistic.

Legal and institutional barriers

The legal frameworks of the countries of central and eastern Europe are still undergoing restructuring and amendment following the upheavals of the late 1980s and early 1990s. Legislative agendas remain heavily charged. Some laws, especially those that have undergone repeated amendment, are open to alternative interpretations. For example, there are major inconsistencies in parking regulations in Prague.

6.8. CONCLUSIONS

Few reliable data on external costs of transport have been collected in central and eastern Europe. Estimates of external costs are therefore characterised by relatively great uncertainty and aggregation. The estimates that have been made are generally lower than for other ECMT countries. This reflects, in some cases, methodological deficiencies and, more generally, lower levels of road passenger and freight movements. Strong growth in road traffic is forecast. Sharp increases in accident rates since 1989 illustrate the potential for rapid changes in trends. On certain routes external costs are already severe, exacerbated by outdated technology, inadequate vehicle maintenance and bottlenecks resulting from infrastructure inadequacy.

The adjustment to more market oriented economies has already led to the adoption of fiscal instruments suited to implementation of internalisation policies. Although the levels of charges such as fuel excise duty are low in many of the newer ECMT Member countries, in a number they are already close to, or even above, levels in western Europe's largest economies. Where existing charges are very low, it may take longer to reach levels required for internalisation, although some countries made a rapid transition to high levels of charge.

Establishing regulatory and charging structures appropriate to internalisation is possible even if charges at a level to create sufficient incentives would not generally be acceptable in the short term. Taking initial steps now towards eventual internalisation would enable countries to avoid obstacles to internalisation policies when these become urgent to contain external costs during the coming projected period of rapid growth in road and air transport demand.

This report's general conclusion that instruments for internalisation should be phased in gradually to avoid economic shocks, is particularly important in the context of economies in transition.

Annex A

VALUATION METHODS FOR THE ENVIRONMENTAL EXTERNALITIES OF TRANSPORT

TABLE OF CONTENTS

A.1. INTRODUCTION TO ENVIRONMENTAL VALUATION

A.1.1. Economic value and economic efficiency

Economic value derives from the preferences of individuals. In a market, these preferences are revealed by consumer behaviour. The preferences are expressed through individuals' willingness to pay for a good. The "willingnesses to pay" of all consumers taken together form the demand curve for a good. The objective of valuing a non-marketed good is to estimate individuals' willingness to pay (WTP) values for that good.

There are three basic concepts of value in economics: total value, average value and marginal value. Values can be positive (benefits) or negative (costs). To illustrate the concepts: for a produced good, total cost is the entire expense of producing a certain quantity of the good. Average cost is the cost per unit. Marginal cost is the increase on total cost incurred by producing one additional unit.

Economic efficiency refers to a situation of maximising net benefits. This occurs where marginal benefits equal marginal costs: that is, where the extra benefit arising from the last unit of output is the same as the extra cost of its production. At this point, total costs will not equal total benefits; rather, the excess of benefits over costs will be maximised: this is net social benefit, analogous to profit for a firm.

Economic efficiency is only one of the goals a decision maker may subscribe to; another is equity or "fairness". Using individual preferences as the indicator of value, the assumption is implicit that the underlying distribution of wealth and income is optimal. This is because willingness to pay is partly determined by ability to pay – that is, the wealth and income of individuals. If policy makers have distributional goals which are not satisfied in the *status quo*, the approach favoured by economists is to weight costs and benefits for different individuals or groups according to these goals. This holds for both marketed and non-marketed goods. Equating marginal costs and benefits for the weighted values would lead to outcomes which were internally efficient according to the weighting scheme used.

A.1.2. External effects and market failures

Some characteristics of goods and services are not represented in markets. For example, neither the air pollution discharged by a road vehicle nor the noise created by an aircraft is bought or sold in markets. These are examples of the external effects of transport.

External effects are important because they influence others' welfare. Air pollution, for example, reduces the health and quality of life of those exposed to it. But drivers and other transport users have no incentive to consider such impacts when they decide how much to travel, or what mode to use. Because transport users consider only their own private costs and ignore the external costs suffered by others, the resulting level of transport use is higher, and the technology used more polluting, than would be socially efficient.

This situation is known as "market failure". The market has "failed" to account for certain characteristics of transport, leading to an inefficient outcome. A government can implement a wide range of policies to "correct" for this kind of market failure:

- taxing emissions;
- taxing inputs to polluting processes;
- setting emissions limits, in total or per unit of output;
- setting ambient pollution standards to be met at given locations;

- establishing systems of tradable emissions or inputs permits;
- banning certain types of activity or particular processes at given locations;
- valuing non-marketed inputs to public projects.

By implementing these policies, a government can enable the attainment of an efficient level of pollution. Such government activity is itself costly, but some external effects are significant enough to warrant intervention nonetheless, because the benefits of a more efficient outcome more than offset the costs. This is likely to be the case for transport air pollution, for example, because policies are available which are cheap to implement relative to the pollution costs that can be avoided. In other cases, if the external effect in question is not of enough significance, relative to the costs of policy measures, a policy is unlikely to be justified.

A.1.3. Valuation techniques

The object of any valuation study is to derive estimates of the value of some non-marketed good. The two principal routes by which this might be achieved are revealed preference and stated preference valuation techniques.

Revealed preference techniques use observations of real behaviour in markets for certain goods to derive valuations of the non-marketed components of the goods. For example, the travel cost method looks at real recreation time and travel decisions, and uses these to determine the value placed on recreation at sites visited. The hedonic price technique uses differences in the prices and characteristics of different units of a marketed good (such as houses) to estimate the value attached to certain component characteristics of the good which are not themselves directly marketed (for example, noise levels).

The advantage claimed for revealed preference techniques is that they are based in actual market behaviour, and therefore genuinely reflect actual decisions and preferences. However, there are statistical problems with their application, and limitations on their applicability.

Unlike revealed preference techniques, stated preference techniques do not rely on actual market behaviour but involve observing responses to a controlled hypothetical situation. Values can be derived directly via a questionnaire (contingent valuation) or indirectly by eliciting hypothetical behavioural responses (conjoint analysis).

The main advantages of this approach are the high degree of control offered by the ability to create a scenario to evaluate specific effects, and the ability to measure all types of value. The main disadvantages arise through putting respondents in an artificial situation, which may cause their responses to deviate systematically from their true values.

Avoidance cost or replacement cost estimates are often suggested as a third category of valuation technique. However, the costs of avoiding or repairing environmental damage are in no way equivalent to the value of the effect in question. For example, the value of damage caused by pollution could be greater or less than the costs of avoiding emissions or cleaning up afterwards.

Avoidance cost estimates are not an alternative to damage cost estimates, but rather are complementary to them. It is important to know both the costs of avoidance (or replacement or clean-up), and the value of the damage, so that these two distinct quantities may be compared. This comparison tells whether action to avoid or clean up the damage is worth undertaking.

A fourth technique often looked on as a valuation technique is the construction of dose-response relationships. In fact, this is not really a separate valuation method, but is rather a means of transforming complex effects into a series of items which can be valued more easily.

For example, direct valuation of air pollution emissions is potentially very difficult, although attempts are made using both revealed and stated preference techniques. Indirect valuation using dose-response relationships is potentially simpler: separate functions can be estimated relating air pollution emissions to various damage categories: human health indicators, damage to buildings, damage to crops, etc.

Each of the physical damage categories so estimated can then be valued in monetary terms. Sometimes, the damage categories will involve marketed goods, such as crop yields, and market prices can be used, although ideally any effect on the market price brought about by the damage should also be considered. Many other categories will still be non-marketed (*e.g.* health effects), in which case the effects must be valued using stated or revealed preference; the advantage is that valuation of several separate and clearly defined effects is simpler than any attempt to value the more nebulous overall cause.

A.1.4. Reliability of valuation estimates

Valuation of non-marketed goods is not an exact science. Uncertainty is inherent in techniques based on statistical inference, and furthermore it is not possible to control for all relevant variables in a diverse population. This leads to the question of how much error can be accepted in estimates.

It must be emphasised that the valuation of market goods is not exact, either, for similar reasons. Observation of the market price and quantity demanded at any given time yields only one point on the demand curve for the good. Estimating the whole demand curve is complicated: it can be done with varying degrees of sophistication, but error ranges of plus or minus 50% are normal.

The error may be of this magnitude in some non-market value estimates, and much greater in others. But even with large error ranges, values can be useful. So long as the estimate is unbiased, the estimated value is likely to lie closer to the true value than does zero, which is the implicit value if the effect is ignored.

This suggests that high variance in an estimate does not in itself make the estimate useless. Of course, there are limits, but these will depend on the individual case: the range of error must be interpreted with reference to the level of other costs and benefits included in the analysis, as well as with respect to the mean level of the estimate itself. What is generally more important is the possibility of bias in the estimate. Bias yields estimates that are expected to be systematically different from the true value. The variance of the estimate is of secondary importance to the extent by which the estimate is likely to deviate from the true value. Biased estimates may still be of use, provided it is known that the bias is small; heavily biased results will not be useful.

Unfortunately, bias can be difficult to detect: in general, estimation methods are unbiased according to a certain set of assumptions. The problem is that it is often not possible to test the validity of these assumptions.

Assuming the estimates are unbiased, a measure of the possible range of outcomes which could arise can be derived using sensitivity analysis. Cost-benefit calculations are performed for upper limit, middle and lower limit values for the effect in question. This can be based on one study, using the mean estimate of the value and the standard error associated with that value, to create a given confidence interval for the value. The mean estimate gives a "best guess" of the outcome, while the upper and lower bound estimates allow information about uncertainty in valuation estimates to be presented clearly to decision makers.

Where more than one estimate is available, it is possible to proceed in a similar fashion by taking the highest and lowest estimates. However, this approach does not make full use of all the information available. It is preferable to conduct a meta-analysis (explained later in this chapter), in which some "degree of confidence" weighting is given to each estimate, often based on its standard error. This procedure will give rise to a single mean estimate and associated standard error, based on all the original studies, which can then be used to conduct sensitivity analysis as just described.

A.1.5. Validation and divergence of estimates

There are two types of validation to be considered: from studies of the same type, and from studies using different methods. As a general criterion of scientific research, results should be reproducible. For example, values derived in a contingent valuation study should be reproducible in an identical study using another sample from the same population.

Moving beyond this, the results of qualitatively different applications of the same technique to the same good may be different. It should be possible to explain these differences with reference to the differences in the precise methods used. The problem then is how to determine which value is correct. In other words, it is necessary to determine which study conditions yield the less biased results. If two different ways of conducting a study are in principle both unbiased, then their results should not differ when applied to the same good.

Support for the general internal validity of a method as applied to a particular type of good or value would be given by consistent results arising from repeated applications to that good. However, this is not strictly sufficient to show the validity of the method for applications to other goods or values. For example, since stated preference methods are the only feasible means of estimating existence values, it is not possible to validate their use for this purpose; we simply have to assume that the method is suitable, although we may feel more secure in this assumption if applications of stated preference techniques to use-values can be validated with other techniques.

Sometimes, studies will be available for a given good using more than one valuation technique. This is often the case for unit values which are of repeated use. That is true of estimates of the statistical value of life, and noise valuation, for both of which numerous different studies have been conducted using both stated preference and revealed preference methods.

Validation arising from studies of a different sort is valuable, because validation using the same method is always susceptible to the possibility that the method suffers from a persistent bias in a given application: it is less likely that two different techniques both suffer from the same amount of bias.

However, because the methods are different, estimates can vary. This might be because the goods being valued are not really the same. For example, contingent valuation results can detect all different categories of value, including existence value, whereas revealed preference is capable of detecting only use-values. In other words, valuations of the same good may in fact be measuring different things; contingent valuation can be expected to yield values greater than corresponding revealed preference values.

Any particular case can also give rise to differences between methods. For example, hedonic studies of noise can detect only valuations of noise suffered in the home, whereas contingent valuation studies will often pick up a broader range of the effect. Another example occurs in mortality valuation, where individuals value different risks or means of death differently, as reflected in differences among hedonic wage studies and different applications of stated preference.

If persistently differing results between methods cannot be explained with reference to different actual objects of valuation, the alternative explanation is that one (or both) of the techniques is yielding persistently biased results. The problem then becomes how to decide which one, and this may be no easy task.

A.2. THE HEDONIC PRICE METHOD

A.2.1. Introduction

The hedonic price method is used to derive value estimates for individual characteristics of marketed goods. The basic theory rests on the idea that a good, such as a house, can be described by a list of its characteristics: number of rooms, location, age and so on. The observed variations in prices for different houses can be explained in terms of differences in these characteristics. For any one of the characteristics, it is then possible to estimate the effect on the value of the good from an increase or decrease in the level of the characteristic.

This model gives an opportunity to estimate the value of various non-marketed goods. The most common examples are noise, air pollution and accident risk. Estimates of the value of changes in noise and air pollution levels are derived from hedonic price studies of the property market, where differences in house prices or rents are explained using a variety of house characteristics, including a measure of noise or air pollution exposure for each property. Estimates of the value of changes in risk levels are derived from hedonic wage studies, where differences in wage levels for different jobs are explained by a variety of job characteristics, including the accident risk associated with each job.

Taking the example of valuation of noise using the housing market, the first stage is to estimate a price or rent function for a sample of households. Variables in the estimated equation include: physical attributes of the house (*e.g.* age, number of rooms); indicators of accessibility (*e.g.* distance to shops); characteristics of neighbourhood (*e.g.* leisure facilities); and indicators of environmental quality (*e.g.* noise levels).

Sometimes, the estimated relationship between noise and house price or rent derived from this equation is taken directly to give the value of quiet. However, it is more correct to attempt to estimate the demand curve for quiet. This can be difficult, as it requires information from several separate housing markets, along with data on incomes and other socio-economic characteristics, so that the demand function may be identified.

A.2.2. Main sources of error and bias

- Damage will be reflected only to the extent that individuals are aware of it and are capable of detecting differences (*e.g.* in noise or pollution) between areas.
- The assumption of equilibrium in the housing market is questionable, because of imperfect information and high transaction costs for moving house.
- The assumption that all possible combinations of housing characteristics are available on the market – which is necessary if all households are to be in equilibrium – is difficult to sustain: often, the range of alternative housing types is limited.
- A related problem is that there is often insufficient variation in the environmental variable to allow accurate estimation of its influence.
- Avertive behaviour should be accounted for: for example, double glazing may be used to reduce the impact of noise. Often, however, data are hard to obtain.
- The choice of functional form for the hedonic price equation can have a large impact on the results: unfortunately, statistical tests are not always capable of selecting the best forms.
- Expectations about future changes in environmental quality will influence current house prices: for example, if airport construction is planned, house prices will fall before noise levels actually worsen.
- The private discount rates individuals are using to relate future environmental quality to current house prices are not known.
- The preceding two problems can be surmounted by using rent equations rather than house price equations, because rents apply only to the specific period in question.
- Identification of the demand curve requires observations from several separate housing markets, as well as controls for income and preference variables, which can be difficult to achieve.

A.2.3. Conclusions and guidelines for application

The discussion above suggests that the hedonic method will generally involve error, in the form of both bias and variance in the estimates. Hedonic estimates of value may be accurate to little better than an order of magnitude. However, the estimation of rent or price differences will be more exact, and therefore valuation of marginal changes will be more accurate than total cost estimation.

Comprehensive requirements for successful applications are difficult to set down. However, an adequate study should have the following characteristics:

- a large data set, at least several hundred observations;
- testing of several variables representing each relevant category of characteristics (*e.g.* accommodation, neighbourhood, accessibility, environment);

- tests of different functional forms;
- significant variation in the environmental quality variable of interest across the data set;
- inclusion of variables in the hedonic price function to represent each relevant characteristic;
- interpretation of estimated rent differences only as the marginal value of noise changes, not as valuation of larger changes;
- for larger changes, use of data from separate markets in an attempt to estimate the demand curve;
- aggregation that takes into account the different socio-economic characteristics of different households, and their consequent different valuations.

A.3. THE TRAVEL COST METHOD

A.3.1. Introduction

The travel cost method is a revealed preference technique which may be used to estimate the value of recreation sites and the value of changes in environmental quality at such sites.

Individuals decide whether and how often to use particular recreation sites. The basic idea behind the travel cost method is that they base these decisions on the various costs associated with travel to the site, and on the benefit they derive from using it. By comparing different levels of visitation to a site from populations with different travel costs to reach that site, the value of the site can be estimated.

The most straightforward form of the technique is the zonal travel cost method, carried out as follows:

- the area surrounding the site is divided into concentric circular zones, and the travel cost for a return trip to the site is estimated for each zone;
- visitation rates are calculated for each zone (number of visits divided by population);
- visitation rates are regressed on travel cost and selected socio-economic variables;
- observed total visitation is made to represent one point on the demand curve for each zone;
- other points on the curve are estimated by assuming that visitors respond to an ECU 1 increase in admission price just as they would respond to an ECU 1 increase in travel cost.

This involves assigning the same travel cost to all individuals in each zone, which is clearly an approximation. The amount of error involved can be reduced by increasing the number of zones used, or by allowing the zones to take irregular shapes, branching out along main routes and so on, to more accurately reflect the actual travel cost faced by any given individual.

The least straightforward form of this method is individual travel cost, in which travel cost varies across all individuals. This approach allows full account to be taken of the actual travel time from an individual's home to a given site. More importantly, it allows for different values of time to be used in estimating the travel cost for each individual.

Travel cost techniques may also be used to value specific characteristics of recreational sites. For similar sites with different environmental quality characteristics, analysis of differences in travel costs and visitation rates allows the value of changes in environmental quality at the sites to be estimated. It is important in such applications to control for other relevant differences among sites.

A.3.2. Main sources of error and bias

- The model relies on the assumptions that the demand structures are identical and preferences the same in every respect other than those controlled for. It is relatively straightforward to control for differences in incomes, but more difficult to control for different tastes and different access to substitute sites.

- Valuations are assumed to be independent of the number of people using the site, which ignores the possibility of congestion.
- Some trips have multiple purposes; for example, people may combine a recreational visit with shopping or visiting friends. For major sites, people may visit the site more than once during the same trip, staying overnight in the area. There has been no satisfactory solution to this problem of multi-purpose or multi-visit trips.
- Travel cost estimates are highly sensitive to functional form, but statistical tests to select the best form may be inconclusive.
- There is a problem with "truncation bias", because values are observed only for those people currently making trips, yet if environmental quality improved, new visitors would be attracted.
- A large proportion of total travel cost is accounted for by the value(s) of time assumed, so these have a large and significant influence over the end results. But it does not seem feasible to make accurate estimates of the various time values required for each individual.

A.3.3. Conclusions and guidelines for application

The travel cost method is most applicable to the valuation of recreation at significant sites to which a large number of visitors are attracted. It is not in general suitable for valuing the flow of services from a small park or public building. The most successful applications have been to large areas with unique features, such as the Grand Canyon and Yosemite park.

It is hard to think of useful applications of the travel cost method with respect to European transport, except possibly for valuation of certain forms of land-take for new transport infrastructure. For monuments and other sites of national or international significance, travel cost is unlikely to be sufficient: it can measure only the value of direct use of a site, whereas for important sites, other values will exist.

Travel cost studies should satisfy the following criteria:

- the resource in question must be suitable for valuation with the travel cost method: there must be a significant number of visitors, for whom there is a substantial travel cost (including time);
- for a large majority of visitors, a visit to the resource should be the primary (preferably the sole) purpose of the trip;
- the individual travel cost method is preferable to zonal travel cost, although it entails greater expense;
- individual travel cost applications should include a wide range of socio-economic variables, and should account for different population levels of these variables in aggregation;
- zonal applications should incorporate consideration of differences in socio-economic variables between the samples and the population;
- the availability of substitute goods should be detailed for the relevant population – either there should be no close substitutes, or there should be little variation across the population in the costs associated with using substitutes;
- sensitivity tests of the results should be available for a range of values for travel time and on-site time;
- individual travel cost applications should use individual time values, with sensitivity tests for different estimations of these values (*e.g.* different fractions of the wage rate);
- tests of functional form should be presented, with results given for more than one form if these tests are inconclusive.

Even if all the above are satisfied, several shortcomings with the method remain. Most notably, it has been suggested that problems determining the values of travel time and on-site time mean the method cannot give absolute estimates of values. However, as long as costs increase with trip time, the method can give relative rankings of values for different sites.

A.4. STATED PREFERENCE METHODS

A.4.1. Introduction

The basic idea behind stated preference methods is to ask individuals questions which reveal information about their valuation of a change in provision of some non-marketed good. The main stated preference technique is contingent valuation. Conjoint analysis shares many characteristics with contingent valuation, but is less common.

These methods have a degree of flexibility absent from revealed preference techniques, in that they can conceivably be used to estimate values for any good, including non-use and existence values. On the other hand, they are not based in real market behaviour, and face several consequent problems. They are also fairly expensive, because of the need to generate original data and the cost of several complications required to avoid potential sources of bias.

In conducting a contingent valuation survey, the researcher creates a hypothetical scenario in which respondents are provided with information relating to changes in the level of provision of an environmental good. The respondents are then asked how much they would be willing to pay, through some voluntary contribution or tax mechanism, to secure the change. The survey can be conducted in person, by telephone, by mail, or, more recently, by computer.

The question eliciting values can be posed in several different ways:

- open ended, asking the respondent to state a value;
- bidding game, where interviewer suggests increases in the stated value until respondent declines increase;
- payment card, with respondents offered a range of values;
- suggested bid, followed by incremental increases (decreases) until a negative (positive) response is given;
- dichotomous choice, requiring a yes or no response to a suggested bid.

It is important for all aspects of the scenario to be plausible and easily understood, and a crucial element is that the good which the respondents are imagining must match the one the researchers wish to value. Extensive pre-testing is used, with debriefing of respondents and, increasingly, the use of ‘‘verbal protocols’’ where paid pre-test respondents are tape recorded while answering the questions.

Pre-testing enables problems with perception to be detected and addressed, and allows the researchers to establish which pieces of information are being relied on most by respondents and which are surplus to requirements. It is also possible to detect problems (see below) of scenario rejection, protest bidding and embedding using this approach.

Following satisfactory pre-testing and redesign, a full survey is conducted. In addition to questions directly related to the good in question, various socio-economic characteristics of the respondents are noted. These are used in statistical analysis to develop generalised estimates of individuals’ values.

Conjoint analysis

The basic idea behind conjoint analysis is that preferences can be revealed through hypothetical ranking or choice decisions. It is argued that, because respondents compare different levels of provision of real goods, rather than comparing goods and money, some of the sources of bias present in contingent valuation can be avoided.

If the results of conjoint analysis are to be of use in deriving environmental values, it is not enough simply to derive relative valuations involving different sets of environmental goods and other non-financial variables (spare time, accident risk, etc.). It is essential for choices to be made at some stage involving either a financial option, or a physical option which can readily be translated into money equivalents (*i.e.* a marketed good, or a non-marketed good which can be valued).

If this is achieved using a financial option, then this stage of the technique is similar to dichotomous choice contingent valuation. If using a marketed good, it is essential to assume that the respondents share identical valuations of that good. And if using a non-marketed good which may be valued, the process is dependent on the accuracy with which this original valuation is conducted, before any further error is introduced during the conjoint analysis itself.

Respondents may find it as difficult to compare different packages of environmental and other goods as to compare different packages of environmental goods and money. Also, conjoint analysis typically involves comparing bundles which vary in respect of more than two variables. To take a real example, respondents may be asked to compare options which vary in terms of noise, air pollution, journey costs and journey times. This is much more difficult than the contingent valuation approach of simply comparing one environmental variable at a time with money.

These points suggest that in practice applications of conjoint analysis may suffer not only from some of the same problems as contingent valuation but also from some new ones. Contingent valuation is by far the more common of the techniques, probably because of the difference in difficulty of the questions from the point of view of the respondents.

A.4.2. Main sources of error and bias

- Respondents might try to answer strategically in an attempt to exert a disproportionate influence on the results, though this is unlikely and indeed is not possible with some techniques.
- There is evidence that the hypothetical nature of contingent valuation questions leads to biased responses: hypothetical responses tend to follow a skewed distribution, in contrast to bids in actual markets.
- The payment card method and bidding game have both been shown to be subject to "anchoring" bias, due to the suggestion of an answer to the respondent.
- Dichotomous choice and open ended methods generate different results: the dichotomous choice results tend to be around three times higher. Clearly at least one of the methods is systematically biased, but there is no consensus as to which.
- Dichotomous choice is more expensive to conduct: each individual gives only a yes-no response, so much less information is generated per respondent. A much bigger sample size is therefore required.
- "Protest" bids can be given by respondents who reject either the idea that they should pay for environmental goods, or the idea that environmental goods can be valued in monetary terms. This can take the form of false zero bids or very high bids in open ended valuation; in dichotomous choice, as only yes-no answers are given, protest bidding is harder to detect and potentially less of a problem.
- "Embedding" describes a variety of situations in which contingent valuation can give several different valuations of the same good. The most straightforward type is where valuations are not influenced by the amount of the good provided: for example, a survey might find similar values for preservation of 1 000 ha of woodland as for preservation of 10 000 ha. This is a serious problem.
- In theory, the means of payment should not influence the amount volunteered; in practice, many individuals do respond to the payment vehicle proposed, with different results for tax increases, voluntary payments and price rises. Likewise, different results can arise from elicitation of one-off contributions compared with periodic contributions. But it is not objectively obvious which scenario should be used.

A.4.3. Conclusions and guidelines for application

The general validity of stated preference techniques is supported by the fact that the private sector finds it profitable to invest large sums of money each year on market research, often using contingent ranking type experiments. In addition, stated preference techniques have been used to estimate values for marketed goods, allowing comparison between hypothetical and market results. But this is not really sufficient to show that stated preference methods are suitable for non-market good valuation in general, nor for the estimation of existence values in particular.

Although there is evidence from market research of strong links between stated preference results and actual choices, the slopes of the relationship between real and hypothetical choices differ sharply by product category and with promotional efforts. Thus it may be that the best that can be expected of stated preference techniques, even with attempts to take account of the problems outlined below, is some ranking of values. This leaves the problem of how to rescale the responses to match market values; whether a satisfactory solution to this problem can be found is not clear.

The extent to which contingent valuation is capable of giving valid and reliable estimates of the value of environmental goods depends very much on scrupulous survey design, implementation and analysis. Where this is achieved, the results might be useful as indicators of willingness to pay, at an order of magnitude level or better, depending on the specifics of the case. Nevertheless, some bias is likely to remain in even the best contingent valuation estimates.

The following characteristics are most likely to minimise bias in results of a contingent valuation study:

- elicitation of willingness to pay values only (*i.e.* no questions eliciting willingness to accept);
- use of the open ended elicitation format, or of both open ended and dichotomous choice for comparison;
- dichotomous choice applications restricted to one valuation question only, to avoid the anchoring influence of the first question over response to any subsequent questions;
- sample sizes of at least 300 (preferably more) for open ended and at least 1 000 for dichotomous choice;
- precise and credible definition of the good, payment vehicle and means of provision;
- provision of relevant information concerning the good in question and any substitutes which may be available;
- use of verbal protocols in pre-tests to check for information and other effects;
- use of a realistic and familiar payment mechanism;
- reminders to respondents of the budget constraint they face, and of the need to reduce spending on other goods and services if they choose to contribute to the good;
- elicitation of lump sum, rather than periodic, payments;
- questions eliciting self-reported embedding, and corresponding adjustment of results;
- questions checking for protest bids, and subsequent removal of non-zero protest bids;
- in open ended surveys, questions checking the reasons for zero bids, and subsequent use of a dummy variable to correct for protest and strategic responses;
- in open ended surveys, use of the Box-Cox transformation to adjust for hypothetical bias in the results, so long as this is statistically justified;
- in open ended surveys, use of weighted least squares if the usable responses are non-representative of the population;
- careful selection of the relevant population for aggregation.

This lengthy list of requirements reflects the great care required in design and application of contingent valuation surveys. The cost of following best practice through from extensive pre-testing to final design, implementation and analysis of results is high; in addition, a complete study is likely to take a fairly long time. Contingent valuation studies are, therefore, best suited to two main categories: one-off valuation of very important monuments, areas of land or other environmental goods; and elicitation of values for common effects, which can then be used repeatedly, such as accidents, the barrier effect of traffic or the health impact of pollution.

A.5. DOSE-RESPONSE TECHNIQUES

A.5.1. Introduction

Dose-response work involves estimating physical or medical relationships linking environmental variables to quantifiable effects. Valuation is then conducted on the effects. This technique has been applied in particular to the impact of air pollution on health, materials and vegetation.

Direct valuations are of use only where people are aware of the linkages. Even where linkages are clear, individuals may find it easier to value specific health effects than to value general damage from air pollution. Therefore dose-response is particularly useful in moving from an effect which is difficult or impossible to value directly to a number of effects which can be directly valued.

The basic approach is to conduct a regression of observations of an effect on corresponding observations of explanatory variables, aiming to explain as much as possible of the variation in the incidence or severity of the effect. The data can be a time series for one region, a cross-section for one period, or panel data combining both aspects. One or more of the explanatory variables represent environmental conditions, and the estimated coefficients allow the marginal impact of changes in these conditions to be assessed.

For health work, mortality or morbidity indicators are regressed on variables such as age, sex, income, smoking and particulate pollution. Depending on the scale of the study, these can enter the equation on an individual level or as population proportions. Different variables are required for material and vegetation damage work, but the principles remain the same.

A.5.2. Main sources of error and bias

- Suitable data can be hard to find: they are often inaccurate or overly aggregated. Air pollution measurements, for example, are commonly taken at only one or a few sites in an area.
- Multicollinearity occurs where the values of two or more explanatory variables tend to increase or decrease in similar proportions at the same time. This is commonly the case with air pollutant measures, because the pollutants often come from the same main sources. When two variables move together, it is very difficult to tell which of them is driving an effect. This problem can be reduced by the use of meta-analysis looking at results from different areas or periods, because the relationship between levels of different pollutants may vary with space and time.
- The choice of functional form will influence the results, but it is often difficult to select the best form and statistical tests can be inconclusive. This problem is aggravated by the possibility of thresholds for some effects, and by synergistic interactions among pollutants.
- The technique as discussed above is mechanistic, incorporating no model of how individuals behave. In reality, people modify behaviour in response to risks: for example, increased traffic volumes may lead parents to accompany children to and from school or prevent them from playing in the street. Both responses have a cost, but this will not be detected by a function relating traffic levels to accidents. Avertive behaviour should be accounted for, but is often ignored.
- The valuation of impacts is not always straightforward. Usually, some effects will be non-marketed (for example, health damage), so some non-market valuation will be required, with the possibility of error in the estimates used. Even for marketed effects, error is likely because it is difficult to take into account the possible effects of damage on the market price: for example, widespread air pollution which reduces crop production may influence the price of affected crops.

A.5.3. Conclusions

Calculations based on dose-response relationships are likely to provide only rough estimates of costs. Although there are problems with the theory, notably the mechanistic nature of straight dose-response work, the principal problem lies in the real difficulties of specifying and estimating the physical relationships.

However, scientific and medical knowledge is continually improving, and the data sets are coming to include better measurements and more of the relevant variables. So dose-response estimates can be expected to improve, though the extent to which they can be refined is not clear; it seems likely that much of the uncertainty will remain unresolved for some time.

For current practical purposes, confidence in the method must depend on the extent to which convergent results can be derived from different studies. This does not necessarily imply a need to find identical coefficients; rather, the variation in results should be explicable by differences among studies. Meta-analysis is potentially a useful tool for testing this proposition.

A.6. TRANSFERABILITY

A.6.1. Introduction

This approach is useful if values estimated in one geographical area, or for a particular subset of the population, can be used elsewhere. The two principal advantages are that: *a)* cost transfers are cheaper than primary studies; and *b)* time transfers do not involve the substantial lead time of primary studies.

Differences in the characteristics of the population and the environmental good in each individual case will inevitably lead to some bias. Thus two key issues are: how best to employ techniques to minimise the extent of bias in any given transfer; and how much residual bias can be tolerated.

Selection of suitable source studies

Any transfer can only be as good as the original study; problems with the original valuation will be magnified in transfer applications. The level of additional imprecision introduced by use of a transferred value rather than a primary study will vary from case to case, and is difficult to measure.

When looking for potential surrogate studies, situations as close as possible to the one in question should be selected. The non-marketed good to be valued should be the same; for example, a value estimated for a boating lake would not be suitable for transfer to a fishing lake. The characteristics of the relevant populations should be as similar as possible, although it may be feasible to correct for certain differences, given enough information.

Any prospective transfer study which meets these criteria should be evaluated in its own right. The principal question is whether the estimated value is unbiased. Also of interest is the size of the error range around the mean estimate. To evaluate validity and reliability, one must consider:

- theoretical construct (was the value estimated the intended value?);
- adequacy of data collection and treatment;
- suitability of statistical techniques employed;
- inherent properties of the valuation method used.

This may be difficult, because the required information is not always available: reports and journal articles often give only brief details. It may be possible to approach the original researchers to help fill gaps. One particular problem is that there are often no clear guidelines by which valuation studies may be evaluated. The suggested guidelines at the end of the discussions of each valuation method above may be too restrictive for past studies, being intended as a guide for future research. In general, preference should be given to more recent, state-of-the-art studies.

Where possible, more than one study should be drawn upon in each case. This allows compromise estimates to be reached, reducing the risk of relying on unrepresentative or poorly conducted studies. Meta-analysis is useful for combining the results of several studies, and is discussed in more detail below.

Adjusting for differences between study and transfer site

The next step is to evaluate validity on the intra-site level. In the rare case where there is little or no variation between sites as regards the characteristics of the population and the environmental good, any bias is likely to be small and a direct transfer can be made. But normally it will be preferable to consider whether the value can be transformed to remove bias, using an adjustment based on differences in the attributes of each area and in the socio-economic characteristics of the populations.

Extrapolation to values for variables which are far outside the range of those in the original studies should not be relied on. The question of the correct functional form for the hypothesised relationship may also be difficult to answer, with existing statistical tests perhaps being unable to distinguish among various possible forms.

With only one or a few source studies, analyses of this type may not be possible for all relevant variables: while variation in socio-economic characteristics may be observed within a single study, there is some evidence that site characteristics may be more important, and to observe variation in values with site variables requires many studies in different areas. In general, better results will be achieved if several source studies are available, allowing meta-analysis to be used.

Meta-analysis

"Meta-analysis" is a generic term for statistical means of pooling the results from several econometric studies to obtain aggregate results in which more confidence may be placed. Environmental research using this technique has included applications to hedonic price studies of air pollution, travel cost analyses of recreational benefits and dose-response studies of the health effects of air pollution.

One form of meta-analysis assumes that the parameters which are the object of estimation in each of the component studies are themselves drawn from a "mother" distribution. Estimates of the mean and standard error of the mother distribution are made. The meta-analysis procedure takes account of the different sample sizes and standard errors in the original studies, in effect giving more weight to studies with larger samples and smaller errors.

Another approach is to use regression techniques to attempt to explain the variation in the results of other studies of a certain type. The results of the studies are regressed on various characteristics – for example, what independent variables were included, what functional form was used and so on. But although the results of the regression equation can be used to predict the results which would arise under ideal study conditions, it may not always be clear what these conditions should be.

Transfers of unit value estimates

When conducting a value transfer, in particular from one country to another, it is desirable to try to correct for income differences. Often, this is attempted at the aggregate level by expressing total costs from a particular class of environmental damage as a percentage of GDP. But for unit value estimates, such as the value of a day of respiratory illness or a 1 dB improvement in noise levels, expression as a percentage of GDP is not meaningful.

This raises the issue of how to cope with currency differences among countries. Market exchange rates do not take account fully of differences in price levels. Instead, purchasing power parity exchange rates should be used. These take account of differences in real price levels among countries, and thus reflect the actual goods people are willing to sacrifice, rather than simple financial sums. In general, the effect of using PPP rates instead of market exchange rates is to reduce the difference between values used for each country.

Where differences in tastes and preferences between populations can be picked up through observable variables (such as age structure, religion or membership rates in environmental organisations), adjustments can be made to correct for these differences. This will not be possible for differences in tastes stemming from cultural or other factors which cannot be quantified or proxied for.

Often, the number of suitable source studies available will be limited, so that regression analysis to explain variation in results becomes impossible, difficult or unreliable. In such cases, any bias introduced by differences in population characteristics will be unavoidable and unmeasurable. If the populations are thought to be reasonably similar, however, any such bias is unlikely to be excessive. This may be true for most cases of transfers among European countries (although the populations of some countries seem to display greater awareness and concern about environmental issues than those of others). Even then, however, it will be desirable to make certain adjustments on the basis of *a priori* expectations of relationships between valuations and certain variables, such as income, as discussed above.

Transferability in time

As noted above, the population characteristics at the study site and the policy site should be as close as possible. Hence, it should be stressed that population characteristics at a given location change through time because of demographic, social and economic influences. Aspects of the environmental good in question, and the availability of substitutes, may also change.

Thus it is useful to picture the use of environmental values after the actual period in which they were estimated as being value transfers on the time dimension, analogous with the geographical transfers discussed above. Transfers in time can be seen as valid until such point as the characteristics of the population or environmental good have changed to the extent that significant bias is introduced. As with spatial transfers, it may be possible to scale values to different situations, thus expanding their useful lifetime.

A.6.2. Conclusions

There is a clear trade-off between validity and reliability on the one hand, and costs and time on the other. An analysis of existing values will often provide useful information on the likely range of values in an area of policy interest, and for many purposes that may be sufficient.

For some decisions, the cost of an original study would not be justified; furthermore, using expensive primary studies more than once increases their worth to society. Both statements imply that value transfers can be seen as expanding the usefulness of environmental valuation studies.

There will always remain some cases which are sufficiently individual that transfers will not be acceptable: for example, unique monuments or areas of great environmental significance. The individual characteristics of these goods are so central to their value to society that generalisation is not possible. For example, it would probably not be acceptable to transfer value estimates from a study of Westminster Abbey in London to analysis of Notre Dame in Paris, although it might be argued that the goods are similar. Where value is thought to be site specific in this way, there is no substitute for an original study.

A.7. EVALUATING THE EXTERNAL EFFECTS OF TRANSPORT

A.7.1. Introduction

The external effects of transport are numerous, and among the best studied of any sector or industry. This is because transport is one of the most important sectors of the modern industrialised economy, and because it of necessity involves populated areas, whereas some polluting industries can be confined away from those potentially affected. The following effects of transport are among the most important (note that not all are environmental, and not all are wholly external):

- air pollution (local, regional and global);
- noise and vibration;
- accidents;
- congestion;

- use of land;
- solid waste generation;
- water pollution;
- "severance" of human and animal communities by infrastructure or traffic flows;
- aesthetic impacts of infrastructure and traffic.

Coverage of these effects in the valuation literature is extremely uneven. Some costs associated with transport, such as accident costs, have received ample attention, reflecting in part their perceived importance. Other effects have not been dealt with because it is presumed (sometimes without justification) that they are too insignificant; aesthetic impacts of traffic flows may fall into this category. Yet other costs (*e.g.* severance) have gone unnoticed, even though they may be very important, because of lack of understanding at a theoretical level. In many cases the limited treatment reflects the fact that some environmental costs almost defy quantification, while in other cases the difficulty lies in providing an objective measure of the impact (such as vibration resulting in possible damage to buildings). Solving these problems must precede valuation of the effect in question.

This section does not attempt to deal with all social costs associated with transport. In particular, since the essential problem of congestion is that of time lost rather than degradation of the environment, and since valuation of accident costs literature is already well developed, neither congestion nor accident costs are discussed in much detail in this chapter, although they are among the most important social costs of transport. The rest of the following subsections take each of the remaining effects in turn, discussing first the scope and significance of the effect, then the potential for its valuation and the likely suitability of particular valuation techniques, along with some indication of what constitutes best practice.

A.7.2. Local and regional air pollution

Local air pollution (occurring in the immediate vicinity of a pollution source) from transport is a particular problem in urban areas. Health effects are the primary concern, with particulate matter and aromatic hydrocarbons being the most significant pollutants involved. Soiling of buildings and clothing, and damage to materials used in buildings and other structures, are also of interest.

Regional air pollution covers a wider area, after dispersal of pollutants in the atmosphere. Acid precipitation is the best known example, one to which transport contributes by the emission of nitrogen oxides and, to a lesser extent, sulphur dioxide. These compounds can travel some distance before being deposited. Following deposition, the effect is localised.

Some gases have effects at more than one level. For example, NO_2 has local effects on health (inhibition of the respiratory system) as well as regional effects through its contribution to acidification. In the upper atmosphere, it also contributes to the greenhouse effect. The division here into local, regional and global refers more to individual effects than to properties of pollutants, and some gases will have effects requiring valuation under more than one category.

Attempts have been made to value air pollution using direct application of stated preference or revealed preference methods. However, poor understanding by the public of the effects of air pollutants in general, and in particular of the different impacts of different pollutants and of their synergistic effects, can impede the usefulness of valuations based on stated or revealed preference. Some effects will be overlooked because individuals are not aware of all the risks to which they are exposed, or of the links between an effect and exposure to air pollution. Conversely, some individuals may overestimate the significance of air pollution.

Hedonic studies incorporating air pollution tend to suffer from multicollinearity if more than one pollution variable is included, so differential valuation of individual air pollutants is not possible. In addition, hedonic studies can only pick up the effects of air pollution suffered as a result of residential location, which is likely to underestimate the overall valuation. Also, avertive behaviour is ignored. In general, indirect valuation using dose-response relationships as the first stage seems more promising, in particular if attempts are made to account for avertive behaviour on the part of individuals.

The general difficulties with dose-response estimation are noted above in the section on that method. Poor data, multicollinearity in variables and other statistical problems may lead to large errors in estimated relationships. However, these errors are perhaps less likely to be systematic than those arising in direct estimates, and meta-analysis may be useful in deriving narrower confidence intervals for effects.

The best choice is always to conduct dose-response modelling *in situ,* thereby avoiding the dangers inherent in transferring estimates from elsewhere (for example, different protocols regarding the positioning of air pollution monitors). But, given the sheer cost of such an exercise combined with deficiencies in pollution monitoring data for many countries, dose-response relationships estimated for other countries will frequently have to be used instead. This is likely to involve the use of meta-analysis to combine studies drawn from other countries.

Many different substances emitted in the transport sector come under the umbrella of air pollution. Separate valuation of each would likely result in substantial double counting. The correlations existing among many pollution variables imply a similar effect for separate analyses: a single pollution variable in an equation is likely to pick up some of the effects of other pollution. The converse of the double counting problem is the risk of ignoring some effects. If a study of only one pollution variable is conducted, some of the effects of other pollution and most or all of the effects of noise will not be counted. Unfortunately, it is not always possible to determine for any particular approach exactly which impacts are being fully valued, which partially valued and which overlooked.

After the dose-response function is established, revealed or stated preference valuation remains to be done for each of the effects, and the ease and accuracy of their valuation may vary. Some effects have been the subject of extensive study – for example, the value of statistical life – while others have been less researched. Added to uncertainties in the dose-response function and in the data, then, is the further difficulty that arises in the determination of these unit prices.

For example, much of the excess mortality associated with air pollution is likely to occur among the elderly. The issue of the valuation of life at different ages is difficult. There is conflicting evidence concerning WTP from people of different ages, with some studies showing WTP rising from youth to middle age and then falling, but others finding no such effect. In addition, there is the question of quality of life; it may be fair to say that WTP values may be lower for an individual with low quality of life due to the sort of illness which may make the individual more susceptible to the effects of air pollution.

Dose-response functions can also be derived for many lesser health impacts – respiratory hospital admissions (RHA), emergency room visits (ERV), restricted activity days (RAD), minor restricted activity days (MRAD), asthma attack, acute respiratory symptoms, chronic bronchitis, eye irritation and so on. These morbidity impacts can be valued using stated preference techniques. However, some costs are not borne by the individual (for example, government expenditures on health services), and these costs should be additional to WTP estimates.

Air pollution has many impacts beyond those on health. Damage to materials, including stone, brick, painted surfaces, metals, rubber and fabrics, is a widespread problem. Damage to crops, forests, heathlands and water systems, in particular from acid precipitation, is also common.

Dose-response functions are available for many of these other damage relationships, in particular for damage to materials. In general, there is a fair degree of uncertainty about the functions. It is not always possible to derive a clear and objective measure of ''damage''. Synergistic effects among pollutants and interaction with meteorological conditions can further confound the relationship. And the mechanistic nature of dose-response ignores avertive behaviour, such as use of corrosion resistant materials, which can be a significant cost factor.

For many crops, some dose-response functions exist for ozone, the most important pollutant for crop damage, and for SO_2 and NO_x. For damage to forests, dose-response functions exist, but are simplistic. For damage to water, and to ecosystems more generally, suitable dose-response functions do not exist and data of any sort are scarce.

Given a dose-response relationship, valuation then requires the compilation of an inventory of materials exposed. This is a major task in itself. After this, valuation of unit impacts is required. In the case of crops and building materials, market prices can provide a rough guide, although they do not take account of avertive expenditures or the influence of damage over market price.

In general, valuation of non-health impacts of air pollution is much less advanced than is health effect valuation. It is possible nonetheless even with current knowledge to derive some useful order of magnitude estimates of damage to crops and buildings from air pollution.

A.7.3. Global air pollution

The two best known examples of global air pollution are the greenhouse effect, to which transport is a major contributor through emissions of carbon dioxide and other so-called greenhouse gases, and ozone layer depletion, to which transport contributes little.

The greenhouse effect and global climate change constitute a major challenge for valuation. There are two main figures of interest. The first is the total cost of climate change. The second is the marginal contribution to this cost made by marginal greenhouse gas emissions. It should be noted that the marginal damage cost of emissions is not the same concept as the optimal carbon tax, which can be calculated only in conjunction with the marginal costs of abatement.

The usual approach to damage estimation is essentially dose-response. The climatic effects of greenhouse gas emissions are estimated, as are the impacts of the changed climate on economic activity, human amenity and the environment, and these impacts are valued. This enumerative method, whereby each impact is valued individually, is a partial analysis which may involve large errors compared to a general equilibrium approach. On the other hand, general equilibrium models may be too aggregate to take proper account of the impacts of climate change. Ideally, the direct economic impacts of warming should be fed back into the model using (for example) input-output analysis, to reveal the full macroeconomic effects.

Climate change is often summarised by the expected global mean temperature increase associated with a certain atmospheric concentration of greenhouse gases. But the effects are more wide ranging, with the actual temperature rise varying according to season, time of day and region. Increased evapotranspiration is expected to lead to mean increases in precipitation, again with the actual impact varying. Sea level rise, via ocean thermal expansion and the melting of land based ice, is expected in the very long term, although its extent is uncertain.

Beyond this, accurate predictions are difficult. The resolution of current general circulation models does not permit precision regarding regional effects. It is generally accepted that there will be an increase in extreme weather. In addition, there is a small but real risk of unpleasant surprises such as changing ocean currents leading to dramatic changes in weather patterns. There are other known possibilities, and perhaps some not yet thought of.

It is not desirable simply to ignore low probability events, without consideration of their costs. The view that such events would have a negligible impact on expected cost calculations is correct only if the probabilities fall faster than the costs rise. Thus there is considerable uncertainty associated with the dose-response stage of the valuation process.

In enumerative analysis, the economic effects of physical changes can be divided into marketed and non-marketed impacts. The market price associated with marketed impacts provides a starting point for valuation, but simple multiplication of the change by the current market price is not generally sufficient. Account should be taken of the extent to which prices adjust as quantities change. For example, to value changes in agricultural yields at current market prices could result in serious underestimation of the desired measure of welfare, the sum of consumer and producer surplus lost. Both the increase in production costs for the food still produced, and the increased marginal valuation of food when supplies fall, must be considered.

Further complication is added by the need to take account of optimal adaptation measures, such as changes in agricultural practices and coastal protection. The "dumb farmer hypothesis", for example, refers to the unrealistic (implicit) assumption that cropping patterns will not change as climate alters.

The use of this assumption leads to overestimates of damage. However, accounting for adaptation is difficult, and fairly *ad hoc* assumptions are commonly made concerning both the extent to which mitigation is possible and the costs involved.

Several studies are aimed at estimating the costs associated with the warming arising from "2xCO_2", a popular benchmark consisting of a doubling of atmospheric concentrations of carbon dioxide equivalent gases over pre-industrial levels. This benchmark is expected to be reached in the second quarter of next century, with the full climate impact occurring some 30 years later thanks to ocean thermal lag. The Intergovernmental Panel on Climate Change estimates the global mean warming associated with 2xCO_2 to be around 2.5°C.

Given the available alternatives, best practice is to use as shadow prices for carbon those tax rates necessary to procure the optimal cutback in emissions. But deciding what constitutes the optimal emissions strategy turns out to be complicated, requiring an empirically based "integrated assessment" (IA) model of climate change. IA models attempt to condense a diverse body of information – relating to economic growth assumptions, carbon emissions forecasts, abatement cost estimates and global warming damage functions – and incorporate them into a single model. The simplest such models take baseline economic output and greenhouse gas emissions as given, then compute forecasts of atmospheric concentrations of CO_2 dependent upon a model of the carbon cycle. Average global temperatures slowly adjust to elevated CO_2 concentrations. This temperature rise is taken as an index of global environmental change, which is assumed to cause economic damage. Such losses are quantified in terms of a "damage function".

The damage function is basically a relationship between global temperature rise and economic damage in terms of percentage loss of GNP. Current enumeration of the impacts of climate change using an array of valuation techniques suggests that a benchmark 2.5°C rise in temperature would reduce global GNP by approximately 1.5%. These estimates purport to account for the extent to which adaptation to a changed climate is possible. However, rather than tracing the impacts through the economy simultaneously, they adopt an approach whereby each impact is valued separately.

While it is interesting and useful to have some indication of the costs associated with a benchmark such as 2xCO_2, taking a "snapshot" of the dynamic process of climate change is not sufficient. Though 2xCO_2 will inevitably be reached at some stage, climate change will continue. The factors within our control, given the physical processes at work, are the rate at which warming is allowed to proceed, and the extent of climate change beyond the doubling point. Valuation efforts should also focus on the damage associated with these aspects of the problem. For example, individual component damage could be estimated for two or more future climates, say 2xCO_2 and a long term warmer scenario. Extrapolation could be conducted between the estimates for each category, allowing estimates of total damage to be made for any given climate change scenario. This would also allow for the consideration of likely threshold effects in certain damage categories.

A further shortcoming of all such techniques is the reliance on extrapolations from present to future economic structure. Given economic growth, the implicit assumption is unitary income elasticity of demand for all goods and services. While it is impossible to know future preferences with certainty, one could estimate how the future WTP for different goods will vary from the present, using estimates of cross-section income elasticities.

A further source of serious error is extrapolation from the US economy to the rest of the world. Many existing estimates are of damage suffered by the US as a percentage of its GDP. But the majority of the world's population lives in areas very different from the US in terms of climate and agricultural systems. Valid extrapolations cannot be made from a large and relatively robust industrialised economy to a developing world still heavily reliant on agriculture, in which large groups are highly vulnerable to climatic upsets such as drought and flood. More estimates are required of the direct impacts on these vulnerable countries.

The conclusion is that current estimates of global warming damage are seriously flawed. Nevertheless, they do suggest that damage is likely to be significant. As scientific knowledge of the effects improves and more sophisticated economic studies are conducted, the value of global warming damage estimates can be expected to improve.

A.7.4. Noise and vibration

Unlike air pollution, noise is specific in space and especially in time; noise causes nuisance only at the time and place it is emitted. Transport is a major source of noise in modern societies, in particular because transport activity by definition must occur near residential and working areas.

As in the case of air pollution, the direct valuation of noise is subject to the criticism that individuals' revealed or stated willingness to pay values will cover only those effects of which they are aware, and which they know to be caused by noise. Indirect estimation, however, is beset by substantial scientific and medical uncertainty in relating exposure to effects. Because many impacts of noise are more psychological than physiological, objective measurement is difficult. This is the case for nervousness and fatigue from sleep interruption, for example, although these can give rise to physiological effects in severe cases. In addition, estimation of unit values for such loosely defined impacts is difficult.

Hence, with current scientific knowledge, methods to value noise have to be direct, despite the poor individual understanding of the effects. The two principal alternatives are hedonic price estimation and stated preference applications. Use of the hedonic price method has been reasonably successful, often showing a clear relationship between house prices or rents and noise levels, from which WTP can be estimated. These valuations are incomplete inasmuch as they pick up only the effects of noise suffered in the home. Noise suffered at work or during outdoor recreation may also be significant.

Stated preference applications have the important advantage, in theory at least, of being able to measure willingness to pay to eliminate transport noise in any context. Stated preference studies may thus be preferred to hedonic studies for the purpose of measuring the value of noise reductions. As different individuals are exposed to different levels of noise nuisance, replies concerning WTP for a given reduction will vary; therefore respondents are also asked to choose a verbal description of the level of noise nuisance to which they are exposed. These descriptions are then coded and used to explain the variations in WTP responses.

In a second stage, the number of people describing themselves as belonging to a particular level of suffering has to be linked to a measurable index of noise nuisance. Thus, at a given level of noise, a certain fraction of the population will describe themselves as "annoyed" or "very annoyed", and as the noise index increases the proportion of "annoyed" and "very annoyed" individuals will increase too. Knowledge of this relationship and of the number of sites suffering particular levels of noise nuisance permits the results of a willingness to pay survey to be extended across a whole country.

As usual with applications of direct valuation techniques, no account is taken of avertive behaviour. An individual's WTP for noise reduction will be less if that individual has fitted double glazing, for example. To the extent that avertive behaviour is motivated by a desire to avoid the negative impacts of the effect, it should be accounted for in the estimation of the damage cost. If the avertive behaviour brings about other benefits, such as reduced heating or cooling costs in the case of double glazing, these should also be taken into account.

There is a body of work which seeks to base willingness to pay estimates on either the observed costs of noise abatement devices or the estimated costs of reducing noise to an "acceptable" level. But it is often difficult to determine what investments are made by private individuals (or governments) for noise abatement rather than for any other purpose. Moreover there is a certain circularity in arguing that because the government is spending a given amount on noise abatement, that is precisely the correct amount to spend. Nor is there necessarily a link between the amount it would cost to reduce noise to some arbitrarily chosen standard and the willingness to pay for it. Accordingly, both approaches are seriously flawed from a methodological perspective and produce results which differ markedly from those obtained by the stated preference and hedonic techniques.

Vibration is caused by all large land vehicles, particularly on uneven surfaces. It can cause damage to transport infrastructure, buildings, underground pipes and drains, and so on. Humans can also be directly affected through disruptions to sleep and consequent health and activity reductions. Aircraft cause inaudible vibration as well as noise during flight, which similarly influence human environments when produced at low altitude during landing and take-off. And waterborne transport creates vibration which can cause erosion to banks and shores, and is potentially damaging to marine life.

Valuation of these effects is very difficult. The problem lies in the definition of the dose-response functions, because there is no easily applicable technique for measuring vibration from transport, or its effects.

A.7.5. Accidents

Transport is a major source of accidents in most societies. All accidents are a ''negative effect'' of transport, but not all are ''external'': individual drivers and transport users consider at least their own accident risks when making decisions about when and how to use transport; thus, people drive more carefully in bad weather, and so on. In addition, the laws of most countries require drivers and transport operators to be insured to cover certain accident costs. To the extent that accident risks are reflected in insurance payments, accident costs are internal. Still, much of the cost of accidents remains outside the market, and it falls to government to decide on how much to spend on various safety projects.

The estimation of the absolute level of accident risk, or of the change in this risk associated with any piece of infrastructure investment, is conducted using dose-response style techniques. The valuation of the outcomes is usually conducted using stated preference techniques, although hedonic wage studies can also be used in some cases.

It must be remembered that estimation of this sort does not account for avertive behaviour. The value of accidents does not take into account disutility or expense of actions undertaken to avoid accidents, such as accompanying children to and from school, or trip reduction for elderly people. The full social cost of the accident risks of transport ought to incorporate both the actual level of accidents caused, and the costs of avertive behaviour.

A.7.6. Congestion

Congestion is a particularly interesting case, because it is external to individual transport users but its effects are largely confined within the group of all transport users. For example, road congestion primarily affects those who use the roads. This has led to mistaken assertions that there is no need for government intervention. However, there is a market failure in that a scarce resource, road space, is not priced in any market, leading to inefficient allocation. The fact that the cost of this inefficiency is borne by road users alone is not relevant in terms of the extent of the inefficiency or the potential for its reduction. It may be seen as relevant in terms of the fairness of any policy, but this is a separate issue from efficiency.

The essential problem of congestion is the time lost. The valuation of time can be carried out using stated preference techniques. However, the marginal value of increasing increments of time lost need not be constant, which complicates the estimation of time values. In addition, this relationship may vary significantly among individuals and with the specifics of any case. For example, many people may find ten one minute delays to their journey less frustrating than a single ten minute delay, even though the overall effect is the same. Thus the unbiased aggregation of time values is potentially complicated.

Realistically, policy appraisal is likely to be conducted with a single unit value for time, or perhaps with different unit values for work time and leisure time, possibly with further breakdown of these categories. Value should be derived by stated preference techniques, rather than by using wage rates. Using of wage rates would imply that any time saved would be devoted to additional work, which may not be the case. Although in theory wage rates will be equal to leisure time valuation at the margin, in practice few individuals can freely vary the amount of time they spend working so as to reach such equilibrium. Even if each individual were at equilibrium, the use of wage rates would fail to account for any direct (dis)utility associated with travel time.

This suggests that the stated preference questions used to value time lost through congestion should focus on the valuation of travel time saved. Ideally, distinctions should also be made between different types of journey (*e.g.* work, shopping or leisure trips), or between journeys made at different times of the day, or between different journey lengths. The valuation of time will probably not be independent of context, so values derived from any specific set of questions may be different from values derived for other time types. This is relevant for comparisons of time valuation studies, and for attempts to validate time valuations.

A.7.7. Land-take

Transport infrastructure is one of the major land uses in most developed countries. The basic principle in the valuation of land used for transport projects (or any other purpose) is that it should be valued at the opportunity cost – that is, the social value of the best possible alternative use. Often, the market price of land may not reflect its social value fully.

It is important to distinguish between sunk (irretrievable) costs of land-take and costs which could in principle be recovered by converting transport infrastructure to an alternative use. Costs of structures such as bridges, tunnels and road surfaces are properly considered sunk costs. Many forms of development are also irreversible in terms of the environmental costs they impose. Sites of archaeological interest, for example, may be destroyed by the development of transport infrastructure. Irretrievable losses cannot be accounted for in current methods for establishing the opportunity cost of transport infrastructure.

This suggests that the social costs that transport infrastructure imposes are different before and after construction. After construction the appropriate procedure is to multiply the quantity of land given over to transport infrastructure by the land rental price. All other assets which occupy or occupied the land are assumed to be irretrievably lost. Before construction, however, many other costs are to be considered as part of the opportunity costs of development. Some are the financial costs of the infrastructure development itself, but of more interest here are the environmental costs associated with development. These are unlikely to be reflected adequately in the cost of acquiring the land.

Market prices will not reflect opportunity cost if there are external social costs or benefits, or if there are restrictions on the free operation of the market, including restrictions on the use of land. The market is often thus restricted by land use planning systems. For example, in "green belts" around towns and cities, land is protected from certain forms of development. One result is that the market price of such land is less than it would be without restrictions.

The market price which would prevail in the absence of restrictions would be a better reflection of the true social cost of green belt land use. It represents the value of the best alternative development use. Normally, it is greater than the market price, because without restrictions the land would likely be highly valuable for commercial and residential development.

Yet, the true social value of the land could be greater still. Valuing the land at the land price for the best alternative development assumes that some form of development is optimal. In fact, the decision to have green belts around cities presumably reflects a view that development is not the optimal option, that an external social benefit arises from leaving land undeveloped.

To estimate this full value would require the application of a stated preference technique. Valuations may be site specific, making individual studies necessary in each case, which would be expensive. But if several studies have been conducted, it may be possible to estimate a relationship between various characteristics of a town, including such aspects as population and proportion of unbuilt area, and the valuation of green space around that town.

Hedonic techniques could be used to detect value associated with proximity to open land, but would detect only the value to residents. For green belt land, value can arise simply from the aesthetic benefits of travelling through unbuilt areas during commuting; and if the land is used for recreation by non-residents, these values will also be missed. Hedonic applications are therefore most likely to be useful if taken in conjunction with stated preference results.

Many other kinds of land use also have external benefits; examples include historic sites and monuments, wooded areas and the like. Some such areas may have entrance fees, which will partially reflect the social value but will not reflect the consumer surplus (benefits to consumers above the fee paid). Other areas will have values which are not reflected at all in the market value of the land, although they may have a hidden influence on the economy of the area via tourism and recreation for residents.

Generally, value will be site specific, so measurement requires separate studies. This is clearly the case for unique monuments and landscapes, but for other areas it may be possible to follow a similar approach to that suggested for green belt land, with several studies of representative areas being used as the basis for wider valuation. Stated preference techniques are the most likely choice for estimation of values, although in some cases the travel cost method might be applied.

A.7.8. Waste generation

Use of vehicles generates several kinds of waste, including used oil, coolant and hydraulic fluid, used tyres and batteries and scrapped vehicles. Infrastructure construction also results in large quantities of waste, in particular spoil from earthworks. To the extent that the disposal costs are borne by society rather than the individual creating the waste, an external cost exists.

The financial costs of waste disposal are relatively straightforward to estimate. Most waste has to be landfilled or possibly incinerated, though some can be recycled, with possible benefits. The financial costs of landfill will reflect true social costs only if the land used has been appropriately valued.

Additional social costs may be associated with waste disposal due to leachate or gas emissions from landfills or incinerators. Few studies exist relating to this form of external cost. The most likely valuation technique would involve dose-response estimation of the relationship between waste volumes of a certain type and the amount of leachate reaching watercourses, or of air pollutants emitted. This would need to be followed by dose-response estimates of the effects of the resulting ambient concentrations of pollutants, and by subsequent valuation of the impacts using unit values from stated preference studies. The results for air emissions may be useful, but for leachate the problems in establishing dose-response functions relating water pollution to health and other impacts are likely to be too great, given present knowledge, to allow useful valuations.

A.7.9. Water pollution

Water pollution is a lesser known impact of transport, but much more significant than might be imagined. In particular, surface run-off from road surfaces and gasoline stations carries large quantities of hydrocarbons to watercourses and sewers. Salt and chemicals used to de-ice roads, weedkillers used on roadsides and infrastructure, and leaks from underground storage tanks can all reach watercourses and groundwater. This has direct environmental impacts, as well as imposing costs on local authorities responsible for water quality control. Water pollution from shipping is also a problem.

The first stage of any attempt to value water pollution is to establish a link between emissions and concentrations of pollutants in the environment. It is much more difficult to establish links involving non-point sources such as transport than for point sources such as chemical factories. In addition, water pollution from transport tends to have an uneven distribution through time, occurring in spates (*e.g.* road run-off during rain). Therefore, there are problems in quantifying the contribution of the transport sector to the overall level of the effects.

The valuation of impacts is also difficult, in particular due to problems in estimation of dose-response functions between concentrations of water pollutants and impacts on health, fish populations and so on. Essentially, there is much less scientific knowledge in this area than for air pollution. The current prospects for valuation of water pollution using a dose-response approach are poor for most pollutants.

It would be possible to attempt application of stated preference methods to valuation of water pollution. However, the results might not be particularly meaningful, because people's knowledge of the effects of various pollutants is likely to be poor.

The principal unresolved issues in the valuation of water impacts are scientific, not economic. The main requirements for progress are improved data and research into the connections between emissions and water pollution, and between water pollution and damaging effects.

A.7.10. Severance

Transport infrastructure and the traffic using it can create varying degrees of severance of human and animal communities. These effects range from mild hindrance of social links between neighbours on opposite sides of roads and risks to children playing outside, to complete separation of one part of a community from another by a substantial barrier such as a busy motorway or rail track. Changes in behaviour are required to reduce the risk of accidents while walking or cycling in such an environment. Severance has not featured in many estimates of the social costs of transport, partly through lack of appreciation concerning the theory but also because measurement can be difficult. Nevertheless, it seems important to acknowledge the existence of severance.

The ease of measuring the cost of avertive behaviour depends on whether avertive actions might contribute to welfare in their own right or are undertaken solely to alter the level of risk to which an individual is exposed. Avertive costs are easier to measure in the latter case. Empirical evidence in the form of reductions in the number of miles walked or cycled is highly suggestive of avertive action, although it might also be due to some extent to changes in preferences. But adaptation to increased traffic volume extends beyond changing the number of miles walked or cycled. Many individuals wear reflective clothing to help drivers see them, or protective headgear, or have bought such things for a child in their care. Journeys by foot or bicycle are significantly lengthened by waiting to cross busy roads. It is hard to describe these actions as being anything other than purely avertive.

It is possible to conceive of a very large number of actions and purchases having at least some bearing on the costs of falling victim to a road accident. While in principle all these should be considered, in practice the list of avertive actions is limited to changes in distance travelled and speed taken. In a simple model, in which the two major actions taken to avoid being hit by a car are to reduce the distance travelled and to increase the time taken per unit of distance, it can be shown that the marginal willingness to pay for a change in traffic flow has five components. The first is the observed increase in accidents multiplied by the value of statistical life (see Annex B). This is what is conventionally measured. The second term is the value of time saved by a unit reduction in distance walked multiplied by the marginal reduction in distance travelled. The third term is the value of the time saved for a marginal change in speed multiplied by the marginal change in speed. The fourth term represents the probable marginal valuation of an extra unit of distance walked multiplied by the marginal change in distance walked. The final term is the probable marginal valuation of a unit change in speed. These two last terms, unlike the others, cannot readily be measured.

If the change in optimally chosen speed, as well as the optimally chosen number of journeys made, can be estimated as a function of exogenous variables, then the changes in time spent and the number of journeys undertaken can be determined by differentiating this dose-response function with respect to traffic characteristics. This is combined with information regarding the length of time spent walking in a particular area along with the time taken per unit distance covered. If the value of time is known from other sources, then it will be possible (at least in principle) to provide a lower bound to the barrier effect of traffic. More comprehensive approaches can be proposed, but implementing them requires an unduly large amount of information involving complete specification of preferences.

In contrast to the behavioural approach, the main problem with stated preference applications lies in defining a credible object of valuation, without risk of including other factors in responses. For example, questions concerning WTP for pedestrianisation of streets may lead respondents to consider (erroneously, in this context) any benefits they would derive from reduced noise, air pollution, etc. It is difficult to see how these problems can be overcome, so stated preference approaches cannot be recommended for use in this purpose.

A.7.11. Aesthetic impacts

Both transport infrastructure and its use influence the aesthetic quality of the environment. The obvious impacts are negative: reduced visibility brought about by air pollution, disruption of scenic views by busy roads, etc.

The literature includes several attempts to value such impacts, in particular visibility effects, though these are all site specific. Attempts to value visibility or visual intrusion usually focus on a particular point source, such as a power station and its plume. Such studies have had some success in applying contingent valuation techniques. Thus carefully designed contingent valuation studies could be commissioned to value particular aesthetic impact cases.

The most useful valuations are likely to be those available before construction on a proposed infrastructure project. But valuations elicited under these conditions are likely to be less accurate than valuations elicited *ex post*, because expectations of the disruption may not coincide particularly well with how people actually feel after the fact. This is difficult to control for. It might be possible to determine a relationship between pre-construction and post-construction valuations by conducting ''before and after'' studies. However, it is not certain that a stable relationship of this sort would exist for any given type of infrastructure, let alone for infrastructure in general.

Annex B

DETAILS OF THE ESTIMATION OF EXTERNAL COSTS

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B.1. DERIVATION OF SHADOW VALUES FOR UNIT EFFECTS

B.1.1. Objectives

In this annex estimates of the total costs of the key transport externalities – accidents, noise, air pollution and climate change – are reviewed from the literature. External costs are then apportioned among modes and transport services, and estimates derived for external costs in terms that can be used in designing internalisation policies. The approach followed is to estimate total costs for each externality by mode for a country or region, then distribute this estimate among different transport services. Based on the literature, two indicators are derived: estimates of total external costs in terms of percentage of GDP; and shadow prices in terms of ECU per unit of impact. From these, average unit costs are calculated in terms of ECU per passenger- or tonne-kilometre.

B.1.2. Meta-analyses of total cost estimates

The information cited on the total external costs of transport draws on an extensive body of literature. The expression of these estimates in terms of percentage of GDP is of use in allowing comparisons among countries, and to an extent in informing priorities. Problems exist, however, because the studies regularly fail to make clear the assumptions used, often because they are secondary research based on consideration of several primary studies. Also, studies may be based on very different techniques which aim to measure different aspects of a problem, or sometimes even different effects altogether. These considerations open the door to two related errors: wide variation in the estimates could be interpreted as a general failure of attempts at measurement; or close similarity of estimates could be interpreted as confirmation. Either conclusion might be wrong if the basic underlying assumptions of studies differ significantly.

A potential solution to these problems is to attempt very basic meta-analysis of different studies – processing several studies together, treating their results as belonging to a single distribution. This is possible only if enough information on the assumptions made in each individual study is available. Where such meta-analyses are feasible, they are of use in deriving genuine consensus estimates in a statistically justifiable manner.

B.1.3. Marginal cost estimates

Design of optimal policies and comparisons among modes requires information on marginal external costs, rather than total costs. The most common way unit costs have been approximated (also followed here) is to employ a ''top-down'' approach, with total cost estimates for the transport sector split among modes, and so on, down to costs per vehicle- or passenger-kilometre (the basic data for distributing costs is summarised in Tables 33 and 34). The resulting estimates are of course average costs, however, not marginal costs.

In some cases it can be argued that marginal costs can be assumed as constant; that is, that the marginal cost does not change with different total levels of the effect. If marginal costs are indeed constant, then average and marginal costs will be equal, and in many cases the available information may be insufficient to allow us to progress beyond this assumption.

A few studies take a ''bottom-up'' approach, starting with a base of primary valuation studies and attempting to relate marginal values of an effect (say, noise or air pollution concentrations) with marginal contributions to the effect from a cause (say, marginal noise or pollution emissions from road

Table 33. **Road transport volume data for 17 Western European countries, 1991**

Country	Vehicle km			Utilisation factor		
	Cars	Buses	Goods vehicles	Cars	Buses	Freight*
	billion vehicle km/a			Passengers/vehicle		Tonnes/vehicle
Austria	42.0	0.5	5.2	1.71	27.85	2.52
Belgium	50.5	0.4	5.7	1.50	26.14	4.52
Denmark	30.7	0.5	6.3	1.79	20.80	1.65
Finland	33.1	0.7	5.4	1.40	12.46	4.42
France	325.0	4.0	105.0	1.84	10.75	1.41
Germany	406.0	3.4	44.6	1.71	21.00	4.55
Greece	9.4	0.5	3.4	2.03	10.24	3.64
Ireland	19.7	0.2	5.0	1.85	15.70	1.01
Italy	259.8	4.8	45.5	2.03	33.05	3.67
Luxembourg	3.0	0.0	0.4	1.50	26.14	1.90
Netherlands	77.8	0.6	12.9	1.95	22.31	1.80
Norway	23.2	0.3	3.1	1.73	11.92	2.45
Portugal	35.0	0.6	2.0	1.91	17.07	5.40
Spain	76.0	2.0	24.2	1.91	19.22	6.21
Sweden	60.5	0.7	5.1	1.51	15.21	4.97
Switzerland	48.0	0.2	4.9	1.85	14.19	2.61
United Kingdom	329.7	4.3	60.0	1.72	9.53	2.08
Total	1 829.0	24.0	339.0	1.79	18.79	2.84

* Average for all goods vehicles.
Source: INFRAS/IWW (1995).

transport). Where sufficient data are available, this approach can yield the full range of marginal costs relevant to any given total level of effect. However, in most cases information is not sufficient to allow such full estimation of marginal costs.

Table 34. **Railway transport volume data for railways in 17 Western European countries, 1991**

Country	Companies	Train-km				Passenger-km	Tonne-km
		Diesel		Electric traction			
		Passenger	Freight	Passenger	Freight		
		million km/a				mp-km/a	mt-km/a
Austria	ÖBB	15.1	3.3	71.7	39.9	9 208	12 696
Belgium	SNCB/NMBS	7.7	7.9	64.0	12.7	6 771	8 349
Denmark	DSB	33.8	6.8	14.1	0.0	4 797	1 907
Finland	VR	7.9	8.1	16.8	7.3	3 230	7 700
France	SNCF	84.9	24.2	233.1	136.1	62 101	53 665
Germany	DB/DR	196.6	58.3	387.7	204.1	55 936	81 790
Greece	CH	..	..	..	..	1 995	606
Ireland	CIE	7.7	4.1	1.9	0.0	1 290	603
Italy	FS	54.3	4.4	182.8	62.9	46 427	20 581
Luxembourg	CFL	0.9	1.0	2.8	0.6	220	626
Netherlands	NS	13.7	2.6	92.7	8.9	12 796	3 187
Norway	NSB	4.2	2.3	19.4	6.5	2 150	2 666
Portugal	CP	14.9	4.3	14.4	2.9	5 688	1 727
Spain	RENFE	27.1	9.9	100.3	35.3	15 022	10 507
Sweden	SJ/BV	5.5	3.3	52.0	35.1	5 524	18 026
Switzerland	CFF/BLS	0.0	0.2	103.0	27.8	12 793	8 728
United Kingdom	BR	177.7	47.8	195.6	6.8	32 058	17 274
Total		652	188	1 553	587	278 006	250 638

Source: UIC International Railway Statistics 1991; INFRAS/IWW (1995).

To the extent possible, information on marginal costs has been incorporated in the design of the indicators of external costs retained for the policy analysis in this report. The results of the limited work on marginal damage estimates are compared with the results from the bulk of the literature.

The actual damage related to an individual vehicle-kilometre can vary greatly according to location, speed, time of day and so on. The approach taken here accounts for this only at a very broad level of generalisation, so the results must be seen as rough averages. For cost-benefit studies of particular infrastructure projects, expected changes in noise and air pollution for a clearly defined population must be estimated. Some of the shadow prices derived in this report would therefore not be suitable for use in project evaluation.

B.2. ACCIDENT COSTS

B.2.1. Overview

In 1995, over 2 million people were injured, 67 thousand of them fatally, in road traffic accidents in the 27 European countries for which the ECMT keeps records. Since the early 1970s, as a result of safety measures introduced by most governments (speed limits, mandatory use of seat belts, etc.), the number of people involved in accidents in western Europe each year has fallen by nearly 35%, despite a steady increase in road traffic. This trend could be reversed, however, as witness the gradual increase in casualties in the early 1990s in ECMT Member countries. The situation is disturbing in many countries, especially in central and eastern Europe and other places where vehicle ownership is rising rapidly. The overall situation is far from satisfactory.

Although statistics on accidents, injuries and fatalities could be improved and standardised internationally, they are the most complete source of data currently available on the external and social effects of transport.

Road accidents are by far the main contributors to transport accident costs. Quinet (OECD, 1989) classifies the effects of road accidents as follows:

- damage to vehicles and the immediate vicinity;
- police and emergency services expenditure;
- legal, insurance and funeral costs;
- medical treatment;
- compensation for pain, grief and suffering to those involved in accidents or to their relatives;
- loss of output;
- loss of whatever value society attributes to the life of its members and their continued survival.

Money spent on education and training could also be seen as an investment that is wasted when young people are killed in traffic accidents. All these losses are social costs of transport accidents. Some of these costs are internalised, for example by insurance premiums covering certain aspects of the losses. Medical costs, however, are only partly covered by insurance. To establish the external costs of transport accidents a distinction must first be drawn between costs that are already internalised and costs that have to be borne by the community. External accident costs are defined in this report as costs not covered by insurance.

Valuations based on official government figures for loss of life yield social costs (including material costs and costs covered by insurance) averaging 1.25% of GDP for the 14 countries shown in Table 35.

Any study will be particularly sensitive to the valuation of non-material damage. Human costs through loss of life and injury invariably account for the largest share of both social and external costs. Table 36 shows the official values for a statistical life used in a selection of countries, some of which include non-material damage in their estimation and some of which do not (generally the lower values). Table 37 gives values for a statistical life from a more recent survey which only covers estimations that include an element for the non-material costs of death.

Table 35. **Social costs of road and rail accidents, based on official reference values for loss of life**

million 1989 ECU

Country	Road	Rail	% of GDP
Germany	14 033	132	1.31
Austria	1 973	34	1.74
Belgium	2 335	8	1.60
Denmark	635	5	0.65
Spain	4 426	10	1.26
Finland	1 649	60	1.92
France	7 423	51	1.00
Luxembourg	60	1	0.92
Norway	359	5	0.47
Netherlands	1 130	5	0.56
Portugal	152	2	0.39
United Kingdom	11 879	86	1.57
Sweden	2 020	21	1.24
Switzerland	2 137	99	1.45
	50 211	519	
% of GDP	1.24	0.01	1.25

Source: Hansson and Markham (1992).

Table 36. **Official valuations for the loss of life for selected countries**

1990 ECU

Germany	625 697
Denmark	628 147
Spain	100 529
Finland	1 414 200
France	269 129
Netherlands	80 000
Portugal	78 230
United Kingdom	935 149

Source: Hansson and Markham (1992).

Table 37. **Estimates of the social value of a statistical life used by National Road Administrations for infrastructure project assessments in selected countries**

1991 ECU

Country	Year of estimate	Value of statistical life
United Kingdom	1990	876 170
Austria	1990	1 267 510
Finland	1990	1 302 930
Sweden	1992	1 465 310
Switzerland	1990	2 037 200

Source: INFRAS/IWW (1995).

Putting a price on life is of course a sensitive issue and one which more properly belongs to the realm of ethics, but the value may be approximated as the price society is willing to pay to save lives. The same principle can be applied to road safety as to other non-market "good" such as air quality or freedom from noise: people's willingness to pay (WTP) – in this case, what they are willing to pay to reduce their probability of death on the roads. The method of estimating WTP used in the latest studies is derived from "stated values" based on responses to user surveys. For instance, if a population of 100 000 were willing to pay ECU 1 million to reduce the probability of fatalities from 10 in 100 000 to 8 in 100 000, each human life would have a monetary value of ECU 500 000. Surveys can be conducted to establish such figures. Stated preference methods such as this tend to place a high value on the factors that this study wishes to estimate.

In France, a report by a study group (Boiteux, 1994) found that such surveys were not easy to conduct, but one such study, whose validity is not questioned, is nevertheless being carried out at the request of France's Commissariat Général du Plan. Pending its results, the Boiteux report recommends that the figure for loss of human life be calculated as the loss of output at present values, *i.e.* ECU 525 000, or almost double the value shown in Table 36.

In Sweden, Austria, Switzerland, the United Kingdom and Finland, where the WTP method has been used in calculating the costs of infrastructure improvements, official values for loss of life ranged from ECU 0.9 million to ECU 2 million.

In the study conducted by INFRAS and IWW for the International Union of Railways (UIC), the value used by Sweden (ECU 1 438 247 in 1991) was taken as the reference value and weighted to reflect purchasing power parities in the countries studied. With this method, the external value placed on human life in Europe (17 countries) averaged ECU 1 million. The INFRAS/IWW study assumes that people's underlying preferences as far as road safety is concerned are the same in all countries; it is difficult to assess how valid this is.

Elvikj[1] estimated the value of human life using a function of the utility for the community of a reduction in road accident risk. For the purpose of this estimate, "society" was divided into four interested parties: the individuals who run the risk of a road accident, the families of these individuals, private third parties (enterprises, etc.) and the public sector. All four stand to benefit from a reduction in the road accident risk. An analysis of 190 estimates led Elvikj to conclude that the intrinsic value of human life was about ECU 1 million; or, if the social benefits of a saved life were included in the calculations, ECU 1.5 million, *i.e.* a figure similar to the value given in Table 36 for Finland; it is also near the figure INFRAS/IWW gives for Norway.

The same method can be used to establish the external costs per non-fatal injury in transport accidents. The total external costs comprise medical costs, costs of temporary replacement in the workplace and net output loss minus insurance payments, which are already internalised.

The INFRAS/IWW study stresses that some accidents are not reported, but the majority of these involve only minor injuries. Accordingly, the external cost per non-fatal injury in Europe (17 countries) was calculated at around ECU 45 000 (1991). It is difficult to apply the same correction factor to all countries, since the number of accidents not reported may vary greatly depending on national practice. Leaving this problem aside, the total external cost that INFRAS/IWW obtained by multiplying the external costs of fatalities and injuries by the number of casualties in each category amounted to ECU 148 billion for Europe (17 countries, EU, Norway and Switzerland, 1991), *i.e.* 2.5% of overall GDP. Over 99% of the external costs are attributable to road accidents; the remainder stem from rail accidents (INFRAS/IWW did not study air transport). Injuries generate 57% of the external costs and fatalities 43%. In both instances the human costs accounted for over 90% of the total.

Table 38 gives external costs that are higher than the social costs cited in Table 35, mainly as a result of the values attributed to loss of life and injury. Most of the loss of life values given in the INFRAS/IWW study are much higher than the official figures given in Table 36. The distinction that needs to be drawn is between estimates based on willingness to pay, which are recognised by classical economic theory as most appropriate, and official values based on other approaches.

Table 38. **External costs per fatality**

1991 ECU

	Administrative costs (police, justice, etc.)	Medical costs [1]	Loss in output	Loss in life	Total external costs
Germany	20 114	4 879	105 193	1 103 003	1 233 190
Austria	19 417	4 710	91 193	1 064 785	1 180 106
Belgium	18 277	4 434	84 694	1 002 236	1 109 640
Denmark	22 884	5 551	110 864	1 254 919	1 394 218
Spain	16 945	4 111	59 004	929 228	1 009 288
Finland	24 831	6 024	72 732	1 361 681	1 465 268
France	18 425	4 470	70 697	1 010 385	1 103 977
Greece	14 118	3 425	11 460	774 179	803 182
Ireland	17 119	4 153	40 028	938 785	1 000 085
Italy	18 819	4 565	68 753	1 032 007	1 124 145
Luxembourg	18 463	4 479	311 044	1 012 489	1 346 475
Norway	23 458	5 691	117 496	1 286 391	1 433 036
Netherlands	18 618	4 516	91 505	1 020 953	1 135 592
Portugal	12 144	2 946	30 169	665 928	711 187
United Kingdom	17 878	4 337	45 788	980 378	1 048 381
Sweden	26 227	6 362	115 597	1 438 247	1 586 434
Switzerland	24 837	6 025	268 376	1 361 971	1 661 209
Average	**18 390**	**4 461**	**74 969**	**1 008 463**	**1 106 283**
Share	1.66 %	0.40 %	6.78 %	91.16 %	100%

1. Includes costs to business of replacing deceased workers.
Source: INFRAS/IWW (1995).

Table 39 gives the total number of transport sector casualties (fatalities and injuries) and the external costs as a percentage of GDP for the 17 countries. These data are from the INFRAS/IWW report, which it will be recalled, takes the Swedish valuation of loss of life as the reference value, weighting it to reflect purchasing power parities.

Table 39. **External costs of casualties, 1991**

Country	No. of casualties	External costs (% of GDP)
Germany	14 114	2.9
Austria	1 817	3.6
Belgium	2 091	3.6
Denmark	855	1.4
Spain	8 929	3.5
Finland	948	1.7
France	11 712	2.2
Greece	1 579	4.4
Ireland	450	2.5
Italy	9 076	2.2
Luxembourg	109	2.5
Norway	472	1.4
Netherlands	1 479	1.6
Portugal	2 444	8.2
United Kingdom	4 947	2.3
Sweden	1 204	1.4
Switzerland	1 468	1.7
Total	63 694	2.5

Source: INFRAS/IWW (1995).

Table 40 compares estimates of external costs based on WTP with estimates derived from official government valuations of human costs. As can be seen, the estimates for Finland, Sweden, Switzerland and the United Kingdom are close; these countries used the WTP method in attempting to evaluate external and social costs for their official estimates. For other countries, the values obtained by the WTP method are at least twice as high as those obtained by the output loss and other methods used in the official valuations. For Portugal, for instance, the figures based on the Swedish reference value weighted for purchasing power parities are more than 20 times higher than the official valuations. It would seem that in the past – since the current figures are higher – official figures in Portugal considerably understated the human costs. Recall that Boiteux (1994) recommended doubling the official 1990 values used in France. The figures in Table 41 are estimates taken from the INFRAS/IWW study, which applies the Swedish reference value to different countries.

Table 40. **Ratio of INFRAS/IWW values for external costs of accidents to estimates based on official values of life, 1991**

Country	% of GDP			Method used for (2)
	INFRAS/IWW (1)	Official value 1990 (2)	Ratio (1/2)	
Germany	2.9	1.31	2.20	Output loss and gross costs
Austria	3.6	1.74	2.06	"
Belgium	3.6	1.60	2.25	"
Denmark	1.4	0.65	2.15	"
Spain	3.5	1.26	2.77	"
Finland	1.7	1.92	0.88	Willingness to pay
France	2.2	1.00	2.20	Life expectancy valuation
Luxembourg	2.5	0.92	2.70	Output loss and gross costs
Norway	1.4	0.47	2.97	"
Netherlands	1.6	0.56	2.80	"
Portugal	8.2	0.39	2.10	"
United Kingdom	2.3	1.57	1.46	Willingness to pay
Sweden	1.4	1.24	1.12	"
Switzerland	1.7	1.45	1.17	"
Average	2.5	1.25		

Source: ECMT Task Force based on INFRAS/IWW (1995).

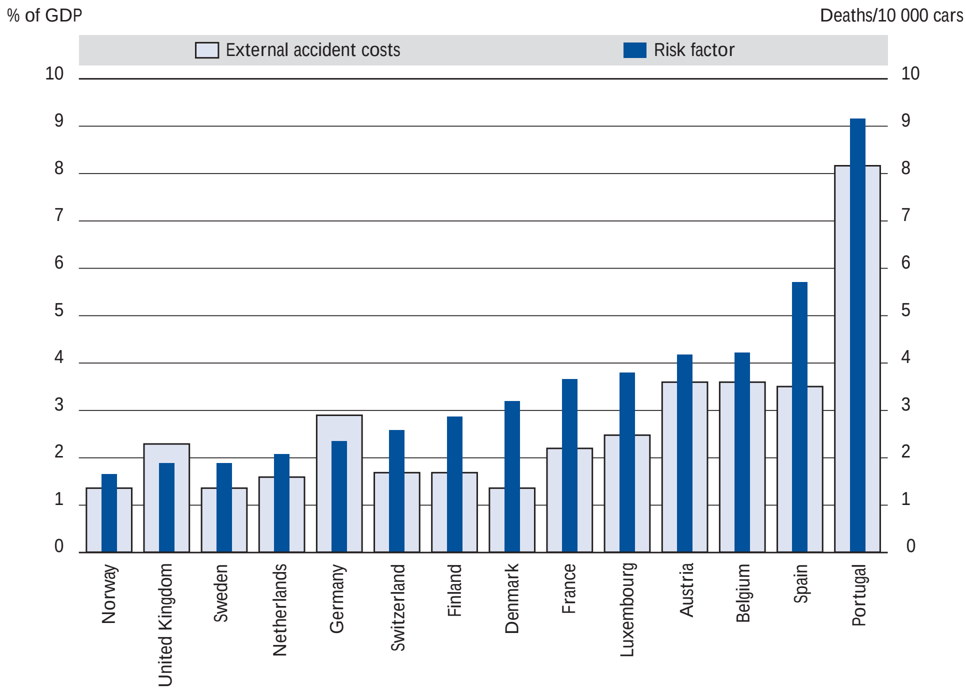
Table 41. **External costs of accidents as % of GDP, 1991**

Country	No. of casualties	External costs as % of GDP
Germany	427 571	2.9
Austria	62 041	3.6
Belgium	82 520	3.6
Denmark	10 871	1.4
Spain	155 247	3.5
Finland	12 179	1.7
France	215 585	2.2
Luxembourg	1 740	2.5
Norway	12 035	1.4
Netherlands	48 672	1.6
Portugal	73 177	8.2
United Kingdom	321 406	2.3
Sweden	23 269	1.4
Switzerland	29 100	1.7

Source: Casualties, ECMT; External costs based on INFRAS/IWW (1995).

The countries examined can be put into three groups: *a)* Austria, Belgium and Spain, where external costs are higher than 3% of GDP; *b)* Germany, France, the United Kingdom and Luxembourg, with external costs lower than 3% of GDP; *c)* Norway, Finland, Denmark, the Netherlands, Switzerland and Sweden, where external costs are lower than 2% of GDP.

◆ Figure 15.***External costs of road accidents and exposure to risks***



Source: ECMT, based on INFRAS/IWW (1995).

The value attributed to life evidently reflects – if only in cost-benefit analyses – the stringency of road safety policies. The data presented tend to confirm that the countries which value safety highly achieve the best results. However, it must be understood that a high value on human life may reflect a general societal attitude towards road safety which manifests itself in a whole range of different measures (speed limits, measures to combat driving while intoxicated, etc.) that all combine to produce significant results.

In conclusion, based on the values obtained by contingent valuations (surveys), the external costs of accidents (except for Portugal) range from 1.5 to 3.5% of GDP, and average 2.5%.

In its 1996 green paper, ''Towards Fair and Efficient Pricing in Transport'', the European Commission states: ''The gross under reporting of injury accidents radically affects overall accident costs.'' Stressing how much people in the European Union would be willing to pay to reduce the risk of accident (ECU 150 billion), the paper concludes that the external costs of accidents amount to 1.5% of GDP. It also notes that further investigation is warranted, mainly to allow for users taking accident risk into consideration in making travel decisions (an approach viewed as unjustifiable by the authors of the present report - see following section).

B.2.2. Shadow prices

Jones-Lee (1990) provides a review of some estimates of the value of statistical life. Viscussi (1993) presents a wide ranging survey, covering many avertive behaviour and hedonic wage studies, but giving less detail on each. And Calthrop (1996) gives results of a meta-analysis covering many of the studies listed in the other two. Most of the results, summarised in Table 42, project higher values than those in the INFRAS/IWW study (ECU 1 million).

Table 42. **Results of some life valuation studies**

Study	Estimate range	Comments
Cited in Jones-Lee (1990):		
Jones-Lee *et al.* (1985)	ECU 3.2 m	United Kingdom survey of 1 100
Persson (1989)	ECU 2.6 m	Swedish survey of 500
Maier *et al.* (1989)	ECU 3.0 m	Austrian sample of 100
Jones-Lee (1989)	ECU 2.9 m*	mean revealed preference: 7 United Kingdom, 13 United States, 1 Australia
Cited in Viscussi (1993):	(1990 $)	
Dardis (1980)	$ 0.6 m	smoke detector purchases
Garbacz (1989)	$ 2.0 m	smoke detector purchases
Marin & Psacharopolous (1982)	$ 2.8 m*	United Kingdom wage-risk study
Labour market (pre-1980 data)	$ 4.6 m mean*	range $0.6 m to $10.3 m
Labour market (post-1980 data)	$ 7.5 m mean*	range $1.6 m to $16.2 m
Calthrop (1996)	ECU 2.4 m	std error = 0.5 m

* Some wage studies use gross instead of net wages and their results should therefore be adjusted downwards to reflect marginal tax rates.
Source: ECMT Task Force.

The above results draw on many studies using rigorous applications of economic valuation techniques. They have not been subjected to manipulation on political or other grounds as a precursor to use in policy formation. Although considerable uncertainty clearly remains, there is some degree of convergence in the estimates. The meta-analysis by Calthrop supports this idea and suggests that the value of statistical life should lie in the range of ECU 1.4-3.4 million, which is two standard errors about the mean in his study, ECU 2.4 million.

The statistical value of life retained for estimating external costs

It remains to select an appropriate value for the statistical value of life to be used in the calculation of the external costs of accidents as the basis of the policy options to be developed in this report. From a theoretical standpoint Calthrop's mean of ECU 2.4 million is the best value available. However, this report adopts a conservative approach aimed at reaching acceptable lower bound estimates of the social costs of transport. From this perspective the mean value of the official estimates that incorporate an element for non-material costs, presented in Table 37, provide a firm basis for a politically based lower bound. This computes to ECU 1.4 million in 1990 ECU, or ECU 1.5 million in current terms, at the bottom of the range calculated by Calthrop.

The following equation may be used to transfer a value between different countries, or across different time periods:

$$\text{Value}_1 = \text{Value}_0 \times (\text{Income}_1/\text{Income}_0)^e$$

where "0" indicates the original country/time, "1" indicates the country/time transferred to, and "e" is the income elasticity for the value. One reasonably consistent result is that the income elasticity of safety valuations is estimated at 0.3. Studies supporting this include Jones-Lee *et al.* (1985) for the UK, Persson (1989) for Sweden and Blomquist (1979) for the US, seeming to indicate a relationship which is fairly constant across countries and times. This suggests that safety is a "normal" good, meaning, for example, that when real incomes rise, safety valuation will increase in real terms, albeit by a smaller proportion than the increase in incomes. The effect will be to reduce the variation of real safety values among countries, and also across time periods.

These results relate to cross-sectional elasticities within each study for a particular place and time, so it remains possible for the elasticity to be different for value transfers across time. Calthrop (1996) used a figure of 0.5 to update other studies for his meta-analysis, citing Loehman's finding (1994) of a 0.26 to 0.6 elasticity range. The 0.5 figure is certainly not unreasonable. For transfers across countries here, a figure of 0.3 will be used.

Technically, marginal valuation of risk changes ought to consider the absolute level of risk to which each individual is already exposed, as well as the change in risk under consideration. However, data are not readily available at this level of detail. The normal procedure when applying risk values is to combine risk changes with populations exposed to yield the expected number of lives lost or saved by a policy or decision. This figure is then multiplied by the estimated "value of statistical life" to give the total value of the policy. (The term "statistical" is required as a reminder that such valuation concerns small risks summed over many people, rather than specific individual lives.)

The implication is that a 1 in 1 000 risk of death for 1 000 people is given the same value as a 1 in a million risk for 1 million people. This assumed linearity of risk valuation is not theoretically justified, and should not be pushed to extremes: for example, certain death for one person could not be valued in the same way. However, for the range of risks associated with transport policy, the assumption is more acceptable. It does have the appealing characteristic that one statistical life saved will be valued the same as any other, regardless of the specific situation.

That being said, there has also been much work concerning differential valuation of life for different transport modes. This work has been motivated to an extent by desires to rationalise the current situation, in which safety standards are significantly greater for air travel and (to a lesser extent) rail travel than for road. Two principal rationalisations have been suggested: first, that disasters in which many people die are weighted more heavily than a series of smaller accidents killing the same number in all; second, that people's attitudes to risk depend on the amount of control they have, and that travellers have no control over air or rail safety but feel much more in control of their risks when driving themselves.

There has been much recent research relating to valuation of non-fatal effects of accidents and of air pollution. O'Reilly *et al.* (1994) present the results of a major UK research project on the valuation of serious non-fatal injuries, which will be drawn on here to derive shadow prices.

The main advantage of using the O'Reilly *et al.* results is that one technique employed involved eliciting valuations relative to life valuation. Thus, the results are expressed as a fraction of the life value, which may be applied to whatever life value is to be used, if it is assumed that people's preferences regarding safety adapt in the same way for fatal as for non-fatal injuries. Such evidence as there is on elasticities would not refute this.

Direct contingent valuation yielded higher values, but the authors expressed reservations about the validity of these results. A third strand of research, using health experts' rankings of severity of different injury states and recovery times, alongside relative measurements of "time lost", gives values in between the two other techniques. Table 43 shows the results of all three approaches.

The results for different specific serious injuries were weighted by the annual UK probability of suffering each injury in a road traffic accident, to give an overall figure which may be applied to "serious non-fatal accidents".

The recommendation made here will be to use 13% of the life value as the value of a serious non-fatal accident. This means a value of ECU 0.2 million per case. The definition of "serious" is that used in the UK statistics, as in the original study design, though the figure may not be accurate for use in other countries, to the extent that recording criteria differ.

Table 43. **Ranking of serious injury as fraction of life value**

Valuation method	Fraction of life value
Standard gamble	8.6-12% (best = 9.5%)
Contingent valuation	29-54% (best = 37%)
Expert rankings	18-20%

Source: O'Reilly *et al.* (1994).

To estimate shadow values for fatal and serious non-fatal casualties in European countries, the estimates above must be transferred. For this, it must be decided which country they are based in. Because the studies are from many different countries, all covered by the meta-analysis, this is a little subjective. Taking the simple mean of purchasing power parity incomes per capita for the US, UK, Austria and Sweden suggests a base assumption of French-equivalent income, which will be used here.

In Tables 44 and 45, the entries in the PPP columns show the ratio of incomes at purchasing power parity for each country with respect to France. The PPP^e columns show this ratio raised to the power of 0.3, the assumed income elasticity of safety valuation. It is this value which is multiplied by the estimated shadow prices of ECU 1.5 million for life, and ECU 0.2 million for serious injury, to give the national valuations.

The ''other costs'' columns show estimates of administrative and medical costs taken from INFRAS/IWW (1995). The estimates for France have been used, and transferred to other countries at the ratio shown in the PPP column – the 0.3 elasticity relates only to safety valuation. The total shadow price for fatal or for serious injury accidents is the sum of the shadow life/injury value and other costs.

The fatal accident statistics are for 1992 and come from Transport Statistics Great Britain 1994. The serious injury statistics are from INFRAS/IWW (1995). The calculations of cost of serious injuries take into account the fact that the INFRAS/IWW figures are for officially reported accidents. For the UK statistics, serious injuries form about 15% of this total. Since the UK definition is the basis for the serious injury

Table 44. **Shadow prices and valuation of transport fatalities**

Country	PPP	PPP^e	Shadow life value ECU m	Other costs ECU m/ fatality	Road deaths in 1992		Rail deaths in 1992	
					No.	ECU m	No.	ECU m
Austria	0.97	0.99	1.49	0.019	1 403	2 117	30	45
Belgium	0.98	0.99	1.49	0.020	1 672	2 525	11	17
Denmark	0.96	0.99	1.49	0.019	577	871	7	11
Finland	0.78	0.92	1.38	0.016	601	839	15	21
France	1	1	1.50	0.020	9 900	15 048	126	192
Germany	1.10	1.03	1.55	0.022	10 631	16 712	146	230
Greece	0.45	0.79	1.19	0.009	2 102	2 520	21	25
Ireland	0.67	0.89	1.34	0.013	415	561	5	7
Italy	0.94	0.98	1.47	0.019	8 029	11 955	51	76
Luxembourg	1.18	1.05	1.58	0.024	73	117	1	2
Netherlands	0.92	0.98	1.47	0.018	1 285	1 912	21	31
Norway	0.95	0.98	1.47	0.019	325	484	7	10
Portugal	0.53	0.83	1.25	0.011	3 217	4 057	85	107
Spain	0.69	0.89	1.34	0.014	7 818	10 586	11	15
Sweden	0.89	0.97	1.46	0.018	759	1 122	14	21
Switzerland	1.20	1.06	1.59	0.024	834	1 346	24	39
United Kingdom	0.88	0.96	1.44	0.018	4 379	6 385	39	57

Source: ECMT Task Force estimates.

Table 45. **Shadow prices and valuation of transport injuries**

Country	PPP	PPP [e]	Shadow value of serious injury thousand ECU	Other costs thousand ECU	Total road injuries in 1992		Rail injuries in 1992	
					No. thousand	ECU m	No. thousand	ECU m
Austria	0.97	0.99	198	2.4	60.5	1 942	0.07	2.2
Belgium	0.98	0.99	198	2.5	80.6	2 595	0.05	1.6
Denmark	0.96	0.99	198	2.4	10.3	331	0.03	1.0
Finland	0.78	0.92	184	2.0	11.5	340	0.01	0.3
France	1	1	200	2.5	205	6 663	0.11	3.6
Germany	1.10	1.03	206	2.8	506	17 052	0.38	12.8
Greece	0.45	0.79	158	1.1	27.3	677	0.07	1.7
Ireland	0.67	0.89	178	1.7	9.9	281	0.02	0.6
Italy	0.94	0.98	196	2.4	240	7 632	0.16	5.1
Luxembourg	1.18	1.05	210	3.0	1.7	59	0.001	0.0
Netherlands	0.92	0.98	196	2.3	47.4	1 503	0.05	1.6
Norway	0.95	0.98	196	2.4	11.7	372	0.01	0.3
Portugal	0.53	0.83	166	1.3	69.8	1 829	0.14	3.7
Spain	0.69	0.89	178	1.7	146	4 146	0.01	0.3
Sweden	0.89	0.97	194	2.2	21.1	660	0.02	0.6
Switzerland	1.20	1.06	212	3.0	28.2	981	0.04	1.4
United Kingdom	0.88	0.96	192	2.2	317	9 827	0.18	5.6

Note: See text for details of calculation.
Source: ECMT Task Force estimates.

valuation survey, this proportion is assumed to hold throughout. The total cost of reported accidents is therefore 15% of the number of accidents multiplied by the shadow value of serious accidents, plus 100% of accidents multiplied by the other costs arising from reported accidents.

Although INFRAS/IWW adjust for underreporting, it is assumed that all serious injury accidents are reported. Any omissions beyond this have negligible impact on the results, because the other costs of injury accidents are relatively minor.

Finally, the figures have been used to estimate the total cost of road and rail fatal accidents and serious injuries. Financial figures are in million ECU unless otherwise stated, deaths are absolute numbers, and serious injuries are thousands.

B.2.3. Accident costs per kilometre

To divide risks among modes and vehicle types, the following figures were taken from INFRAS/IWW (1995): for road, 72% of accident costs are attributable to cars, 2.9% to buses and 15% to freight vehicles; for rail, 80% to passenger trains, 20% to freight trains. These are averages; more accurate results could be obtained using national statistics.

Note that Table 46 omits motorbike costs, which amount to some 10.6% of road transport accident risks. These figures yield mean weighted average European unit costs of ECU 52.9/v-km for cars and ECU 53.2/v-km, on average, for light and heavy goods vehicles taken together.

Table 48 compares relative road and rail accident costs by converting costs per car to costs per passenger on the basis of national data on occupancy rates and load factors recorded by INFRAS/IWW (average occupancy of 1.8 per car and average freight load factor of 2.84 tonnes, see Table 33).

Table 46. **Road accident costs for 1991, by vehicle type**

	Accident costs	Cars			Buses		Freight (trucks and vans)			
	ECU m	bn km	ECU/ 1 000 v-km	ECU/ 1 000 p-km	bn km	ECU/ 1 000 v-km	bn km	ECU/ 1 000 v-km	bn t-km	ECU/ 1 000 t-km
Austria	4 059	42.0	70	41	0.5	235	5.2	117	13.1	46
Belgium	5 120	50.5	73	49	0.4	371	5.7	135	26.0	30
Denmark	1 202	30.7	28	16	0.5	70	6.3	29	10.4	18
Finland	1 179	33.1	26	19	0.7	49	5.4	33	23.8	7
France	21 611	325	48	26	4.0	157	105	31	148	22
Germany	33 764	406	60	35	3.4	288	44.6	114	203	25
Greece	3 197	9.4	245	121	0.5	185	3.4	141	12.3	39
Ireland	842	19.7	31	17	0.2	122	5.0	25	5.1	25
Italy	19 587	260	54	27	4.8	118	45.5	65	167	18
Luxembourg	176	3.0	42	28	0.0	na	0.4	66	0.8	35
Netherlands	3 415	77.8	32	16	0.6	165	12.9	40	23.3	22
Norway	856	23.2	27	16	0.3	83	3.1	41	7.69	17
Portugal	5 886	35.0	121	63	0.6	284	2.0	441	10.9	82
Spain	14 732	76.0	140	73	2.0	214	24.2	91	150	15
Sweden	1 782	86.2	15	10	0.7	74	5.1	52	25.4	10
Switzerland	2 327	48.0	35	19	0.2	337	4.9	71	12.8	27
United Kingdom	16 212	330	35	20	4.3	109	60.0	41	125	20
Weighted averages			**53**	**33**		**166**		**53**		**21**

Note: Weighting affects ratios between average figures in terms of vehicle and passenger/tonne kilometres, complicating comparisons (for example, although the average load factor for freight vehicles both in this table and in Annex D is 2.87, the ratio between the weighted averages of the last two columns of this table is 2.52).
Source: ECMT Task Force estimates.

Table 47. **Rail accident costs for 1991 per passenger and freight kilometre**

	Accident costs	Passenger		Freight	
	ECU m	m p-km	ECU/ 1 000 p-km	m t-km	ECU/ 1 000 t-km
Austria	47.2	9 208	4.10	12 864	0.73
Belgium	18.6	6 771	2.20	9 348	0.40
Denmark	1.2	4 797	0.20	1 858	0.13
Finland	21.3	3 230	5.28	7 634	0.56
France	196	62 101	2.52	50 632	0.77
Germany	243	55 936	3.48	79 793	0.61
Greece	26.7	1 995	10.71	606	8.81
Ireland	7.6	1 290	4.71	603	2.52
Italy	81.1	46 427	1.40	21 680	0.75
Luxembourg	2.0	220	7.27	709	0.56
Netherlands	32.6	12 796	2.04	3 038	2.15
Norway	10.3	2 150	3.83	2 641	0.78
Portugal	111	5 688	15.61	1 783	12.45
Spain	15.3	15 022	0.81	12 499	0.24
Sweden	21.6	5 524	3.13	18 575	0.23
Switzerland	40.4	12 793	2.53	8 576	0.94
United Kingdom	62.6	32 058	1.56	17 274	0.72
Weighted averages			**2.70**		**0.75**

Source: ECMT Task Force estimates.

Table 48. **Summary of specific accident costs, 1992**

	ECU/1 000 passenger km		ECU/1 000 tonne km	
	Cars	Rail	Trucks and vans	Rail
Average accident costs for Europe	33.0	2.7	21.4	0.8

Source: ECMT Task Force estimates.

B.3. TRAFFIC NOISE

B.3.1. Overview of total costs

Noise is not always the transport related disamenity most frequently cited in studies of the impact of transport, yet it can be a very real nuisance to the most exposed populations. Road traffic has more than doubled since 1970. Other things being equal, doubling the volume of traffic raises noise levels by 3 dB, which is considerable.

Improvements in vehicle technology and infrastructure planning are beginning to play an important role in noise abatement. All motor vehicle manufacturers have undertaken large scale research into reducing engine and tyre noise, and manufacturers of railway rolling stock have made similar efforts, especially for high speed trains. However, even measures such as lower speed limits will be of only limited impact if road traffic – especially the number of HGVs – continues to rise at a rapid pace. Moreover, populations are increasingly sensitive to traffic noise.

It is difficult to measure noise levels, as they vary at different times of day. In practice, they are measured in dB(A) Leq, the equivalent continuous noise level in terms of energy produced over a specified period. The thresholds above which noise is considered a nuisance are somewhat arbitrary. Levels of 50-60 dB may well be judged a nuisance but the thresholds adopted in the studies reviewed are more of the order of 65 dB. In France, surveys conducted in sample populations exposed to noise have arrived at a nuisance threshold of around 60-62 dB(A); areas with levels of 65 dB(A) or above are classed as "high noise" zones and those with levels of 70 dB(A) or above as noise "black spots".

Not only is it difficult to assess what constitutes a "reasonable" or "tolerable" level of noise, but the duration, frequency and regularity of noise are also hard to assess and measure. Noise generates multiple effects, all interrelated: for example, lack of sleep causes impaired efficiency at work. The many effects of noise nuisance range from reduced work efficiency to depreciated property values. The monetary value of noise induced effects in any country is dependent on how urbanisation has developed and on the geographical location of activities on a national level, since noise is primarily a problem in cities.

Most transport infrastructure is used by both freight and passenger transport and it is difficult to apportion noise effects between the two. Studies have shown that the level of noise emitted by one lorry is equivalent to that emitted by six light goods vehicles and, at locations in urban areas where vehicles are accelerating (*i.e.* where vehicle speeds are not constant), to ten or more cars. In terms of acoustic energy equivalents, one HGV generates as much noise as ten private cars. As the noise made by a truck differs in quality from that made by a car, however, any comparison is necessarily a simplification.

Several methods are used to evaluate the incidence of noise due to road traffic, or to transport in general:

- the rarely used damage cost method, which attempts to estimate the effects on health, an extremely difficult exercise;

- revealed preference or stated preference valuation techniques, which use real or hypothetical situations to estimate the effects of noise on the rental value of property (*i.e.* the fall in value attributable to high exposure to noise);
- prevention cost methods, which assess the cost of the measures needed to reduce noise to acceptable levels in high noise zones, ranging from measures at source (vehicle noise emissions standards) to preventive measures (noise barriers) in exposed areas.

Estimates of the external costs of noise from the literature reviewed range from 0.02 to 2% of GDP (see Table 49 and Figure 16). Some details of these studies follow. Most studies of noise measure the nuisance from road traffic only. The nuisance levels derived from prevention expenditure are lower, in all but one case, than those reported for studies using methods based on stated preference. Stated preference could be regarded as an indicator of what is desirable and avoidance programmes as a minimum measure of what is feasible (based on policies actually implemented). As a general rule, measures actually implemented by government fall far short of what is desirable.

Notes on studies of external costs of noise

Tefra (1991) proposes two valuations for road traffic noise in an urban environment in France:

- central and local government expenditure on noise prevention or abatement in the 1980s, which amounted to 0.02% of GDP;
- the fall in property values due to noise, estimated (among other factors affecting house prices) as equivalent to 0.06% of GDP, based on surveys and opinion polls.

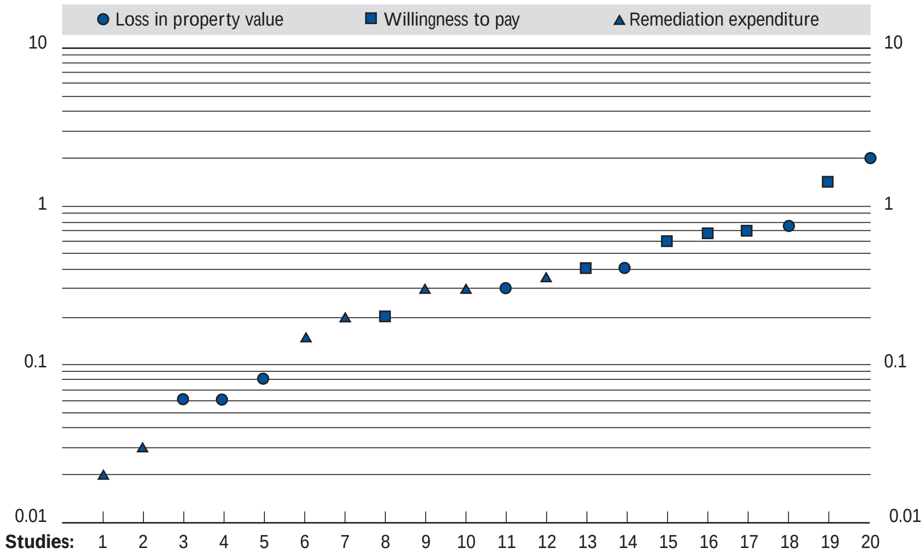
Table 49. **Valuations of external costs of road noise (% GDP)**

	Country	Source	Year	Method: Expenditure	Method: Loss in property value	Method: Stated preference	Notes
1	France	Tefra	1990	0.02			Roads, urban environment, prevention expenditure
2	France	Perez	1990	0.03			Roads, prevention expenditure
3	France	Tefra	1990		0.06		Roads, property depreciation
4	Norway	Ringheim[4]	1983		0.06		Roads, fall in property value
5	France	Lambert	1986		0.08		Roads, fall in property value
6	West Germany	Planco[3]	1985	0.15			Roads, prevention measures 55 dB (A) threshold
7	West Germany	Dickman[2]	1990	0.2			Roads, prevention measures
8	Sweden	INFRAS/IWW	1995			0.2	Roads, stated preference
9	Finland	Himanen[3]	1992	0.3			Roads, prevention expenditure
10	Finland	quoted by Lambert	1989-91	0.3			Roads, prevention expenditure
11	Switzerland	Jean-Renaud	1988		0.3		Roads, fall in property value
12	France	CETUR[2]	1993	0.36			Roads prevention expenditure
13	France	OECD, 1991	1990			0.2 to 0.6	Roads, desirable expenditure
14	Sweden	Hansson, Markham	1992		0.4		Roads, fall in property value
15	Switzerland	INFRAS/IWW	1995			0.6	Roads, stated preference
16	West Germany	quoted by INRETS	1989			0.6-0.75	Roads, stated preference
17	Germany	INFRAS/IWW	1995			0.7	Roads, stated preference
18	France	Merlin[2]	1992		0.75[1]		All modes 1.5% GDP
19	Germany	Weinberger[2]	1992			1.4	Roads, stated preference + damage to health
20	West Germany	Wicke[2]	1987		2		Roads, lost output, fall in property value

1. Merlin's study covered all modes. Using the results reported in Table 50, roughly half of these costs can be expected to be related to roads.
2. Cited in Boiteux, 1994.
3. Cited in Hanson and Markham.
4. Cited in Tefra.

Source: Compiled by ECMT Task Force.

◆ Figure 16.***External costs of road noise***



Source: See Table 49, for sources.

Perez (1990) concentrates on noise generated by HGVs in urban areas and road transport in general, in France in 1990. HGVs were found responsible for 17% of the urban road traffic noise necessitating public expenditure on noise control measures. The threshold level at which spending on abatement starts in France is 70 dB(A) Leq (between 8 a.m. and 8 p.m.). In the author's view, the annual cost of damage remaining after noise control measures have been taken is approximately equal to the actual annual expenditure on noise control. On this basis, Perez estimated the cost of urban road traffic noise at 0.03% of GDP in 1990.

A study by CETUR, France (1994) estimated that avoidance and control measures to limit noise exposure in urban areas to 65 dB(A) would total 0.36% of GDP. It took into account a much wider range of costs than the previous study, including the costs of at-source (vehicle) measures, porous asphalt road surfacing, facade insulation and noise barriers.

A study on noise nuisance costs conducted by the Finnish Roads Authority in 1989-91 for a housing noise insulation survey found that: a) out of 350 000 people living in areas exposed to noise from trunk roads, 125 000 experienced nuisance and the annual cost of housing insulation totalled Mk 620 million; and b) out of at least 500 000 people living in areas exposed to noise from local service roads and streets, 215 000 experienced nuisance and the associated annual costs totalled Mk 1 billion. In all, the study estimated road traffic noise costs at 0.3% of GDP.

Other studies have been based on what people are willing to pay to reduce noise nuisance. Generally, these produce higher nuisance incidence estimates, although most people are generally thought to overstate the nuisance level when declaring WTP without actually having to pay.

Based on the WTP method, the government of western Germany estimated that in 1989 transport noise cost DM 15-18.5 billion, broken down as follows:

road, DM 10.7-2.8 billion;
rail, DM 4-5.3 billion;
air, DM 0.3-0.4 billion.

Lamure and Lambert (INRETS, 1989) calculate the cost of the road nuisance level reported in this German study as 0.6-0.75% of GDP, which indeed indicates a nuisance level (assessed in terms of stated preference) higher than those in the other studies.

INFRAS/IWW (1995) also gives estimates based on stated preference. The method was based on national estimates of the numbers exposed to different noise levels. A noise level reference cost, derived from cost-benefit analyses conducted in Sweden, was established for each mode. Adjustments were made for purchasing power parity relative to that of Swedish households. The results are comparable to those obtained in the western German study: the external costs of noise were found to be equivalent to 0.69% of GDP.

Relative noise nuisance from road, rail and aviation

Some studies operate on the assumption that noise generated by rail traffic causes less nuisance than road traffic noise, as it is at lower frequencies and is less continuous. Rail traffic noise thresholds are therefore routinely set 5 dB higher than those for road. However, this approximation would seem to warrant further analysis. The approach used in the INFRAS/IWW study shows, logically enough, that the effects of noise across a given country depend on geographical settlement patterns and forms of urbanisation. In Sweden, for example, railways cover long distances through sparsely populated areas, whereas in Switzerland nuisance levels are higher because railways cross densely populated valleys.

Road traffic is certainly the largest contributor to transport noise, but that is no reason to dismiss the part played by rail and air traffic. A European Commission green paper in 1992, ''Impact of Transport on the Environment'', gives the following breakdown of transport related noise based on data supplied by the Frauenhofer Institute in Karlsruhe: road 64%; air 26%; and rail 10%. Within the road category, motorcycles contribute a disproportionately high level per person transported. A poll conducted in 1986 in western Germany by W. Rothengatter reported the number of households subject to nuisance from transport noise as shown in Table 50. These results confirm that roads are responsible for the largest part of noise nuisance but also demonstrate that rail noise is far from negligible.

Table 50. **Sources of noise nuisance**

	Rothengatter		Frauenhofer
	Nuisance	Serious nuisance	Overall Nuisance
Road	65%	25%	64%
Rail	19%	4%	10%
Air	47%	17%	26%

Source: Rothengatter (1986); Frauenhofer Institute for the European Commission (1992).

Selection of a value for noise nuisance for use in developing policy options

Table 49 and Figure 16 summarise the results of those studies surveyed that indicate the approach to evaluation employed. It should be borne in mind that the studies did not all use identical methods or assumptions (for example, noise nuisance thresholds vary); nevertheless, all attempt to describe the same phenomenon. The results show a wide variation for the cost of road noise nuisance, from 0.02 to 2% of GDP, with a median value of 0.3% and a mean of 0.4%. Quinet (1990), in a paper prepared for the OECD, undertook a literature survey (11 studies in common with the results reported here) that also yielded a median value of 0.2-0.3% of GDP for the cost of road noise.

For the purpose of policy making some of the results reported in Figure 16 can be discounted. The lowest result is not reliable, as there was no investigation to confirm that the target noise levels were achieved by the measures taken. The two lowest results are inappropriate as a basis for policy making because the target they use, 70 dB(A), is too high to be a generally acceptable exposure limit. Following a conservative approach to selecting lower bound estimates for use in policy making, the two highest estimates should probably also be ignored. Eliminating the top and bottom two estimates leaves a range for the cost of road noise of 0.06 to 0.75% of GDP with mean and median values of 0.3%. Following the indications for the shares of road, rail and air related noise nuisance produced by the Frauenhofer Institute, concluding that road traffic accounts for 64% of total transport noise, total transport noise nuisance costs might represent close to 0.5% of GDP and road and rail noise together around 0.4% of GDP.

The European Commission's 1996 green paper is based on the review of studies by Quinet yielding a range of values for noise nuisance from 0.1 to 2% of GDP. The studies covered estimates based on prevention expenditure, stated preferences and property values. An average figure of 0.2% of GDP was retained, although the green paper identified approaches based on WTP as more appropriate to the purpose of the paper, acknowledging that they yield higher valuations than the average.

B.3.2. Shadow price for noise

A hedonic study (based on property values) of noise in the Swiss town of Neuchâtel (Soguel, 1994) has the following advantages as a basis for calculating a shadow price for noise:

- methodology conforming to the best practice identified in Annex A;
- a European setting (most studies are North American, and so less suitable for transfer to ECMT countries);
- more recent estimates than most alternative studies;
- a focus on road transport noise rather than air;
- use of dB(A) 16 hour Leq, which is directly interpretable;
- use of rents rather than house prices.

The results of the study showed a highly significant influence of noise on rent levels, with average rent depreciation of 0.91% per 1 dB(A) of noise increase. Other studies of Swiss towns have yielded results of similar magnitude: Iten (1990) estimated 0.9% for Zurich; Pommerehne (1986) reported 1% for road noise at 30 dB(A), rising to 1.4% at 70 dB(A).

The results can be used to calculate WTP for a 1 dB(A) noise reduction per household per month according to noise level and income. Although WTP increases slightly with the level of existing noise, the change is not statistically significant. This suggests that the existing level of noise can be ignored when valuing changes in the noise level. In other words, these results provide no evidence against the assumption that the average and marginal costs of noise changes measured on the dB(A) scale are equal.

Table 51. **Monthly WTP for 1 dB(A) noise reduction, by pre-tax income**
(1989 SF)

Monthly taxable income	Monthly WTP for 1 dB (A) reduction
2 500	5.07
5 000	6.15
7 500	6.88
10 000	7.45

Source: Soguel (1994).

Unlike noise level, income is clearly an important factor in determining WTP. This is to be expected. While it would be difficult to determine income levels for each individual exposed to a noise level change, it is possible to determine average income levels for different areas. This approach will be used here in the transfer of shadow price estimates among countries.

It is also possible to account for different average income levels at the local scale, although the political implications may be thought objectionable. This could be used to support, for example, a policy of diverting through-traffic flows from richer areas to poorer areas within a city. For the purposes of this report, however, only an average shadow price will be presented, based on average incomes for each country. If desired, these could be altered to reflect subnational income variations.

The mean pre-tax income level in the study was SF 4 169 (at 1989 prices). WTP for a 1 dB(A) reduction in noise at this income level may be calculated as SF 5.85 per month. This works out to around ECU 55 a year at 1993 prices.

Because most other hedonic noise studies have looked at house prices rather than rents, their results are not directly comparable with Soguel's. However, it is possible to add the annual WTP estimated here over several years for comparison with a lump-sum payment.

The period taken for summation is 50 years, which seems a reasonable estimate of how long one may expect to be a householder. Expanding the time beyond this would in any case make little difference to the total, because of the discounting procedure. A variety of discount rates could be considered: here, 5%, 15% and 25% are taken. The first might be applied by a public sector body and the second by private industry, while the third is more representative of the sort of discount rates sometimes revealed by individual household behaviour. Table 52 shows that the Soguel results are within the range of other recent studies.

Table 52. **Comparison of hedonic studies based on house prices**

Study		Lump sum WTP for a 1 dB (A) noise reduction
Soguel (1994)	5% discount	ECU 994
	15% discount	ECU 366
	25% discount	ECU 220
Colins and Evans (1994)		ECU 199 (appartment value ECU 30 500)
		ECU 734 (semi-detached house, garden, ECU 57 350)
		ECU 1 129 (detached house, ECU 107 600)
Levesque (1994)		ECU 770 (house value ECU 42 600)
Uyeno *et al.* (1993)		ECU 698 (house value ECU 105 000)

Source: ECMT Task Force.

An alternative to hedonic estimation is the stated preference technique. Sælensminde and Hammer (1994) elicit WTP values for various percentage changes in perceived noise levels. Their results suggest an average annual WTP of ECU 25-56 for a 1 dB(A) noise improvement.[2]

These results correspond well with the Swiss results of around ECU 55 per annum. The similarity of the figures should not be overemphasised, due to possible errors in estimation and differences between the studies. Nevertheless, the finding of similar results from stated preference and hedonic studies should further increase confidence in the results' validity.

Shadow prices need to be presented as ECU X per dB(A) per person per year. From the results presented by Soguel, the cost per household can be estimated in ECU per dB(A). The mean number of persons per household in the study was two, so dividing that value by two will give an individual value. The difference in incomes among countries is treated directly by estimating the equivalent Swiss franc income for each country using purchasing power parity ratios, and inserting this amount into Soguel's equation. The result, shown in Table 53, is that the variation in noise valuations is less than the variation in real incomes. The implication is a fairly low income elasticity for noise, similar to that found in the accident valuation literature.

Table 53. **Shadow values of noise abatement**

(1989 SF)

Country	PPP	Estimated monthly mean income (SF)	Shadow value per dB (SF)	Shadow value per person per dB (ECU/month)
Austria	0.81	3 377	5.52	1.77
Belgium	0.82	3 419	5.41	1.74
Denmark	0.80	3 335	5.50	1.77
Finland	0.65	2 710	5.19	1.67
France	0.84	3 502	5.58	1.79
Germany	0.92	3 835	5.72	1.84
Greece	0.37	1 543	4.44	1.43
Ireland	0.56	2 335	4.98	1.60
Italy	0.79	3 294	5.48	1.76
Luxembourg	0.99	4 127	5.84	1.87
Netherlands	0.77	3 210	5.44	1.75
Norway	0.80	3 335	5.50	1.77
Portugal	0.44	1 834	4.66	1.50
Spain	0.58	2 418	5.03	1.61
Sweden	0.75	3 127	5.40	1.73
Switzerland	1.00	4 169	5.85	1.88
United Kingdom	0.73	3 043	5.36	1.72

Source: ECMT Task Force estimates.

B.3.3. Noise costs per kilometre

Specific noise costs can be calculated by distributing the total costs of noise between modes and services. This can be done on the basis of the shadow prices calculated in section B.3.2 or using the total costs calculated in section B.3.1. Both approaches are presented here to compare results.

Attribution of shadow price data between modes and services

The first step is to estimate the total cost of noise in each country. INFRAS/IWW (1995) present figures for population exposed to different noise levels from each mode, developed on the basis of data from *OECD Environmental Data: Compendium 1993*, supplemented by their own research. These figures have been adjusted to move to dB(A) 16 hour Leq, the noise measure used in Soguel's study of shadow prices.

It is necessary to assume a baseline below which no damage from transport noise is incurred. A level commonly taken is 50 dB(A), but in fact there is no firm evidence for a threshold in the valuation literature, and Soguel's study in particular found that noise levels were not significant determinants of willingness to pay for a 1 dB(A) noise reduction. A threshold level is 50 dB(A) is used here, with acknowledgement that there is likely to be some damage below this threshold, though probably comparatively small. Results are also calculated with a 55 dB(A) threshold for comparison with estimates from section B.3.1.

The calculation is made by assuming that each individual within a noise band suffers the noise associated with the mid-point of that band. Thus those in band 60-65 dB(A) are taken to suffer noise of 62.5 dB(A) and so on. Those exposed to noise greater than 75 dB(A) are assumed to be at 77.5 dB(A). These exposures are then valued according to their excess over the 50 dB(A) baseline.

It is possible to allocate noise damage over all kilometres travelled. It would be more accurate to consider only urban travel, as most noise damage will occur in built-up areas, but suitable data are not available for most countries.

Table 54. **Noise damage in Europe from road transport**

(1991 ECU)

	Noise band: millions exposed to road noise						Value per dB (ECU/ month)	Road noise (ECU m /year)
	50-55	55-60	60-65	65-70	70-75	75+		
Austria	0.72	0.53	0.40	0.65	0.25	0.09	1.77	648
Belgium	3.48	2.57	2.33	0.92	0.08	0.01	1.74	1 572
Denmark	0.65	0.48	0.35	0.35	0.05	0.03	1.77	372
Finland	0.41	0.30	0.21	0.18	0.03	0.00	1.67	192
France	13.92	10.26	7.95	5.30	2.36	0.29	1.79	7 836
Germany	13.79	10.17	8.70	5.08	2.65	0.60	1.84	8 496
Greece	1.61	1.19	0.76	0.50	0.10	0.03	1.43	588
Ireland	0.80	0.59	0.38	0.22	0.07	0.02	1.60	324
Italy	13.12	9.67	6.35	3.68	1.10	0.32	1.76	5 964
Luxembourg	0.09	0.07	0.04	0.03	0.01	0.00	1.87	48
Netherlands	5.92	4.36	2.05	0.34	0.13	0.04	1.75	1 740
Norway	0.70	0.51	0.34	0.21	0.07	0.03	1.77	336
Portugal	2.25	1.66	1.09	0.63	0.19	0.05	1.50	876
Spain	8.53	6.28	4.13	2.39	0.72	0.21	1.61	3 552
Sweden	0.97	0.72	0.35	0.23	0.05	0.01	1.73	360
Switzerland	2.09	1.54	0.81	0.42	0.19	0.03	1.88	888
United Kingdom	19.95	14.71	7.87	3.93	0.43	0.51	1.72	7 248

Source: INFRAS/IWW (1995); ECMT Task Force estimates.

Table 55. **Noise damage in Europe from rail transport**

(1991 ECU)

	Noise band: millions exposed to rail noise, dB (A)						Value per dB (ECU/ month)	Rail noise (ECU m /year)
	50-55	55-60	60-65	65-70	70-75	75+		
Austria	0.05	0.03	0.02	0.03	0.01	0.01	1.77	35
Belgium	0.43	0.32	0.19	0.09	0.03	0.02	1.74	181
Denmark	0.09	0.07	0.04	0.02	0.01	0.00	1.77	38
Finland	0.22	0.16	0.09	0.04	0.02	0.01	1.67	86
France	0.26	0.19	0.20	0.09	0.05	0.04	1.79	180
Germany	6.97	5.14	3.19	1.29	0.38	0.05	1.84	2 834
Greece	0.17	0.13	0.07	0.03	0.01	0.00	1.43	52
Ireland	0.15	0.11	0.07	0.03	0.01	0.01	1.60	60
Italy	4.06	2.99	2.14	1.11	0.34	0.09	1.76	1 877
Luxembourg	0.02	0.02	0.01	0.00	0.00	0.00	1.87	7
Netherlands	0.79	0.58	0.12	0.04	0.03	0.02	1.75	205
Norway	0.01	0.01	0.01	0.00	0.00	0.00	1.77	5
Portugal	0.43	0.32	0.20	0.09	0.03	0.02	1.50	158
Spain	1.65	1.21	0.74	0.33	0.12	0.05	1.61	624
Sweden	0.28	0.21	0.11	0.04	0.01	0.00	1.73	95
Switzerland	0.79	0.58	0.40	0.19	0.09	0.05	1.88	407
United Kingdom	0.77	0.56	0.43	0.15	0.03	0.02	1.72	317

Source: INFRAS/IWW (1995); ECMT Task Force estimates.

To account for the distribution of noise sources within the road mode, a weighting of 10:10:1 is assumed for the relative noise nuisance from HGVs, buses and cars. This is a rough assumption and motorbikes are omitted as accurate data are not available on their noise emissions per kilometre. Within the rail mode, it is assumed that freight trains create four times more noise than passenger trains, following the assumption made by INFRAS/IWW, 1995. Some required data are missing for Greece, preventing the estimation of rail costs per kilometre for this country.

Table 56. **Road noise damage costs by vehicle type, 1991**

	Noise	Cars			Freight		
	ECU m	bn km	ECU/ 1 000 v-km	ECU/ 1 000 p-km	bn km	ECU/ 1 000 v-km	ECU/ 1 000 t-km
Austria	648	42	9.91	5.79	5.2	44.59	17.69
Belgium	1 572	50.5	20.64	13.76	5.7	92.90	20.55
Denmark	372	30.7	6.30	3.52	6.3	28.35	17.18
Finland	192	33.1	3.34	2.39	5.4	15.05	3.41
France	7 836	325	9.83	5.34	105	44.22	31.36
Germany	8 496	406	14.00	8.19	44.6	63.02	13.85
Greece	588	9.4	23.81	11.73	3.4	107.13	29.43
Ireland	324	19.7	7.68	4.15	5	34.55	34.21
Italy	5 964	260	12.83	6.32	45.5	57.75	15.73
Luxembourg	48	3	10.00	6.67	0.4	45.00	23.68
Netherlands	1 740	77.8	12.81	6.57	12.9	57.64	32.02
Norway	336	23.2	9.04	5.23	3.1	40.70	16.61
Portugal	876	35	19.91	10.42	2	89.59	16.59
Spain	3 552	76	19.21	10.06	24.2	86.45	13.92
Sweden	360	86.2	3.30	2.18	5.1	14.84	2.99
Switzerland	888	48	12.68	6.85	4.9	57.04	21.86
United Kingdom	7 248	330	12.08	7.02	60	54.36	26.13
Weighted average			**12.19**	**6.81**		**54.37**	**22.93**

Source: INFRAS/IWW (1995); ECMT Task Force estimates.

Table 57. **Rail noise damage costs split into passenger and freight, 1991**

	Noise	Passenger			Freight		
	ECU m	m train km	m p-km	ECU/ 1 000 p-km	m train-km	m t-km	ECU/ 1 000 train km
Austria	35	86.8	9 569	1.3	43.2	12 296	1.8
Belgium	181	71.7	6 769	12.4	20.6	8 153	11.5
Denmark	38	47.9	4 711	5.1	6.8	1 858	7.3
Finland	86	24.7	3 230	7.7	15.4	7 634	8.0
France	180	318	62 371	1.0	160	51 480	2.2
Germany	2 834	584	55 962	18.1	262	79 793	22.2
Greece	52	n.a.	1 995	–	n.a.	605	–
Ireland	60	9.6	1 290	17.2	4.1	603	62.8
Italy	1 877	237	46 427	18.9	67.3	21 680	8.6
Luxembourg	7	3.7	227	12.0	1.6	712	6.4
Netherlands	205	106	15 195	10.8	12.5	3 036	21.5
Norway	5	23.6	2 150	0.9	8.8	2 681	1.1
Portugal	158	29.3	5 692	13.8	7.2	1 784	43.3
Spain	624	127	15 022	17.1	45.2	10 802	33.9
Sweden	95	57.5	5 634	4.7	38.4	18 815	3.7
Switzerland	407	103	12 383	15.3	27.9	8 108	26.2
United Kingdom	317	373	32 100	6.1	54.6	15 348	7.5
Weighted average				**10.9**			**13.1**

Source: ECMT Task Force; INFRAS/IWW (1995); UIC Railway Statistics 1991.

The threshold assumed for noise nuisance has a profound effect on the calculations. Changing the threshold from 50 dB(A) to 55 dB(A) reduces the average results for cars from 12.19 to 6.29 ECU per 1 000 v-km and for road freight from 54.37 to 28.04 ECU per 1 000 t-km. In the literature reviewed on the total costs of noise, the thresholds used were 55 dB and over. The weighted average costs can be converted to passenger-kilometres and tonne-kilometres as follows.

Table 58. **Average unit noise costs, 1991**

(ECU)

Threshold	Car	Road freight	Rail passenger	Rail freight
50 dB (A)	7/1 000 p-km	23/1 000 t-km	11/1 000 p-km	13/1 000 t-km
55 dB (A)	3/1 000 p-km	12/1 000 t-km	5/1 000 p-km	6/1 000 t-km

Note: Country specific occupancy and load factors averaging 1.8 people per car and 2.84 tonnes per truck/van, see Table 33.
Source: ECMT Task Force estimates.

Distribution of total costs between modes and services

Road noise, as estimated in section B.3.1, amounts to 0.3% of GDP. This can be allocated roughly between passenger and freight services. Where explicit, most studies assume that the relative impact of noise from one truck is equivalent to that of ten cars. An examination of the results of the literature reveals relative impacts between average passenger cars and average freight vehicles to be between 4.5 and 5.5. In the INFRAS/IWW data used to distribute noise costs above, the ratio was 4.5, which will be used here for consistency.

A unit cost of noise, n, is then calculated as follows:

$$n = \frac{0.3\% \text{ of GDP}}{1 \text{ x total car kilometres} + 4.5 \text{ x total freight vehicle kilometres}}$$

Specific costs for cars are then ECU n/v-km, and for freight vehicles 4.5 x n. The calculations are given in Table 59.

INFRAS/IWW (1995), examining exposure to noise from road and rail in 15 countries of western Europe, found 12.4 million people exposed to road noise over 70 dB(A) and 1.8 million people exposed to rail noise above that level. This gives a very rough indication that rail noise disamenity is equivalent to 15% of road noise nuisance although the threshold is extreme. That figure can then be used to derive unit costs for rail in the same way as for roads. If it is assumed that freight trains have four times the impact of passenger trains (as in the earlier calculations), the unit costs are ECU 2.5-5 / 1 000 p-km and ECU 4-8/1 000 t-km for rail. (Assuming that freight and passenger trains have equal effects would yield unit costs of ECU 4.5-9 / 1 000 p-km and ECU 1.8-3.5 / 1 000 t-km.)

Summary of external noise costs per kilometre

Table 60 summarises the averages for the unit costs calculated for noise on the basis of the shadow prices generated in section B.3.2 (55 dB(A) threshold) and the total costs estimated in section B.3.1.

Calculations in other sections of this report are based on figures derived from total costs.[3] These were preferred due to the particular sensitivity to noise threshold noted for the calculations in the shadow price approach and the fact that the shadow price used was based on the results of a single empirical study, rather than a survey of the literature.

Table 59. **External costs of road noise by vehicle type, 1991**

	Noise	Cars			Freight		
	ECU Bn	bn km	ECU/ 1 000 v-km	ECU/ 1 000 p-km	bn km	ECU/ 1 000 v-km	ECU/ 1 000 t-km
Austria	0.397043	42	6.07	3.55	5.2	27.32	10.84
Belgium	0.476694	50.5	6.26	4.17	5.7	28.17	6.23
Denmark	0.315214	30.7	5.34	2.98	6.3	24.02	14.56
Finlande	0.301172	33.1	5.25	3.75	5.4	23.61	5.34
France	2.903499	325	3.64	1.98	105	16.38	11.62
Germany	3.811372	406	6.28	3.67	44.6	28.27	6.21
Greece	0.170922	9.4	6.92	3.41	3.4	31.14	8.55
Ireland	0.105071	19.7	2.49	1.35	5	11.20	11.09
Italy	2.785355	260	5.99	2.95	45.5	26.97	7.35
Luxembourg	0.022515	3	4.69	3.13	0.4	21.11	11.11
Netherlands	0.703783	77.8	5.18	2.66	12.9	23.31	12.95
Norway	0.256383	23.2	6.90	3.99	3.1	31.06	12.68
Portugal	0.16608	35	3.77	1.98	2	16.99	3.15
Spain	1.276106	76	6.90	3.61	24.2	31.06	5.00
Sweden	0.573534	86.2	5.25	3.48	5.1	23.65	4.76
Switzerland	0.561671	48	8.02	4.33	4.9	36.08	13.82
United Kingdom	2.443994	330	4.07	2.37	60	18.33	8.81
Weighted average			**5.24**	**2.95**		**22.26**	**9.12**

Source: ECMT Task Force estimates.

Table 60. **Summary of average unit costs for noise**

	Car (ECU)	Freight average (ECU)	Rail passenger (ECU)	Rail freight (ECU)
Shadow price	6/1 000 v-km	28/1 000 v-km	–	–
approach	3/1 000 p-km	12/1 000 t-km	5/1 000 p-km	6/1 000 t-km
Total costs	5/1 000 v-km	22/1 000 v-km	–	–
approach	3/1 000 p-km	9/1 000 t-km	4/1 000 p-km	6/1 000 t-km

Source: ECMT Task Force estimates.

B.4. AIR POLLUTION

B.4.1. Overview

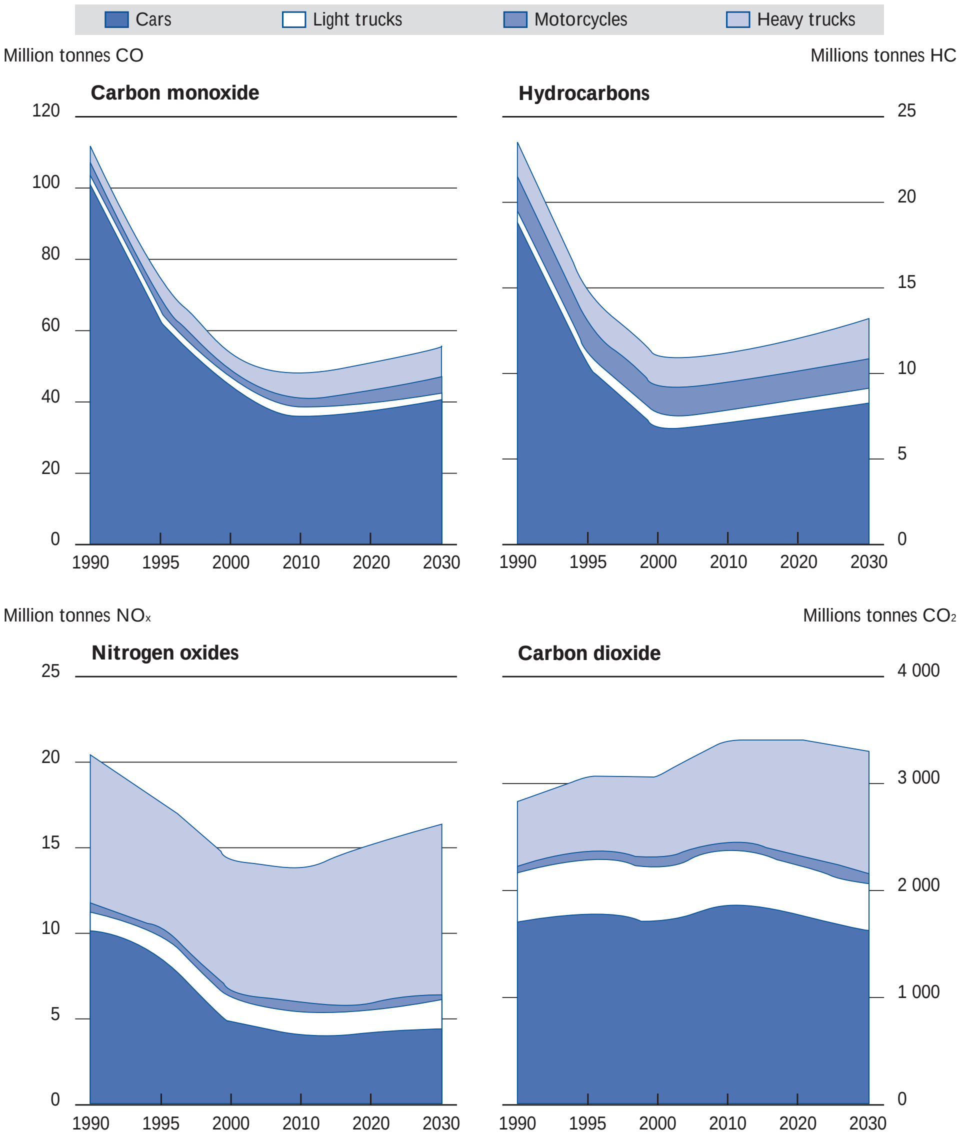
In many countries, growing awareness of the problems posed by pollution has led to the adoption of measures aimed at combating air pollution from transport, especially road transport. As yet, the measures taken fall short of what is required, given the growth in passenger and freight traffic by road, coupled with a slow-down in progress on reducing fuel consumption as vehicles become heavier and their power increases.

The 1995 OECD study ''Motor Vehicle Pollution: Reduction Strategies beyond 2010'' assesses the full extent of the problem with the help of projections. These combine several factors, notably:

- the expected growth of the motor vehicle stock and its use;
- current and future emissions requirements;
- the expected reduction, albeit slight and gradual, in fuel consumption.

The report's analysis suggests that, at best, vehicle emissions are expected to stabilise from 2000 in OECD Europe.

◆ Figure 17. **Projections of motor vehicle emissions in OECD countries of CO, HC, NO_x and CO_2, 1990-2030**



Note: Base-case trend with adopted control measures: 1% annual new car fuel-efficiency improvement. See original publication for projection methodology.

Source: OECD Motor Vehicle Pollution: reduction strategies beyond 2010 (1995).

Tables 61 and 62 show the pollutants emitted by different types of car and by hot and cold engines. This last difference is very important for emissions in urban areas, since 50% of trips in Europe are under 5 km, *i.e.* with cold engines. This makes for particularly high emissions and, consequently, high external costs in towns.

Obviously, not all transport modes are equally polluting on a kilometre for kilometre basis. Table 63 summarises some of the differences.

Table 61. **Average emissions for diesel and gasoline cars**

Vehicle type	CO (g/km)	VOCs (g/km)	NO_x (g/km)	Particulates (g/km)
Gasoline, no catalytic converter	27.0	2.8	1.7	–
Gasoline, with catalytic converter	2.0	0.2	0.4	–
Diesel	0.9	0.3	0.8	0.4

Source: IRER (1995).

Table 62. **Ratio of cold-engine emissions relative to hot-engine emissions**

Vehicle type	CO	HC	NO_x	Particulates
Gasoline, no catalytic converter	1.6	2.0	1.0	–
Gasoline, with catalytic converter	9.6	11.0	1.3	–
Diesel	1.6	1.0	1.2	1.2

Source: IRER (1995).

Table 63. **Energy use and emissions per passenger kilometre for long distance travel**

		Energy use MJ/p-km	CO_2 g/p-km	NO_x g/p-km	VOC g/p-km	SO_2 g/p-km
Aircraft	500 km[1]	2.2	160	0.47	0.06	0.05
	1 500 km[2]	1.6	115	0.40	0.03	0.05
Car	petrol 2 occupants[3]	1.5	110	0.08	0.03	0.02
	diesel 2 occupants[3]	1.3	100	0.39	0.05	0.03
	diesel 1 occupant[4]	3.2	235	0.76	0.09	0.07
Train	high speed[5]	0.7	40	0.24	0.01	0.06
	conventional[6]	0.8	50	0.28	0.01	0.07
Coach[7]		0.3	20	0.29	0.02	0.01
Ferry[8]		0.6	50	0.92	0.04	0.98

1. Average of two modern aircraft types (F50 + B737-400), load factor 65%, detour factor 1.2.
2. Average of four modern aircraft (B737-400, B757-200, B767-300ER, B747-400), load factor 65%, detour factor 1.15.
3. Modern, medium sized petrol or diesel car, detour factor 1.3.
4. Modern, large diesel car, detour factor 1.3.
5. Average electricity production in north west Europe (1990 data), load factor 65%, detour factor 1.3.
6. Conventional international train, average electricity production for north west Europe (1990 data), load factor 40%, detour factor 1.3.
7. Modern coach, diesel, load factor 65%, detour factor 1.3.
8. Load factor 60%, detour factor 1.1.

Source: Roos, Bleijenberg, Dijkstra, *Energy Use and Emissions from Aviation and Other Modes for Long Distrance Travel in Europe,* CE Delft (September 1997).

Table 64. **Energy use and emissions per freight kilometre for long distance traffic**

		Energy use MJ/t-km	CO_2 g/t-km	NO_x g/t-km	VOC g/t-km	SO_2 g/t-km
Aircraft	500 km [1]	19.5	1 420	4.33	0.65	0.42
	1 500 km [2]	11.0	800	2.66	0.25	0.23
Truck	35t gvw [3]	1.34	100	1.20	0.05	0.03
	20t gvw [4]	2.77	200	2.26	0.10	0.05
Train	diesel [5]	0.95	69	1.22	0.07	0.08
	electric [6]	0.83	38	0.07	0.00	0.21
Barge [7]		0.54	40	0.69	0.04	0.04
Coaster [8]	diesel	0.19	13	0.26	0.01	0.02
	fuel oil	0.17	12	0.32	0.01	0.24

1. Average of two modern aircraft types (F50 + B737), load factor 67%, detour factor 1.25.
2. B747, load factor 67%, detour factor 1.13.
3. Modern diesel truck, load factor 55%, detour factor 1.3.
4. Modern diesel truck, load factor 45%, detour factor 1.3.
5. Disel-electric traction, load factor 33%, detour factor 1.35.
6. Average electricity production for north west Europe (1990 data), load factor 33%, detour factor 1.35.
7. Diesel, maximum load 1 500 t, load factor 50%, detour factor 1.5.
8. Maximum load 40 000 t, load factor 50%, detour factor 1.4.

Source: Dings and Dijkstra, *Specific Energy Consumption and Emissions of Freight Transport,* CE Delft (December 1997).

B.4.2. Total costs of air pollution

Local pollution from transport involves a wide range of pollutants emitted by vehicles with combustion engines. These include exhaust gases and particles, evaporative emissions, and dust (particles produced by wear on tyres, break linings, etc.). The quantities of pollutant emissions generated by transport are significant and the substances emitted are harmful to health, with proven impacts ranging from minor irritation to carcinogenic qualities. Though stricter vehicle emissions standards have reduced pollution, since 1970 individual car and HGV traffic has more than doubled and pollution remains a major problem. Table 65 presents total transport sector emissions for selected pollutants and ECMT Member countries (CO_2 emissions are not considered here but are covered in the section on climate change).

CETUR (1994) estimates that transport is responsible for 78% of carbon monoxide emissions in France. Of this total, 88% is emitted by cars. However, as catalytic converters are expected to reduce future carbon monoxide emissions substantially, studies such as Kageson (1992) omit carbon monoxide from their calculations. Such technological progress to reduce pollutant emissions at source is a factor which enters into valuations of external costs under the heading of preventive technology costs. There are two main methods currently used for measuring the impact of local pollution: prevention cost estimates and damage cost estimates.

Damage cost estimates

For Germany, Schulz (1987) estimated the total cost of damage from emissions in the transport sector at DM 9.8 to 16.6 billion in 1985:

- damage to health, DM 2.3 to 5.8 billion;
- damage to buildings, DM 2.0 billion;
- damage to forests, DM 5.5 to 8.8 billion.

These estimates represent 0.6-1.1% of GDP. Another study by the same author on WTP puts the figure at 0.9-3.0% of GDP.

Table 65. **NO_x, HC and SO_x emissions from mobile sources in 1993**
(thousand tonnes)

Country	NO_x	Particulates	SO_x
Germany[a]	1 953	103	96
Austria	119	13[b]	8
Belgium[a]	97		6
Denmark	148		14
Spain[c]	758	33	86
Finland[a]	176		5
France[a]	1 088	76	155
Ireland[c]	60	10	5
Italy[c]	1 224	225	151
Norway	182	8	9
Netherlands	338	22	31
Portugal[b]	131		17
United Kingdom	1 308	232	114
Sweden	328		24
Switzerland	96	1	3
Hungary[a]	94	10	13
Poland	420	22	50

a) 1992.
b) 1991.
c) 1990.
Source: OECD (1993).

In the Netherlands, the 1985-90 environmental protection plan estimates damage caused by atmospheric pollution at Gld 1.73 to 2.78 billion per year, or 0.4-0.65% of GDP.

INFRAS/IWW (1995) provided two damage cost estimates. Both cover western Europe and take account of the relative prices in each country, the relative spatial density of emissions and the extent of urbanisation, to reflect damage costs to agriculture, health and buildings. Estimate I gives damage costs of 0.25% of GDP and estimate II of 1% of GDP. Estimate II took account of critical thresholds, assuming that above a critical emissions level, damage costs increase disproportionately to the volume emitted.

Table 66 and Figure 18 summarise these estimates together with the results of studies reviewed by Ecoplan (1992) on the damage attributable to local pollution.

Prevention cost estimates

Several studies estimating air pollution on the basis of prevention costs were reviewed. INFRAS/IWW (1995) estimated the costs of achieving a NO_x emissions reduction target of 60% on 1991 levels by 2000 and a reduction in SO_2 emissions of 80% on 1980 levels, also by 2000. The prevention costs were weighted to reflect purchasing power parities for 17 countries (EU, Norway and Switzerland). Prevention costs were calculated by multiplying the emissions of each type of pollutant by the weighted prevention cost. The results were as follows:

- on average, annual prevention costs amounted to 0.3% of GDP;
- road transport was responsible for 80% of transport sector prevention costs, with air traffic as the second biggest polluter, accounting for over 10%;
- of prevention costs were attributable to passenger transport and 45% to freight transport.

For an OECD workshop in 1986, F. Perrin-Pelletier estimated the cost of extending catalytic converters to all cars in the (12-member) European Community at 0.5% of GDP, allowing for rises in car prices, fuel consumption and maintenance costs.

CETUR (1990) estimated the cost of possible programmes in France to reduce emissions from private cars with the best available conventional technology. For gasoline cars, this comprised requiring catalytic converters and electronic injection for all cars (the cost of higher fuel consumption was

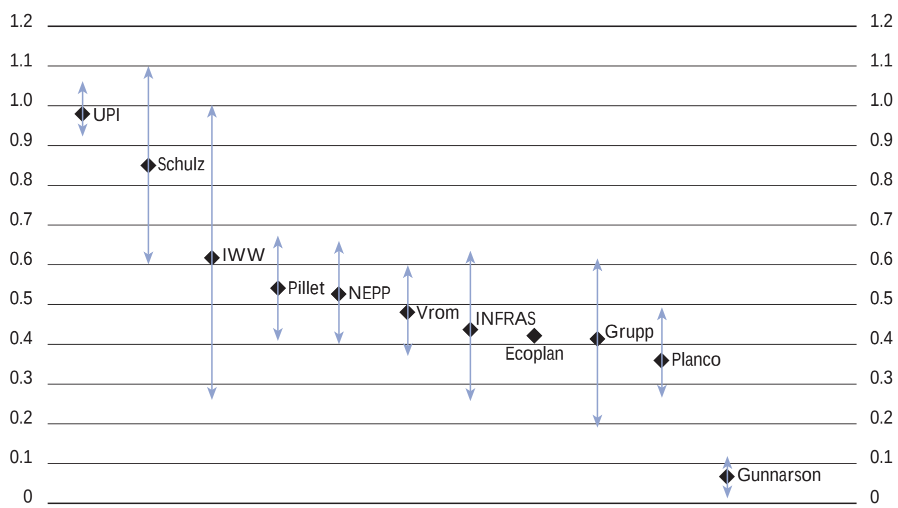
Table 66. **Damage cost estimates of air pollution**
(% of GDP)

Study	Country	Effect on health	Material damage	Effect on vegetation	Total
Schulz (1987)	West Germany				0.6-1.1
NEPP (1985)	Netherlands				0.4-0.65
INFRAS/IWW (1995)	Europe				0.25-1
Summaries from Ecoplan:					
Grupp (1986)	West Germany	0.11-0.42	0.05-0.06	0.03-0.15	0.19-0.63
Planco (1990)	West Germany	0.07-0.18	0.05-0.09	0.13-0.21	0.25-0.48
UPI (1991)	West Germany	0.59	0.07	0.26-0.41	0.92-1.05
Marburger (1986)	West Germany	0.06-0.14	–	–	–
Heinz & Klaassen-Mielke (1990)	West Germany	0.05-0.25	–	–	–
Isecke *et al.* (1990)	West Germany	–	0.05-0.08	–	–
Heinz (1986)	West Germany	–	0.06	–	–
Ewers (1986)	West Germany	–	–	0.13-0.21	–
Pillet (1988)	Switzerland	0.02-0.06	0.21	0.18-0.41	0.41-0.68
INFRAS (1992)	Switzerland	0.01-0.03	0.07-0.16	0.16-0.45	0.24-0.64
Ecoplan (1992)	Switzerland (Bern)	0.14	0.13	0.15	0.42
Gunnarson & Lecksell (1987)	Sweden	0.02-0.06	0.00-0.03	0.00-0.02	0.03-0.11
Hasund *et al.* (1990)	Sweden	–	–	0.06-0.2	–
Vrom (1985)	Netherlands	0.16-0.29	0.08-0.13	0.14-0.18	0.38-0.6
Napap (1991)	United States	–	–	0.01-0.02	–

Source: ECMT Task Force; Ecoplan 1993.

included in the calculations); for diesel cars, one-way catalytic converters, particulate filters and diesel desulphurisation were required. Total capital expenditure and additional costs were estimated at 0.51% of GDP. CETUR also estimated prevention costs for diesel-powered public passenger transport (bus, coach, diesel multiple-units) as 0.03% of GDP, bringing the total for passenger transport (excluding electricity generation) to about 0.55% of GDP.

◆ Figure 18. ***Damage cost estimates for air pollution***
(% of GDP)



Source: See Table 66, for details.

Choice of estimates for policy making

The range of estimates reviewed is large, from 0.03 to 3% of GDP, reflecting the complexity of valuation: it must link emissions to impacts through models of dispersion, ambient concentration and dose-response relations, in addition to attaching financial value to impacts.

Utility valuation techniques (willingness to pay indicated through stated or revealed preference), which are generally the preferred approach to economic valuation, are of limited use for assessing air pollution. Pollution is too dispersed to be reflected in property values and few people have a sufficient understanding of the chemistry and dose-response relations involved to make informed statements of preference.

Damage cost estimates are therefore more common in evaluating air pollution. Damage cost estimates all share a bias towards underestimation, as all researchers caution that they were unable to cover all the effects relevant to the total costs of air pollution. The damage cost estimates reviewed place the cost of air pollution at 0.25 to 1.1% of GDP (one study lay outside this range at 0.03-0.11%). The estimate used by the European Commission in its 1996 green paper was 0.4%, based on an OECD study.

Fortuitously, the prevention cost estimates surveyed all lie in the central range of the damage cost estimates reviewed. The few examples of utility valuations examined provide estimates from the upper end of the range of damage costs up to 3% of GDP. The damage and prevention cost estimates were retained for further analysis, *i.e.* 0.25-1.1% of GDP with a mean value of 0.6% GDP.

Finally, it should be noted that for economies in transition, the problem of local pollution is particularly critical since vehicles in circulation do not yet incorporate technology such as catalytic converters. While estimates of pollution costs in central and eastern Europe are not yet available, they will very likely be at the upper end of the scale.

B.4.3. Shadow values for air pollution

In a literature review, *The social costs of transport* (1994), Bleijenberg, van den Berg and de Wit provide an overview of the financial valuations of various pollutant emissions, on a cost per kilogram basis, from studies using various methods to calculate damage costs. Tables 67, 68 and 69 reproduce some valuations from this review, with reference to the relevant studies.

Table 70 summarises the different studies, proposing three valuation variants for each type of pollutant emission.

According to Bleijenberg *et al.*, in the case of NOx and VOC emissions, the "medium" valuation gives a reliable estimate of the cost of reducing the emissions by 50% between 1985 and 2000. SO_2 emissions have only a small impact on the total external cost. The high variant is not a maximum figure,

Table 67. **Financial valuation of NO_x emissions**
(ECU/kg)

Study	Valuation		
	Low	Medium	High
Grupp, 1986		1.90	
Quinet, 1989		1.80	
Dogs and Platz, 1990	0.80		2.40
Klaasen, 1992	1.70		4.00
Teufel *et al.,* 1993	1.70		5.10
Kågeson, 1993		4.00	
Boneschausker & t'Hoen, 1993	0.08		0.21
Neuenschwander *et al.,* 1992	3.60		18.00
Maubach *et al.,* 1992		11.00	

Note: 1991 exchange rate, 2.31 Guilders per ECU.
Source: Bleijenberg *et al.* (1994).

Table 68. **Financial valuation of VOC emissions**
(ECU/kg)

Study	Valuation		
	Low	Medium	High
Grupp, 1986		1.50	
Quinet, 1989		1.50	
Dogs and Platz, 1990	1.60		5.90
Klaasen, 1992	1.70		4.00
Teufel *et al.,* 1993	0.51		2.70
Kågeson, 1993		4.00	
Boneschausker & t'Hoen, 1993	0.17		0.51
Neuenschwander *et al.,* 1992		7.70	

Note: 1991 exchange rate, 2.31 Guilders per ECU.
Source: Bleijenberg *et al.* (1994).

Table 69. **Financial valuation of SO_2 emissions**
(ECU/kg)

Study	Valuation		
	Low	Medium	High
Dogs and Platz, 1990	0.35		1.20
Klaasen, 1992	1.90		2.70
Teufel *et al.,* 1993	2.60		3.00
Kågeson, 1993	0.35		2.90
Boneschausker & t'Hoen, 1993	0.04		0.08
Neuenschwander *et al.,* 1992		1.60	

Note: 1991 exchange rate, 2.31 Guilders per ECU.
Source: Bleijenberg *et al.* (1994).

Table 70. **Financial valuation of pollutant emissions**
(ECU/kg)

Pollutant	Valuation		
	Low	Medium	High
NO_x	0.77	4.00	5.10
VOC	1.51	4.00	5.90
SO_2	0.34	0.80	3.00

Note: 1991 exchange rate, 2.31 guilders per ECU.
Source: Bleijenberg *et al.* (1994).

in so far as some of the negative effects of these pollutants, according to the authors, have not been included in the valuation. The median value of ECU 4/kg of NO_x, applied to Germany, France, the Netherlands, the United Kingdom and Spain, puts the cost of halving pollutant emissions between 1985 and 2000 as equivalent to 0.62% of GDP in these countries.

INFRAS/IWW (1995) derived estimates for the marginal cost of pollution prevention close to the median value obtained by Bleijenberg *et al.*, estimating the marginal prevention costs for NO_x and VOCs together at ECU 4-6/kg. Dings, Davidson and de Wit, in *Optimal Fuel Mix in Road Trac* (CE Delft, May 1997), also derived similar estimates for marginal prevention costs: ECU 4.8/kg for NO_x and VOCs from rural traffic; and ECU 9.5/kg for NO_x emissions from urban traffic.

Based on this overview of international studies, an average value for NO_x and VOCs can be taken as ECU 5/kg. This value needs to be differentiated between urban and rural areas: acidification and ground level ozone caused by these pollutants affect wide areas, including rural zones, but the impact on human health is concentrated in urban areas. For rural emissions a value of ECU 4/kg of NO_x and VOC emissions is taken and for urban areas it is ECU 8. The weighted average of these values is ECU 5/kg with the differentiation in line with the estimates made by Dings, Davidson and de Wit.

In addition to these shadow prices for NO_x and VOCs a shadow price is required for particulate emissions in urban areas, because of their impact on health. Dings, Davidson and de Wit estimated marginal prevention costs for reducing PM_{10} emissions in urban areas and derived a shadow price of ECU 70/kg, corresponding with the marginal prevention costs associated with measures required to implement the latest proposals from the European Commission (June 1996) regarding fuel quality and emissions standards.

Table 71. **Shadow prices for air emissions**

	Rural Areas	Urban Areas
NO_x and VOCS	ECU 4/kg	ECU 8/kg
Particulates	ECU 0/kg	ECU 70/kg

Source: ECMT Task Force estimates.

B.4.4. Alternative approach to deriving shadow prices

An alternative approach to valuation is through epidemiological damage studies aiming to derive dose-response functions. Some significant difficulties arise in attempts to value air pollution. These have implications for the approach to be adopted here in estimating a shadow value. First, as noted above, people may have little conception of the damage to their health. This makes direct estimation unreliable, so it is probably preferable to use a dose-response methodology.

Second, air pollution consists of a cocktail of many different chemicals. It is hard to separate out individual effects, and little is known about the potential for synergistic or antagonistic interactions among pollutants. One way to address this problem is to use equations relating to a single, representative air pollutant as a proxy for all air pollution. The error involved is probably minor as long as the proportions of different air pollutants remain relatively constant across time and space.

Third, the connection between emissions of pollutants and exposures suffered by people is poorly understood, so it is difficult to use equations which relate ambient exposure to health effects to estimate the damage costs of one unit of emissions. It is commonly assumed that ambient concentrations are in direct proportion to emissions, so that a given percentage reduction in emissions will lead to the same percentage fall in concentrations. The validity of this assumption varies by pollutant, however.

Finally, most epidemiological studies of air pollution have focused on acute effects such as increases in daily mortality. These studies are easier and cheaper to conduct and analyse than studies looking at chronic effects. There is a pressing need for more research into the chronic effects of air pollution, as the acute estimates may be picking up only the end result of a long process.

Given these restrictions, one approach is to focus on the pollutant widely thought to be the most threatening to health – namely, particulates, small airborne particles which are breathed in and can in some cases penetrate the skin, and which can carry other pollutants adsorbed onto their surfaces.

As in the case of noise, there are different ways of measuring particulate levels. Modern techniques collect and weigh particles under standard conditions for total suspended particles (TSP), for particles of 10 microns or less in diameter (PM_{10}), or for particles of 2.5 microns or less (fine particles). Approximate conversion factors exist for switching among these measures.

The advantage of using particulates as the indicator of air pollution severity is that they are an umbrella for many pollutants. Other pollutants forming part of particulates include NO_x and SO_x in aerosol form. Since there is a risk that variations in the actual constituents of particulates could bias the results, meta-analysis to determine the consistency of studies across time and space is especially valuable in the case of particulate pollution.

Desvousges *et al.* (1993) present a meta-analysis of eight studies linking PM_{10} pollution to daily mortality in a number of cities. Meta-analysis is discussed in Annex A: the estimated coefficients and standard errors for each city are assumed to be drawn from city specific distributions, of which the parameters are themselves drawn from a common "mother" distribution representing all areas.

The estimators of the parameters of the mother distribution give a coefficient of 0.101% increase in daily mortality for a 1 $\mu g/m^3$ increase in PM_{10}, with a standard error of 0.042. This is lower than the simple mean of the original studies (0.12%) because the meta-analysis gives more weight to studies with larger samples and smaller errors.

These results will be used to derive shadow prices here. Desvousges *et al.* is thought to be the most suitable study because:

- it considers mainly studies using mass-based measurements of particulates, so conversion factors contain little error;
- the inclusion of three non-mass-based studies at best guess conversion factors makes little difference to the results;
- the meta-analysis used takes account of the different sample sizes and standard errors in the original studies;
- a representative range of initial studies is considered.

Using Desvousges *et al.* involves transferring US dose-response studies to a European setting. This is thought to be justifiable because pollution concentrations in European cities are similar to those in some of the original studies, and the differences between the populations in terms of age structure, general health and so on are taken into account by expressing the dose-response coefficient as a percentage change in mortality. The most suitable use of the results is to estimate the effects of marginal pollution concentration changes. The annual number of deaths is:

$0.101\% \times PM_{10} \times \text{population} \times \text{death rate}$

The PM_{10} concentration is measured in $\mu g/m^3$. The mean death rate in Europe is 11 per thousand population per year. When considering individual countries, specific death rates can be used. To give a shadow value, the result is multiplied by the value of statistical life for each country. The estimated life value is derived exactly as for accident costs (see section B.2), ECU 1.5 million. Again, the base estimate is taken to apply to France, and the valuations for other countries are worked out accordingly. The results are shown in Table 72, with a mean value of ECU 15 per year per $\mu g/m^3$ change in ambient PM_{10} concentrations per person exposed.

This marginal valuation of the cost of air pollution should be seen as conservative, at least in one sense, as it is based on deaths associated with increased ambient concentrations of pollution. Clearly there are additional external costs associated with non-fatal health damage. For example, the

Table 72. **Shadow values of PM_{10} concentration reductions, by country**

Country	Annual death rate per 1 000	Life value million ECU	Value of 1 µg/m^3 fall in PM_{10} per person exposed (ECU/year)
Austria	12	1.49	18
Belgium	12	1.49	18
Denmark	11	1.49	16
Finland	10	1.38	14
France	10	1.50	15
Germany	12	1.54	19
Greece	10	1.19	12
Ireland	8	1.34	11
Italy	11	1.47	16
Luxembourg	11	1.58	18
Netherlands	9	1.47	13
Norway	11	1.47	16
Portugal	10	1.24	13
Spain	9	1.34	12
Sweden	12	1.46	18
Switzerland	10	1.58	16
United Kingdom	12	1.43	18
Mean value			**15**

Source: ECMT Task Force estimates.

Observatoire Regional de Santé d'Ile de France estimates that when ambient levels of SO_2 reach 350 µg/m^3 (level two – out of three – on the French pollution alert scale) daily hospital admissions for asthma cases increase 15% over "normal" levels and home visits by doctors for asthma sufferers increase 30%. This gives an indication of acute non-fatal health damage, though there are probably also significant costs associated with the chronic consequences of exposure to pollution, particularly related to exposure under the age of 3 when the lungs have not completed development, in terms of the treatment and suffering related to asthma, chronic bronchitis, emphysema, colds, coughs and cancer.

Comparison with conjoint analysis results

Sælensminde and Hammer (1994) present results from which Oslo residents' WTP for air pollution improvements may be calculated. Using their segmented approximation of the WTP function, WTP per household for a 25% improvement in air pollution from transport is estimated as NKr 1 875, or about ECU 155 at purchasing power parities. With 2.4 persons per household on average, according to the Statistical Compendium for the Dobris Assessment (1991), this is ECU 65 per person per year.

Particulate levels in Oslo, measured as black smoke, average 25 µg/m^3. Black smoke is approximately equal to PM_{10}, although the exact conversion factor varies. Assuming that transport is responsible for 31% of air pollution, a 25% improvement in pollution from transport is equivalent to a change in particulate levels of 1.94 µg/m^3. Multiplying this by ECU 16, from the Norway entry in the table above, gives a value of ECU 31 per person per annum.

As in the noise valuation case, the similarity of these results should not be overemphasised. But the fact that two different methodologies give results of the same order of magnitude is a useful cross-check that the proposed valuations are reasonable.

Note on morbidity

Numerous non-fatal health impacts of air pollution have been studied, largely in the US, where key end-points have included "respiratory hospital admissions", "emergency room visits", "restricted activity days", "acute respiratory symptoms", "eye irritation", and so on.

There are substantial problems with conducting valuation based on the morbidity literature: a) fewer studies are available for any given effect, making meta-analysis more difficult; b) results are normally expressed as absolute numbers affected, rather than proportionate increases, making function transfer from the US to Europe much less defensible; and c) the valuation of the outcomes is much less well researched than the valuation of fatalities.

Hence, it is thought that little confidence may be placed in morbidity estimates as they have conventionally been presented. This being said, however, improved morbidity estimates are undoubtedly the way forward in the evaluation of the health impacts of air pollution. In particular, cohort studies of the effects of chronic exposure to air pollution would be of much greater use than snapshot studies of acute morbidity (and, indeed, mortality) effects.

B.4.5. Air pollution costs per kilometre

The damage attributable to air pollution can be distributed among transport services on the basis of either the shadow prices in ECU per kilogram for emissions or from the marginal cost of ambient PM_{10} concentrations derived in section B.4.4. Both are presented here for comparison.

Derivation from shadow prices per kilogram of emissions

Unit costs were calculated by multiplying the shadow prices obtained in section B.4.3 by specific emissions characteristics for the current fleet of road vehicles, using emissions factors for the Dutch fleet in 1994 (see Table 73). It should be noted that specific emissions are gradually decreasing with the growing penetration of cars with three-way catalytic converters and tightening of emissions standards for all new vehicle types. Assumed improvements for the fleet around 2000 are also shown in the table. For the calculation of costs per passenger-and tonne-kilometre assumptions were made as to vehicle occupancy rates and load factors. These are summarised in the table, with details given following Table D1 in Annex D. Results for the present vehicle fleet are summarised in Table 74.

Table 73. **Specific emissions from road vehicles**

	Passenger car			Freight transport		
	Gasoline	Diesel	LPG	Van	Truck	Weighted average
Current vehicles, traffic, fuel and emissions (1994)						
Load (person, tonne)	1.80	1.80	1.80	0.20	6	3
Fuel (l/v-km)	0.085	0.007	0.105	0.10	0.35	0.21
CO_2 (kg/l)	2.34	2.62	1.62	2.62	2.62	2.62
NO_x + VOC (g/v-km)	2.60	0.90	1.60	1.40	18	8.9
Particulates (mg/v-km city)	3.40	250	1.70	290	1 750	953
Annual mileage	13 500	28 000	29 000	22 000	75 000	32 400
Urban mileage	32%	23%	23%	70%	23%	49%
Anticipated changes in vehicles, traffic, fuel and emissions (2000 approx.)						
Load (person, tonne)	1.8	1.8	1.8	0.2	8	4
Fuel (l/v-km)	0.08	0.065	0.10	0.10	0.30	0.20
CO_2 (kg/l)	2.34	2.62	1.62	2.62	2.62	2.62
NO_x + VOC (g/v-km)	0.35	0.50	0.35	0.8	8	4.1
Particulates (mg/v-km city)	3	70	1	90	250	163
Annual mileage	13 500	28 000	29 000	22 000	75 000	32 400
Urban mileage	32%	23%	23%	70%	23%	49%

Source: ECMT Task Force estimates.

Table 74. **Average emissions costs per passenger and tonne kilometre**

	Petrol car (ECU/1 000 p-km)	Diesel car (ECU/1 000 p-km)	Van (ECU/1 000 t-km)	HGV (ECU/1 000 t-km)	Freight average (ECU/1 000 t-km)
NO_x + VOCs	7	3	35	15	16
Particulates	0	2	71	5	7
Total	7	5	106	20	23

Source: ECMT Task Force estimates.

Using data on energy consumption and specific emissions it is straightforward to calculate emissions costs for other transport modes (see Tables 63 and 64). On the basis of the shadow prices for air pollution in rural areas (see Table 71), ignoring SO_x emissions, the figures for rail are: high speed trains ECU 1 / 1 000 p-km; conventional passenger trains ECU 1.2 / 1 000 p-km; diesel freight trains ECU 5.2 / 1 000 t-km; electric freight trains ECU 0.3 / 1 000 t-km.

Using similar shadow prices based on prevention costs from two primary sources, INFRAS/IWW calculated average European figures for rail of ECU 0.6-3.5 / 1 000 p-km and 0.2-1.2 / 1 000 t-km. The calculations were made on the basis of assumptions as to the ratio of diesel to electric locomotives, UCPTE data on power generation in its member countries, data on characteristic emissions from *OECD Environmental Data: Compendium 1993* and ECMT statistics for rail freight- and passenger-kilometres.

Derivation from marginal cost of ambient PM_{10} concentrations

An estimate of total pollution costs can be derived from the shadow price estimated from PM_{10} data above in combination with data for populations exposed to significant ambient concentrations of PM_{10}.

Table 75 shows average annual ambient concentrations of PM_{10} in the atmosphere for a selection of European cities. The figures come from individual city reports in Zantvoort *et al.* (1995). Measurement techniques may not have been consistent across or within countries, which could explain some seemingly odd numbers (*e.g.* for Toulouse). The survey suggests that urban particulate concentrations differ markedly across Europe. Scandinavian countries may have slightly below average concentrations, while Italy seems to have significantly higher pollution. Other figures from the same source show even higher concentrations in central and eastern European countries, particularly Ukraine.

Because there are few or no data for many countries, it is not possible to apply a separate estimate for each country. The most appropriate way the results of the survey can be applied across Europe is to use the categories Northern Europe (Finland, Norway, Sweden), Southern Europe (Greece, Italy, Portugal, Spain) and Western Europe (all other countries in the table). The average annual concentrations of PM_{10} for these three broad regions will be taken as 23, 35 and 29 $\mu g/m^3$, respectively. These averages can then be applied to the urban populations of each country, together with national rates of mortality (deaths from all sources) to derive air pollution cost estimates from the marginal shadow price.

The World Resources Institute (1992-93) gives the average percentage of population living in urban areas as 73.4% in 1990. As the definition of "urban" varies by country, comparisons are likely to be somewhat biased; and, unfortunately, the level of urban population assumed has a significant influence over the level of damage estimated. The WRI figures seem to take a very broad definition of urban: 89.1% of the UK population is given as residing in urban areas, but only 52% of people in the UK live in towns of 50 000 or more. A size of 50 000-plus seems a reasonable point at which to draw the line between urban and non-urban areas. Towns of fewer than 50 000 would be unlikely to suffer major traffic induced air pollution, because the surface area in contact with clean air from outside will be high in relation to the volume of polluted air. Therefore the WRI figures have been adjusted downwards by multiplication by 0.58, to account for the more narrow definition of "urban" required for current purposes.

Table 75. **Particulate concentrations in some European cities**

Country	City	PM_{10} estimate (μgm^{-3})
Austria	Vienna	40
Belgium	Brussels	24
	Antwerp	41
Finland	Helsinki	23
France	Lyon	36
	Marseilles	21
	Paris	39
	Toulouse	8
Germany	Berlin	53
	Bremen	18
	Cologne	31
	Dortmund	39
	Dresden	33
	Duisburg	39
	Dusseldorf	32
	Essen	31
	Frankfurt	33
	Hamburg	30
	Hannover	23
	Stuttgart	18
Italy	Milan	38
	Naples	61
	Rome	73
	Turin	85
Ireland	Dublin	41
Netherlands	Amsterdam	20
	Rotterdam	24
Norway	Oslo	25
Portugal	Lisbon	21
Spain	Valencia	43
Sweden	Gothenburg	5
	Stockholm	18
Switzerland	Zurich	21
United Kingdom	Birmingham	26
	Bristol	27
	Cardiff	31
	London	29
	Leeds	27
	Liverpool	29
	Newcastle	29

Source: Zantvoort *et al.* (1995).

It is also necessary to decide how much of urban air pollution transport is responsible for. Small and Kazimi (1995) find for a study in California that road transport contributes 31% to PM_{10} concentrations: one-third direct particulate emissions, one-third NO_x emissions forming aerosols and one-sixth each sulphate and VOC emissions. The 31% estimate will be used here.

The figures in the last column of Table 77 put total costs for air pollution from road use in the region of 0.6% of GDP (close to the mean of the estimates for total costs calculated in section B.4.2). They are conservative estimates, because they consider mortality only in cities of 50 000 or more, and assume that transport emissions cause only 31% of concentrations.

The variation in these figures across countries reflects several factors. The general health level of the population is reflected by the death rate. Three different levels of air pollution have been used for Northern, Southern and Western Europe. Different proportions of the population living in urban areas

Table 76. **Estimates of total air pollution mortality in Europe**

Country	Population (m)	% Urban	Death rate	Mortality
Austria	7.60	34	12	899
Belgium	9.85	56	12	1 920
Denmark	5.16	50	11	823
Finland	5.03	35	10	405
France	57.14	43	10	7 125
Germany	77.33	49	12	13 186
Greece	10.12	36	10	1 275
Ireland	3.90	33	8	299
Italy	57.11	40	11	8 795
Luxembourg	0.38	49	11	59
Netherlands	15.41	51	9	2 051
Norway	4.27	44	11	475
Portugal	10.43	33.6	10	1 227
Spain	39.92	45	9	5 659
Sweden	8.51	49	12	1 151
Switzerland	6.68	35	10	678
United Kingdom	57.86	52	12	10 470
Total	376.70	–	–	56 497

Source: WRI, 1992; ECMT Task Force estimates.

Table 77. **Damage estimates for road transport air pollution mortality**

Country	Mortality	Life value	Road air pollution (ECU m)
Austria	899	1.49	414
Belgium	1 920	1.49	886
Denmark	823	1.49	379
Finland	405	1.38	173
France	7 125	1.50	3 313
Germany	13 816	1.54	6 612
Greece	1 275	1.19	469
Ireland	299	1.34	124
Italy	8 795	1.47	4 004
Luxembourg	59	1.58	29
Netherlands	2 051	1.47	934
Norway	475	1.47	216
Portugal	1 227	1.24	473
Spain	5 659	1.34	2 346
Sweden	1 151	1.46	519
Switzerland	678	1.58	334
United Kingdom	10 470	1.43	4 666

Source: ECMT Task Force estimates.

means different proportions of the population exposed to air pollution. Different life values reflect variations in incomes across Europe.

For splitting road traffic damage costs among cars, buses and HGVs, the proportions 1.5:10:5 have been chosen to reflect approximately the relative contributions per kilometre of these modes to the four pollutants Small and Kazimi identify as contributing to PM_{10} pollution.

The estimated marginal cost of PM_{10} emissions as a proxy for all pollution yields unit costs of ECU 4.7 / 1 000 p-km for cars and ECU 10.3 / 1 000 t-km for goods vehicles, on average.

Table 78. **Road air pollution damage costs by vehicle type**

	Air pollution	Cars			Buses		Freight average		
	ECU m	bn km	ECU/ 1 000 v-km	ECU/ 1 000 p-km	bn km	ECU/ 1 000 v-km	bn km	ECU/ 1 000 v-km	ECU/ 1 000 t-km
Austria	414	42.0	6.6	3.86	0.5	44.1	5.2	22.0	8.73
Belgium	886	50.5	12.3	8.20	0.4	81.8	5.7	40.9	9.05
Denmark	379	30.7	6.9	3.85	0.5	46.0	6.3	23.0	13.94
Finland	173	33.1	3.1	2.21	0.7	20.7	5.4	10.4	2.35
France	3 313	325	4.7	2.55	4.0	31.5	105	15.7	11.13
Germany	6 612	406	11.5	6.73	3.4	76.4	44.6	38.2	8.40
Greece	469	9.4	19.5	9.61	0.5	130.0	3.4	65.1	17.88
Ireland	124	19.7	3.3	1.78	0.2	21.9	5.0	10.9	10.79
Italy	4 004	260	9.0	4.43	4.8	60.2	45.5	30.1	8.20
Luxembourg	29	3.0	6.6	4.40	0.0	––	0.4	22.1	11.63
Netherlands	934	77.8	7.5	3.85	0.6	49.9	12.9	24.9	13.83
Norway	216	23.2	6.1	3.53	0.3	40.6	3.1	20.3	8.29
Portugal	473	35.0	10.4	5.45	0.6	69.1	2.0	34.5	6.39
Spain	2 346	76.0	13.1	6.86	2.0	87.6	24.2	43.8	7.05
Sweden	519	86.2	4.8	3.18	0.7	32.1	5.1	16.1	3.24
Switzerland	334	48.0	5.1	2.76	0.2	33.9	4.9	16.9	6.48
United Kingdom	4 666	330	8.4	4.88	4.3	55.7	60.0	27.8	13.37
Weighted average			**8.4**	**4.70**		**57.5**		**23.2**	**10.25**

Source: ECMT Task Force estimates.

Choice of unit costs for air pollution to be retained

The divergence of the results (for trucks) from those obtained from shadow prices based on prevention costs appear to stem largely from the assumption as to the relative impact of trucks and cars (1.5:10). Due to the sensitivity of this assumption to differences between countries and to maintenance standards for vehicles in use, the results of the calculations based on shadow prices are retained for use elsewhere in the report (see Table 79).

Table 79. **Unit costs for air pollution**

Petrol cars	ECU 7/1 000 p-km
Diesel cars	ECU 5/1 000 p-km
HGVs	ECU 20/1 000 t-km
Road freight average	ECU 23/1 000 t-km
Passenger rail	ECU 2/1 000 p-km
Rail freight	ECU 0.7/1 000 t-km

Source: ECMT Task Force estimates.

B.5. CLIMATE CHANGE

B.5.1. Damage estimates for climate change

CO_2 emissions are the main agent relevant to transport responsible for enhancing the greenhouse effect. The volume of CO_2 emissions from the transport sector is directly related to the volume of road traffic and the specific fuel consumption of individual vehicles. Vehicle fuel efficiency has improved substantially, but progress has slowed as a result of the trend towards increasing weight and higher average power (this applies to passenger cars, and probably also to both light and heavy freight vehicles). Moreover, increased efficiency has been offset by traffic growth. Rising levels of car ownership in some countries that still lag far behind those of the wealthiest countries suggest that CO_2 emissions from transport will continue to rise substantially on the global scale. Road freight traffic has grown faster than passenger traffic over the last 25 years, and the forces driving its expansion – liberalisation of haulage markets, liberalisation of trade and the growth of multinational corporations – will continue to exert pressure for growth in the future.

It is very difficult to predict what the greenhouse effect will actually do to the global climate, as there may well be multiple or contrary effects still to be sufficiently understood or even identified. Moreover, the significance of CO_2 emissions in comparison to other forces driving climate change remains unclear. Many scientists agree, however, that if climate change results, the major consequences are likely to be changes in patterns of precipitation, adverse effects on agriculture through desertification and aridification, an increase in extreme meteorological conditions such as cyclones, and a rise in sea level. Since quantifying damage costs is exceedingly difficult, even where the necessary studies exist, most analyses have valued such phenomena in terms of avoidance or prevention costs.

Most damage cost estimates have been made for the US economy and for a ‘‘benchmark’’ of double the pre-industrial level of CO_2 concentrations. The results mostly suggest damage amounting to around 1-2% of GDP. For some components of damage, the same source studies have been used. For others, there is wide variation in estimates. Similarity of aggregate results should not, therefore, be interpreted as confirmation of their validity. On the assumption that on average in OECD countries transport is currently responsible for 30% of CO_2 emissions from fossil fuel combustion, transport emissions might imply damage of around 0.3-0.6% of GDP.

Table 80. **Some representative results of global warming valuation studies**

Study	Key Assumptions	Estimate Range (% of GDP)
Nordhaus (1991)	2 x CO_2, 3 deg C	0.25% plus X for omitted categories of damage 1% best estimate 2% maximum
Cline (1992)	2 x CO_2, 2.5 deg C	1% plus X for omitted categories of damage 2% possible/probable
	2 x CO_2, 4.5 deg C	2.1-4.3%
	long term – 10 deg C	6-12%
	long-term – 18 deg C	13-26%
Tol (1994)	2.5 deg C – OECD	1.6%
	2.5 deg C – non-OECD	2.7%
	2.5 deg C – World	1.9%
Fankhauser (1994)	2.5 deg C – OECD	1.3%
	2.5 deg C – non-OECD	1.6%
	2.5 deg C – World	1.4%

Source: ECMT Task Force.

Some studies have looked at the very long term, finding higher damage costs. Others have compared damage estimates for different countries, finding that developing countries in general are prone to suffer proportionately more. Aggregate estimates for the world economy remain close to the US estimates simply because the developed economies dominate the figures. Obvious ethical concerns arise here because many poor countries stand to suffer heavily, with estimates of up to 8 or 9% of GDP in South Asia and Africa, largely as a result of emissions from other nations.

B.5.2. Deriving a shadow value for climate change

Moving from a total estimate to a shadow value is not straightforward. There are two principal problems. First, since the expected damage will occur many years in the future, the choice of discount rate is crucial to the final result. Second, average and marginal damage is not likely to be the same – the severity of total damage may rise exponentially with the increase in greenhouse gas concentrations.

Table 81 shows estimates from some studies which have attempted to calculate the marginal damage from CO_2 emissions either at the current level of emissions or at some estimated future optimum level. The figures are expressed in values per tonne of CO_2 rather than the common alternative, per tonne of carbon.

Table 81. **Shadow price and marginal cost estimates for CO_2 emissions**

(1994 ECU per tonne of CO_2)

Study	Shadow price or marginal cost
Nordhaus (1991)	2.0
Cline (1992, 1993)	11.2 (1.6 – 35)
Fankhauser (1994)	5.7 (1.7 – 12.5)
Maddison (1994)	1.6

Source: ECMT Task Force.

These studies, and the others on which they are based, tend to be conservative in the face of uncertainty. This effect is compounded by the fact that some low probability scenarios of catastrophic damage are commonly ignored. Also, each study has several omissions from the categories of damage considered. These points all suggest that the shadow prices presented in Table 81, must be seen as conservative.

Maddison's figures, for example, suggest that the optimum level of abatement is fairly low – 6.9% in 1995, rising to 14.5% in 2095, compared with "business as usual" emissions. This increase in abatement occurs alongside an increase in the shadow price over time, as atmospheric concentrations of greenhouse gases and the economy both grow. Nordhaus's results also suggest that only a small percentage of abatement is required. Both Nordhaus and Maddison also use discount rates which arguably are too high. Maddison uses 5%, while Nordhaus discounts at the rate of income growth assumed in the model plus 3% for pure time preference. A discount rate of 1-3% would seem more appropriate, and would lead to higher shadow values and greater optimal abatement levels.

While the uncertainties in valuation have led the authors of these studies to be conservative and to ignore the risks of catastrophic damage, the precautionary principle would favour using an approach which risks abating too much rather than too little. As scientific understanding improves and more data become available, it can be hoped that estimates of marginal damage will improve and an optimal policy will be approached. But in the interim, action should be taken which is rather stronger than the damage cost estimates presented might suggest. The risk that abatement will turn out to be greater than required may be viewed as the cost of "insurance" against the chance of major damage from the greenhouse effect.

This indeed seems to be the approach adopted by European governments. Countries are committed in the medium term to certain reductions in CO_2 emissions below a future business-as-usual baseline under the UN Framework Convention on Climate Change. When a target is set in this way, the role of economics is reduced to that of ensuring that the target is met in cost-effectively, *i.e.* equalising the marginal costs of CO_2 abatement for all sources, as far as is possible.

The marginal cost of meeting the European Union's target at the time of writing (stabilisation at 1990 emissions levels[4]) is estimated at ECU 50 per tonne of CO_2 (ECU 184 per tonne of carbon) for measures implemented within the Union. This figure is based on calculations by INFRAS/IWW for abatement in Switzerland, which took the average of cost estimates following two approaches: a top-down approach analysing elasticities to estimate the level of CO_2 tax necessary; and a bottom-up approach estimating the costs of several, mainly technological, measures in the transport sector. The results were transferred to other countries on the basis of purchasing power parities.

In this report, ECU 50 per tonne is taken to represent the shadow price of emissions and this is used as a basis for policy options because of the problems noted for damage cost estimates and because this figure is consistent with current government policies. (Meeting the target proposed by EU Environment Ministers in 1997 – an overall cut of 15% in emissions by 2010 – would roughly double this shadow price.) Because of the global nature of the greenhouse problem, it is appropriate that the shadow price estimated should apply equally to both rural and urban traffic. For simplification it is applied across the whole of Europe, although prevention costs might be somewhat lower in central and eastern Europe.

B.5.3. Climate change costs per kilometre

Using emissions coefficients from INFRAS/IWW (1995), the following estimates may be derived for the cost per kilometre of CO_2 emissions from road transport in Europe, using the central assumption of ECU 50 per tonne of CO_2.

Table 82. **External costs of CO_2 emissions in the road sector**

(vehicle-kilometers)

	Cars	Buses	Freight average
Kg CO_2/km	0.2	0.91	0.55
ECU/km	0.010	0.045	0.028

Source: INFRAS/IWW (1995); ECMT Task Force estimates.

For rail transport, emissions depend on the power source. The primary split is between diesel and electric power, but within the latter category there may be a variety of generating technologies, including nuclear power, which emits no CO_2 but has other external risks. Cost estimates per rail-kilometre, therefore, reflect primarily the differences among different countries' rail systems.

Apportioning these costs to freight and passenger markets depends on the locomotive types (diesel/electric) used for freight and passenger trains. ETH of Zurich has made the necessary calculations in a study (Okoinventare Energiesysteme, 1996) based on UCPTE data on electricity production in its member countries. This gives weighted average emissions factors of 23 g CO_2/t-km and 27.8 g/p-km for both high speed and intercity services. On this basis INFRAS/BEW (1992) calculated unit costs for rail of ECU 2.97 / 1 000 p-km and ECU 1.09 / 1 000 t-km. These figures are used elsewhere in the report, although other sources arrive at different figures; see, for example, Tables 63 and 64, where the authors assumed lower occupancy and load factors than in the INFRAS/BEW study yielding figures roughly twice as high.

Table 83. **External costs of CO_2 emissions per rail km**

Country	Rail MtC [a]	Cost (ECU m)	Rail km (m)	ECU/km
Austria	0.187	34.3	130	0.25
Belgium	0.142	26.05	92.3	0.30
Denmark	0.171	31.35	54.7	0.55
Finland	0.074	13.55	40.1	0.35
France	0.461	84.50	478	0.20
Germany	1.608	294.80	847	0.35
Greece	0.038	6.95	16 (est)	0.45 (est)
Ireland	0.032	5.85	13.7	0.45
Italy	0.766	140.45	304	0.45
Luxembourg	0.009	1.65	5.3	0.30
Netherlands	0.226	41.45	118	0.35
Norway	0.025	4.60	32.4	0.15
Portugal	0.107	19.60	36.5	0.55
Spain	0.358	65.65	173	0.40
Sweden	0.035	6.40	95.9	0.05
Switzerland	0.012	2.20	131	0.00
United Kingdom	0.977	179.10	428	0.40
Weighted average				**0.32**

a) The conversion factor from tonnes of carbon to tonnes of CO_2 is 44/12.
Source: ECMT Task Force estimates.

B.6. OTHER DISAMENITIES

Congestion is often ranked at the top of the list of social costs, though not all experts agree that it should be. Congestion occurs mainly in metropolitan areas and on major bridges, in tunnels and on intercity axes and some transalpine links. Estimates for congestion costs in metropolitan areas vary; studies suggest that congestion costs are significant, mainly due to time lost in traffic jams. Effects of congestion on environmental external costs are less well proven but probably significant. Results are difficult to compare, as local conditions are very important. The key assumption is the monetary valuation of ''lost'' travel time of passengers, drivers and vehicles. The size of some estimates (*e.g.* 2% of GDP) suggests the value of travel time might be overestimated and that the framework for comparison is wrong - the economically optimum level of congestion is not zero as is often mistakenly assumed. There are few recent or reliable estimates of congestion.

Bouladon (cited by Quinet, 1993 and subsequently in the European Commission green paper ''Towards Fair and Efficient Pricing in Transport'') estimated congestion costs for 1991, on the basis of erroneous assumptions, to be:

2.1% of GDP for France;
3.2% for the United Kingdom;
1.3% for the United States;
2.0% for Japan and the European Union.[5]

On the basis of modelling marginal costs in Cambridge, Newbery (1998)[5] arrived at a rough national estimate of ⅔% GDP.

These costs are all borne by the community in one way or another but are not entirely external costs. Road users make up a ''club'' whose members bear a part of the cost of their choices. Whatever part is deemed truly external, congestion is a problem requiring a variety of expensive countermeasures (route guidance, alternative public transport, etc.) regardless of whether these costs are internalised, and managing congestion has a significant impact on transport externalities.

Because congestion costs are so highly dependent on local factors, making generalisations difficult or misleading, estimates of total congestion costs are not attempted in this report (they were, however, the subject of an ECMT Round Table[6] in March 1998). Nevertheless, congestion is covered in the policy analysis section of this report, addressed through its impact on infrastructure costs (see Annex C).

Other effects that can be regarded as either external or social costs include:

- severance from transport infrastructure land-take;
- use of space (already a scarce resource) for land transport infrastructure (such space has a market value since it could be allocated to other uses, especially in urban areas);
- surface and groundwater pollution from road run-off;
- generation of waste (*e.g.* used oil) and recyclable materials (plastic, for example) from scrapped vehicles;
- pollution damage to monuments;
- visual intrusion, which can disfigure the landscape;
- depletion of non-renewable fossil fuel resources, and the risks associated with nuclear energy.

Although not all such effects lend themselves to quantification, they are listed here for the sake of completeness. Omitting them from the analysis suggests the values retained for total external costs are likely to underestimate the full external costs of transport.

NOTES

1. Rune Elvikj, TOI, Norway, personal communication.
2. For details of the calculation, see Tinch (1996).
3. Rounding results in a freight average figure of ECU 8 / 1 000 t-km presented in Annex D and Chapter 3.
4. The Third Conference of the Parties under the UN Framework Convention on Climate Change tightened the target to a reduction in emissions of 8% in relation to 1990 by 2008-12.
5. See, ''The Spread of Congestion in Europe'', ECMT Round Table 109, forthcoming.
6. ''The Spread of Congestion in Europe'', ECMT Round Table 109, forthcoming.

Annex C

INFRASTRUCTURE COSTS

TABLE OF CONTENTS

C.1. INTRODUCTION

This annex briefly reviews the state of the available pan-European data on infrastructure costs of road and rail networks. As far as possible, the data is analysed in a way that provides a useful basis for the formulation of incentive oriented internalisation policy. For this purpose, the following steps are carried out:

- Section C.2 gives a brief overview of the relevant methodological questions.
- In section C.3 the available comparable European data are compiled.
- In section C.4 rough figures for short-run marginal costs (SRMC) are estimated.
- Section C.5 shows some rough estimates of long-run marginal costs (LRMC) based on the available data on average historical costs of infrastructure.

C.2. METHODOLOGICAL QUESTIONS

C.2.1. Expenditure or cost figures?

From the methodological point of view an accounting framework based on the opportunity cost principle is preferable to simple expenditure and revenue accounting; application of the opportunity cost principle comes closest to a business type of cost accounting. From the practical point of view, however, an expenditure figure approach is simpler. A framework based on expenditure figures rarely leads to statistical problems and, more importantly, allows international comparisons of data when the elements of the calculus are defined clearly and transparently. Approaches based on cost figures, in contrast, involve statistical and methodological problems. The major inconsistencies arise from different treatment of depreciation, application of different valuation methodologies for the capital stock and use of different interest rates. Furthermore, in most countries expenditures on roads are used as proxies for costs, which is a reasonable approximation if the expenditures do not vary significantly from one period to the next. For these reasons, the expenditure approach is usually chosen for international comparisons of infrastructure cost coverage.

C.2.2. Which revenues should be taken into account?

The major issue in this context relates to the question of which revenues should be interpreted as specific contributions by infrastructure users to infrastructure financing. Revenues from the following instruments are often considered to be earmarked (hypothecated) in this way: *a)* vehicle taxes; *b)* fuel taxes; and *c)* special tolls and charges (only excise duties, *e.g.* special taxes on imported vehicles).

Value added tax is not normally considered as specific to infrastructure use unless differential rates are applied specifically to transport. VAT is regarded as a general tax applied to all turnover in the market. The debate as to whether receipts from VAT on the excise tax portion of fuel prices should be considered specific to roads is unresolved and in most countries it is not clearly specified what share of fuel taxes is considered general tax and what share should be taken into account for covering infrastructure costs. Differences in explicit or de-facto hypothecation lead to problems with regard to international comparability of infrastructure revenue data.

For railways, the revenues usually taken into account are from: *a)* sales of transport services to users; and *b)* compensation payments by public agencies for public service obligations imposed on railway companies. In many countries, however, an indeterminate part of PSO expenditure contributes to wage costs on the system as a whole, rather than maintaining specific infrastructure.

C.3. SUMMARY OF AVAILABLE DATA

C.3.1. UIC study (INFRAS/IWW, 1995)

INFRAS/IWW (1995), in a study conducted for the International Union of Railways (UIC), compiled data on infrastructure costs and revenues for road and rail in 17 European countries (EUR 17 = EU member states plus Norway and Switzerland). The study can be characterised by the following key methodological elements:

- Road infrastructure costs: As information about the real costs of the road network was lacking in most EUR 17 countries, cost figures were estimated on the basis of the expenditure data received, applying a total cost/total expenditure ratio of 1.3. The ratio is an empirical estimate based on cost and expenditure calculations for Germany and Switzerland and information provided through questionnaire responses in the UIC study.
- Road infrastructure revenues: The assumption was made that infrastructure revenues from road users are limited to vehicle registration taxes, fuel taxes, tolls and parking charges.
- Allocation of road costs and revenues: The costs of infrastructure were allocated to vehicle categories with the simplified method of equivalent factors used in the German cost calculation (DIW, 1992). For allocation of revenues to vehicle categories, vehicle specific weights were calculated for the shares of fuel taxes and vehicle taxes paid, using empirical data for Switzerland and Germany.
- Rail costs and revenues: Cost data were estimated as for roads using a cost/expenditure ratio of 1.1 (based on available empirical studies). A special problem of rail cost accounting systems is that no data on infrastructure revenues are separated from data on total revenues. For countries without information about infrastructure revenues, the revenues were estimated using an average cost recovery rate based on information from a few countries.
- Allocation of rail costs and revenues: Costs were allocated to passenger and freight transport on the basis of axle-kilometres. Allocation of revenues to passenger and freight transport was based on questionnaire responses.

Methodological limitations in allocating costs and revenues for different countries meant that only total values for EUR 17 could be presented in the UIC study. The main results are summarised in Table 84.

Table 84. **Uncovered infrastructure costs and cost recovery rates for EUR 17 estimated by INFRAS/IWW**

Parameter	Result
Uncovered infrastructure costs: road	ECU 430 million
Average cost recovery rate	99.6%
Passenger transport	> 100%
Freight transport	82.5%
Uncovered infrastructure costs: rail	ECU 8.5 billion
Average cost recovery rate	55.6%
Passenger transport	67%
Freight transport	43%

Source: INFRAS/IWW (1995).

The main country specific results from the INFRAS/IWW study (see Table 85) serve as a database for the rough estimate of the long-run marginal costs in section C.5.

Table 85. **Infrastructure costs and revenues for EUR 17, based on INFRAS/IWW**

(million 1991 ECU)

	Road (Passenger and Freight)				Rail (Passenger and Freight)			
	Costs	Revenues	Difference	Revenues as % of costs	Costs	Revenues	Difference	Revenues as % of costs
Austria	3 712.5	2 613.0	–1 099.5	70.4	1 282.5	728.5	–554.1	56.8
Belgium	1 151.6	663.9	–597.7	48.1	600.2	350.5	–249.7	58.4
Denmark	1 337.6	2 466.5	1 128.9	184.4	170.8	89.7	–71.1	58.4
Finland	3 068.0	1 829.0	–1 239.0	59.6	283.1	45.5	–237.7	15.1
France	22 834.7	19 406.7	–3 428.0	85.0	4 265.2	2 604.3	–1 650.9	61.1
Germany	25 048.8	22 583.4	–2 485.4	90.1	4 724.2	2 007.8	–2 716.4	42.5
Greece	687.4	756.1	68.7	110.0	111.8	65.3	–46.5	58.4
Ireland	799.5	955.0	155.5	119.4	48.1	28.1	–20.0	58.4
Italy	20 649.3	22 287.8	1 838.3	107.9	2 438.5	1 424.1	–1 014.4	58.4
Luxembourg	284.4	148.5	–135.9	52.2	28.2	16.4	–11.7	58.4
Netherlands	4 142.0	4 919.5	777.5	118.9	522.3	305.0	217.3	58.4
Norway	2 351.1	1 498.0	–853.1	63.7	269.5	157.4	–112.1	58.4
Portugal	676.2	590.3	–85.9	87.3	133.1	77.7	–55.4	58.4
Spain	7 082.1	5 933.9	–1 148.3	83.8	1 718.0	1 003.3	–714.7	58.4
Sweden	2 947.3	4 057.4	1 110.4	137.7	5 216.0	690.0	–4 526.0	19.2
Switzerland	3 637.1	2 793.2	–843.9	76.8	793.9	582.7	–211.2	73.4
United Kingdom	13 141.6	19 750.0	8 808.4	150.3	2 131.8	1 245.0	–886.8	58.4
Total	113 551.1	113 122.0	–429.2	99.5	19 237.8	10 895.8	–8 542.1	55.8

Source: INFRAS/IWW (1995).

C.3.2. T&E Study (1993)

In a study on social costs of transport, T&E (1993) presented figures concerning costs and revenues for road transport in 11 countries. The main sources for the data were national rapporteurs. The main results can be summarised as follows (detailed results are presented in Table 86):

- All the countries studied, except Switzerland, show higher revenues than costs.
- For some countries costs are just barely covered.
- A breakdown of road network costs and revenues attributed to light and heavy vehicles shows an unequal distribution of the tax burden. Most of the countries analysed show uncovered infrastructure costs for heavy vehicles; on average, light vehicles pay much more than their fair share of infrastructure costs.

Table 86. **Financial costs of road infrastructure and revenues from road transport (excl. VAT), based on detailed results of T&E (1993)**

(millions, national currencies)

Country	Year	Revenues	Costs	Cost coverage
Austria	1987	29 755	28 101	106
Denmark	1990	19 397	6 470	300
France	1990[1]	134 100	97 100	138
Germany	1990	57 800	22 300	259
Italy	1989[2]	45 480 000	17 660 000	258
Netherlands	1990	11 364	5 888	193
Norway	1990	15 730	12 674	124
Spain	1990	767 900	564 000	136
Sweden	1990	30 480	13 625[3]	224
Switzerland	1989	4 642	4 802	97
United Kingdom	1991	13 825	5 661	244

1. Excluding private toll roads.
2. Refers to 1986.
3. Costs for local roads refer to 1987.

Source: T&E (1993).

C.4. SHORT-RUN MARGINAL COSTS

From a policy point of view, short-run marginal costs (SRMC) are of interest as they represent the lower bound for the infrastructure costs which should be covered by variable charges (*e.g.* through taxes on fuel, or on ticket sales for rail). It is important to distinguish between infrastructure with congestion problems and infrastructure with spare capacity. Efficient pricing implies that long-run marginal social costs (LRMC) – including future discounted capacity costs – will be charged for users of fully utilised or congested infrastructure. But when capacity is far from fully utilised and capacity costs are zero, only short-run marginal costs* should be charged.

C.4.1. Swiss/Austrian study (INFRAS/Herry/PROGNOS, 1996)

Estimates of short-run marginal costs were made in a joint study for the Swiss and Austrian Transport Ministries that compared the two countries' infrastructure cost accounting (INFRAS/Herry/PROGNOS, 1996). Based on a harmonised infrastructure cost accounting system, the following short-run marginal costs (operating and maintenance) for infrastructure use were estimated:

* Including renewal costs.

Table 87. **Capital and O + M costs for Austria and Switzerland developed by INFRAS/Herry/PROGNOS (1996)**
(million 1990 ECU)

	Capital Costs	O + M Costs	Total	Revenues	Cost Coverage (%)
Road					
Austria	1 243	1 088	2 331	2 398	103%
Switzerland	1 257	1 246	2 503	2 777	111%
Rail					
Austria	700	590	1 290	686	53%
Switzerland	289	333	662	492	74%

Source: INFRAS/Herry/PROGNOS (1996).

The following relative short-run marginal costs can be derived from the above figures when costs are allocated to freight and passenger transport (based on vehicle – and train-kilometres, respectively):

Table 88. **INFRAS/Herry/PROGNOS estimates of relative short-run marginal costs and cost coverage for road and rail in Austria and Switzerland**

1990	Austria	Switzerland	Average (not weighted)
Road			
O+M costs (million ECU):	1 088	1 246	–
million v-km freight	5 200	2 514	–
million v-km passenger	42 000	42 510	–
Relative O+M costs:			
passenger + freight transport (ECU/v-km)	0.023	0.028	0.026
passenger transport (ECU/1 000 p-km)	14	13	13.5
freight transport (ECU/1 000 t-km)	9	6	7.5
Cost coverage:			
passenger transport	105%	113%	109%
freight transport	95%	113%	104%
Railways			
O+M costs:	590	333	
million train-km freight	42	30	
million train-km passenger	75	135	
Relative O+M costs:			
passenger+freight transport (ECU/train-km)	5	2	3.5
passenger transport (ECU/1 000 p-km)	44	22	33
freight transport (ECU/1 000 t-km)	17	7	12
Cost coverage:			
passenger transport	57%	78%	68%
freight transport	51%	69%	60%

Source: INFRAS/Herry/PROGNOS (1996).

For rail, new (preliminary) figures are available which can serve for cross-checking purposes: according to internal estimates based on official figures of the Swiss Federal Railways (SBB), the short-run marginal costs of rail infrastructure are of the order of magnitude shown in Table 89.

The differences between the two estimates can be explained by variations in delimitation of variable and fixed costs and by the use of different rules to allocate variable costs to passenger and freight transport.

Table 89. **Short-run marginal costs of rail infrastructure for Switzerland**

	Passenger Transport	Freight Transport
Marginal costs of infrastructure (million 1995 ECU)	172	165
train-km (million km)	92.1	27.1
O+M costs:		
ECU/train-m	2	6
ECU/1 000 p-km or ECU/1 000 t-km (respectively)	14	20

Source: ECMT Task Force estimates.

C.4.2. Sweden (Hansson, 1993)

Using Hansson (1993), a study of traffic user charges in Swedish transport policy, the following estimates for short-run marginal costs can be derived:

Table 90. **Estimates of short-run marginal costs of infrastructure in Sweden, based on Hansson (1993)**

	ECU/1 000 p-km or t-km, 1991			
	Road		Rail	
	Passenger	Freight	Passenger	Freight
	2	27	11	24

Source: Hansson (1993).

C.4.3. Netherlands (Bleijenberg and Davidson, 1996)

Bleijenberg and Davidson (1996) estimate short-run marginal costs for the Netherlands for road transport only. The results are shown in Table 91.

Table 91. **Estimates of short-run marginal costs of road infrastructure in the Netherlands 1990-95, based on Bleijenberg and Davidson, 1996**

	Passenger	Freight (average for trucks + vans)
ECU/v-km	0.031	0.047
ECU/1 000 p-km or t-km	17	18

Source: Bleijenberg and Davidson (1996).

C.4.4. Synthesis

The available data on short-run marginal costs from Switzerland, Austria, Sweden and the Netherlands allow for a rough estimate of the order of magnitude of European averages, summarised in Table 92.

Table 92. **Estimate of short-run marginal costs of infrastructure use in Europe, based on five sources**

	ECU/1 000 p-km or t-km, ca. 1990-95			
	Road		Rail	
	Passenger	Freight	Passenger	Freight
Switzerland (INFRAS/HERRY/PROGNOS)	13	6	22	7
Switzerland (SBB/INFRAS)	–	–	14	20
Austria (INFRAS/HERRY/PROGNOS)	14	9	44	17
Sweden (Hansson)	2	27	11	24
Netherlands (Bleijenberg and Davidson)	17	18	–	–
EUR 17 (order of magnitude)	~12	~14	~20	~20

Source: ECMT Task Force estimates.

C.5. LONG-RUN MARGINAL COSTS

Long-run marginal costs of infrastructure use are of interest with regard to two arguments:

- From an efficiency point of view, long-run marginal costs (LRMC) (both capital and current costs) should be attributed to users of infrastructure with capacity problems, since theoretically the prospective costs of capacity expansion should be attributed to users. In practice, average historical costs can serve as a proxy for the theoretically more correct long-run marginal costs.
- From the point of view of fairness, long-run marginal costs should be attributed to infrastructure users so that all users pay the full costs they incur. In this context, average historical costs are both practically and theoretically adequate.

C.5.1. Swiss/Austrian study (INFRAS/Herry/PROGNOS, 1996)

Table 93. **Estimates of long-run marginal costs of infrastructure in Switzerland and Austria, based on INFRAS/Herry/PROGNOS (1996)**

	ECU/1 000 p-km or t-km, 1990			
	Road		Rail	
	Passenger	Freight	Passenger	Freight
Switzerland	25	23	30	27
Austria	26	38	58	62

Source: INFRAS/Herry/PROGNOS (1996).

C.5.2. INFRAS/IWW (1995)

Based on the data presented in Table 85, the following cost coefficients can be derived:

Table 94. **Estimated relative coefficients for average covered and uncovered costs, based on INFRAS/IWW (1995)**

	Relative costs of infrastructure use (ECU 1991)			
	Road		Rail	
	Passenger	Freight	Passenger	Freight
Total costs:				
ECU/1 000 p-km or t-km	20	46	36	38
ECU/v-km or train-km	0.04	0.131	4.4	12.4
Uncovered costs:				
ECU/1 000 p-km or t-km	–3.8*	8.1	12.4	23.1
ECU/v-km or train-km	–0.007	0.023	1.5	7.6

* The limited data available suggests there is a small over-coverage of costs in the case of passenger cars. This figure is applied for Europe as a whole elsewhere in the report although more complete information would be desirable.

Source: INFRAS/IWW (1995).

C.5.3. Netherlands (Bleijenberg and Davidson, 1996)

Table 95. **Estimates of long-run marginal costs of road infrastructure in the Netherlands 1990-95, based on Bleijenberg and Davidson, 1996**

	Passenger	Freight (average for trucks + vans)
ECU/v-km	0.051	0.076
ECU/1 000 p-km or t-km	28	31

Source: Bleijenberg and Davidson (1996).

C.5.4. Synthesis

The available data on long-run marginal costs from EUR 17, along with country specific data for Switzerland, Austria and the Netherlands, allow for a rough estimate of the order of magnitude of European averages.

Table 97 summarises estimates of marginal infrastructure costs. The figures are presented in terms of vehicle kilometres to avoid the complication of defining the mix of trucks and vans in the freight vehicle fleet and corresponding load factor. The cost calculations made elsewhere in the report and summarised in Annex D are based on these figures using an average load factor of 2.8 tonnes for current road freight, increasing to 4 tonnes in the future.

As discussed, short-run marginal costs are the appropriate basis for use charges – long-run marginal costs where there is congestion – and these marginal costs are compared with existing variable charges in Chapter 4, Policy Options. The share of SRMC in LRMC is used to determine the appropriate split in

Table 96. **Estimated long-run marginal costs of infrastructure in Europe, based on various sources**

	ECU/1 000 p-km or t-km, ca. 1990-95			
	Road		Rail	
	Passenger	Freight	Passenger	Freight
INFRAS/IWW	20	46[1]	36	38
Switzerland	25	23[2]	30	27
Austria	26	38[3]	58	62
Netherlands	28	31[4]	–	–
EUR17 (order of magnitude)	~25	~35	~40	~40

1. Vans included; total costs allocated to passenger and freight using the simplified methodology of the German cost calculation (equivalent factors of the AASHO road test, which in principle is relevant only for the allocation of capital and capacity costs). Average load factor 2.5 t.
2. Vans excluded; only capital costs are allocated, again using simplified methodology of German cost calculation (equivalent factors of AASHO road test).
3. Vans excluded; only capital costs allocated, using simplified methodology of German cost calculation (equivalent factors of the AASHO road test).
4. Vans included, average load factor 2.44 t.

Source: ECMT Task Force estimates.

Table 97. **Estimates of the share of short-run costs in Europe ca. 1990-95, based on Tables 92 and 96**

	Road ECU/v-km		Rail ECU/train km	
	Passenger	Freight	Passenger[1]	Freight[2]
Long-run marginal costs	0.045	0.10	4	12
Short-run marginal costs	0.022	0.04	2	6
Share of short-run costs (short/long-run costs)	~50%	~40%	50%	50%

1. Average load factor 100 passengers per train.
2. Average load factor 300 tonnes per train.

Source: ECMT Task Force estimates.

fixed and variable charges for infrastructure in the mix of instruments recommended in the policy options chapter. In Chapter 5, Economic Impact, the difference between current cost coverage figures and long-run marginal costs are the basis for calculating the impact of the charges in cost structures recommended.

Annex D

DATA ON ROAD TRANSPORT

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DATA ON ROAD TRANSPORT

This Annex presents a summary of the assumptions required and calculations made for a quantitative estimate of charges needed to internalise the external costs of road transport. The calculations for the other modes, being less complex, are included in Annex B.

The calculations presented here were made on the basis of the cost estimates derived in Annex B and Annex C and summarised in Chapter 3. Table D1 recapitulates the data on fleet characteristics and specific costs used in the report in regard to the current situation and expected future vehicle performance (see section 4.2.9). A spread-sheet was used to calculate the various parameters of the policy mix recommended, with the results summarised in Tables D2 to D6. The upper part of each table indicates the way the calculations were made, with the other 3 sections presenting results in terms of ECU per p/t-km, ECU per v-km and ECU per litre of fuel. Only the last table, D6, gives a direct indication of the recommendations made in the report as to fuel charges; care should be taken in interpreting the figures summarised in the other tables.

The last row in each table, showing use-charges in terms of ECU per litre of fuel, can not simply be taken as an indication of appropriate levels of fuel tax for internalisation, primarily because it is not feasible to levy different rates of tax on different kinds of vehicles for the same fuel. Standard levels of fuel charge, one for gasoline and one for diesel, would have to be set, with separate compensatory payments/charges for categories of vehicles that were under- or overcharged (see Section 4.2.10 in the Policy Options chapter).

DATA SOURCES

The data summarised in Table D1 are from the following sources.

Vehicles, traffic, fuel and emissions characteristics:

Load

- Passenger cars: European average (17 countries (EU plus Norway and Switzerland); INFRAS/IWW, 1995) 1.8 persons per vehicle.
- Vans and trucks: INFRAS/IWW cites a European average of 2.8 tonnes. The same average is used here. For vans an average load of 0.2 tonne is presumed, corresponding with the Dutch average (Janse and Roos, 1994) and the results of a study by INFRAS for the Zürich metropolitan area (see INFRAS/IWW, 1995). For trucks (>3.5 tonnes) the average load is set at 6 tonnes. The assumption when considering future load factors as a basis for policy making is 8 tonnes for trucks, corresponding with the trend towards higher loads, and resulting in an average for vans and trucks of 4 tonnes.

Fuel

- The European Commission's Auto-Oil Programme has estimated the average fuel consumption of the current fleet and the expected fuel consumption of new vehicles sold in 2000.

Table D1. **Input Data**

	Passenger car			Freight transport		
	Gasoline	Diesel	LPG	Van	Truck	Weighted average
Data on current vehicles, traffic, fuel, emissions						
Load (person, tonne)	1.8	1.8	1.8	0.2	6	3
Fuel (l/v-km)	0.085	0.07	0.105	0.10	0.35	0.20
CO_2 (kg/l)	2.34	2.62	1.62	2.62	2.62	2.62
NO_x +VOC (g/v-km)	2.60	0.90	1.60	1.40	18	8.9
Partic. (mg/v-km city)	3.40	250	1.70	290	1 750	953
Annual mileage	13 500	28 000	29 000	22 000	75 000	32 400
Urban mileage	32%	23%	23%	70%	23%	49%
Deaths/billion v-km	24	24	24	24	24	24
Injuries/billion v-km	120	120	120	120	120	120
Anticipated changes in vehicles, traffic, fuel, emissions						
Load (person, tonne)	1.8	1.8	1.8	0.2	8	4
Fuel (l/v-km)	0.08	0.065	0.10	0.10	0.30	0.20
CO_2 (kg/l)	2.34	2.62	1.62	2.62	2.62	2.62
NO_x +VOC (g/v-km)	0.35	0.50	0.35	0.8	8	4.1
Partic. (mg/v-km city)	3	70	1	90	250	163
Annual mileage	13 500	28 000	29 000	22 000	75 000	32 400
Urban mileage	32%	23%	23%	70%	23%	49%
Deaths/billion v-km	11	11	11	11	11	11
Injuries/billion v-km	56	56	56	56	56	56
Shadow prices						
Roads (ECU/v-km)	0.045	0.045	0.045	0.061	0.150	0.101
Short term marginal costs/total infrastructure costs	50%	50%	50%	50%	30%	41%
Deaths (million ECU/death)	1.5	1.5	1.5	1.5	1.5	1.5
Injuries (million ECU)	0.2	0.2	0.2	0.2	0.2	0.2
CO_2 (ECU/kg)	0.05	0.05	0.05	0.05	0.05	0.05
NO_x + VOC average (ECU/kg)	5	5	5	5	5	5
rural	4	4	4	4	4	4
urban	8	8	8	8	8	8
Particulates (ECU/kg)						
rural	–	–	–	–	–	–
urban	70	70	70	70	70	70
Noise average (ECU/v-km)	0.005	0.005	0.005	0.005	0.045	0.023
rural	0.0025	0.0025	0.0025	0.0025	0.0225	0.012
urban	0.0125	0.0125	0.0125	0.0125	0.1125	0.058

Sources: See below.

CO_2

– Fuel and technology based emissions factors.

NO_x + VOC

– The European Commission's Auto-Oil Programme has estimated average emissions of NO_x and VOC combined, for the current fleet and for new vehicles sold in 2000 in the context of development of EU emission standards.

Particulates

– As for NO_x + VOC.

Mileage

– Dutch data are taken for the average mileage driven of each vehicle type and the percentage driven in urban areas (various Dutch Central Bureau of Statistics publications).

Accident rates

– The average number of fatalities in Europe is estimated at 24 per billion v-km in 1991 (cars, buses, vans and trucks; ECMT Accident Statistics and INFRAS/IWW, 1995). Accident rates are falling rapidly, however, and any internalisation policy needs to take account of this development. According to ECMT statistics, the number of road transport fatalities per billion v-km fell by an average of 5% per year over 1970-94. Current estimates (1991) are based on an average of 24 fatalities per billion v-km. For the purposes of this report it is assumed that the accident rate will continue to decline at the same rate for another 15 years, bringing the number of fatalities per billion v-km down to less than half of the current level. This corresponds roughly with current accident rates in the best performing European countries. The calculations anticipating future developments thus are based on ten fatalities per billion v-km.

– The rate of serious injuries estimated at 120 per billion vehicle kilometre in 1991 (cars, buses, vans and trucks; ECMT Accident Statistics and Transport Statistics Great Britain 1994). The same decline in this rate is assumed as for fatalities, above.

– The accident rate is assumed to be the same for all vehicle types. No reliable international data are available to set differentiated rates and the scarce information available suggests that the differences in accident rates between vehicle types are small.

Shadow prices:

Roads

– The short and long term marginal costs for cars and trucks are based on an overview of European data presented in Annex C (see final table in Annex C).

– It is assumed that infrastructure costs for vans are 1.35 times as high as for cars (see Dikmans *et al.*, 1996) and that the short term marginal costs are half of the long term costs, as for cars.

Deaths and injuries

– Details of the estimated shadow prices per fatality and severely injured person are given in Annex B – Details of the estimation of external costs.

CO_2, NO_x + VOC

– See Annex B – Details of the estimation of external costs.

Particulates

– This shadow price is taken from Dings *et al.* (1996) and based on the marginal abatement cost of achieving EU air quality standards.

Noise

– See Annex B – Details of the estimation of external costs.

– The shadow price is differentiated between rural and urban areas based on the assumption by Kageson (1993) that the noise nuisance in rural areas is half the average.

For these results it is assumed that half of anticipated external accident costs are internalised via improved vehicle insurance, half through fuel charges shown in the table. Half of total infrastructure costs allocated to passenger cars are incorporated in the fuel charge (for freight the average figure is

Table D2. **Average use-charges corresponding to current average levels of externality (excluding congestion)**

	Passenger car			Freight transport		
	Gasoline	Diesel	LPG	Van	Truck	Weighted average
Percentage of total covered by use-charge (as against fixed charge)						
Infrastructure	50	50	50	50	30	41
Accidents	100	100	100	100	100	100
CO_2	100	100	100	100	100	100
NO_x + VOC	100	100	100	100	100	100
Particulates	100	100	100	100	100	100
Noise	100	100	100	100	100	100
Use-charges	(ECU/1 000 p-km)			(ECU/1 000 t-km)		
Infrastructure	13	13	13	153	7	15
Accidents	33	33	33	300	10	21
CO_2	6	5	5	66	8	10
NO_x + VOC	7	3	4	35	15	16
Particulates	0	2	0	71	5	7
Noise	3	3	3	25	8	8
Total	61	58	58	649	52	77
Use-charges (ECU/v-km)						
Infrastructure	0.023	0.023	0.023	0.031	0.045	0.041
Accidents	0.060	0.060	0.060	0.060	0.060	0.060
CO_2	0.010	0.009	0.009	0.013	0.046	0.028
NO_x + VOC	0.013	0.005	0.008	0.007	0.090	0.045
Particulates	0.000	0.004	0.000	0.014	0.028	0.021
Noise	0.005	0.005	0.005	0.005	0.045	0.023
Total	0.111	0.105	0.104	0.130	0.314	0.218
Use-charges (ECU/litre of fuel)						
Infrastructure	0.26	0.32	0.21	0.31	0.13	0.19
Accidents	0.71	0.86	0.57	0.60	0.17	0.28
CO_2	0.12	0.13	0.08	0.13	0.13	0.13
NO_x + VOC	0.15	0.06	0.08	0.07	0.26	0.21
Particulates	0.00	0.06	0.00	0.14	0.08	0.15
Noise	0.06	0.07	0.05	0.05	0.13	0.11
Total	1.30	1.50	0.99	1.30	0.90	1.02

Note: Rounding accounts for apparent inconsistencies in totals.
Source: ECMT Task Force estimates.

41%) the rest is covered by fixed charges. Note that it would be impractical to charge different rates of tax on diesel, as the table implies: the fuel charge for all diesel vehicles could instead be based on the weighted average (ECU 0.59/litre), corrected through a surcharge on the fixed charge (vehicle tax) for diesel cars and a rebate for trucks.

Table D3. **Average use-charges corresponding to expected average levels of externality (excluding congestion)**

	Passenger car			Freight transport		
	Gasoline	Diesel	LPG	Van	Truck	Weighted average
Percentage of total covered by use-charge (as against fixed charge)						
Infrastructure	50	50	50	50	30	41
Accidents	100	100	100	100	100	100
CO_2	100	100	100	100	100	100
NO_x + VOC	100	100	100	100	100	100
Particulates	100	100	100	100	100	100
Noise	100	100	100	100	100	100
Use-charges	(ECU/1 000 p-km)			(ECU/1 000 t-km)		
Infrastructure	13	13	13	153	6	11
Accidents	15	15	15	138	3	7
CO_2	5	5	5	66	5	7
NO_x + VOC	1	1	1	20	5	5
Particulates	0	1	0	22	1	1
Noise	3	3	3	25	6	6
Total	37	37	36	424	25	38
Use-charges (ECU/v-km)						
Infrastructure	0.023	0.023	0.023	0.031	0.045	0.041
Accidents	0.028	0.028	0.028	0.028	0.028	0.028
CO_2	0.009	0.009	0.008	0.013	0.039	0.025
NO_x + VOC	0.002	0.003	0.002	0.004	0.040	0.020
Particulates	0.000	0.001	0.000	0.004	0.004	0.004
Noise	0.005	0.005	0.005	0.005	0.045	0.023
Total	0.066	0.067	0.065	0.085	0.201	0.142
Use-charges (ECU/litre of fuel)						
Infrastructure	0.28	0.35	0.22	0.31	0.15	0.22
Accidents	0.35	0.43	0.28	0.28	0.09	0.15
CO_2	0.12	0.13	0.08	0.13	0.13	0.13
NO_x + VOC	0.02	0.04	0.02	0.04	0.13	0.11
Particulates	0.00	0.02	0.00	0.04	0.01	0.02
Noise	0.06	0.08	0.05	0.05	0.15	0.12
Total	0.83	1.04	0.65	0.85	0.67	0.74

Note: Rounding accounts for apparent inconsistencies in totals.
Source: ECMT Task Force estimates.

Table D4. **Expected use-charges for rural areas (excluding congestion)**

	Passenger car			Freight transport		
	Gasoline	Diesel	LPG	Van	Truck	Weighted average
Percentage of total covered by use-charge (as against fixed charge)						
Infrastructure	50	50	50	50	30	41
Accidents	100	100	100	100	100	100
CO_2	100	100	100	100	100	100
NO_x + VOC	100	100	100	100	100	100
Particulates	–	–	–	–	–	–
Noise	100	100	100	100	100	100
Use-charges	(ECU/1 000 p-km)			(ECU/1 000 t-km)		
Infrastructure	13	13	13	153	6	11
Accidents	15	15	15	138	3	7
CO_2	5	5	5	66	5	7
NO_x + VOC	1	1	1	16	4	4
Particulates	0	0	0	0	0	0
Noise	1	1	1	12	3	3
Total	35	35	35	385	21	33
Use-charges (ECU/v-km)						
Infrastructure	0.023	0.023	0.023	0.031	0.045	0.041
Accidents	0.028	0.028	0.028	0.028	0.028	0.028
CO_2	0.009	0.009	0.008	0.013	0.039	0.025
NO_x + VOC	0.001	0.002	0.001	0.003	0.032	0.016
Particulates	0.000	0.000	0.000	0.000	0.000	0.000
Noise	0.003	0.003	0.003	0.003	0.023	0.012
Total	0.063	0.063	0.062	0.077	0.167	0.122
Use-charges (ECU/litre of fuel)						
Infrastructure	0.28	0.35	0.22	0.31	0.15	0.22
Accidents	0.35	0.43	0.28	0.28	0.09	0.15
CO_2	0.12	0.13	0.08	0.13	0.13	0.13
NO_x + VOC	0.02	0.03	0.01	0.03	0.11	0.09
Particulates	0.00	0.00	0.00	0.00	0.00	0.00
Noise	0.03	0.04	0.02	0.02	0.08	0.06
Total	0.79	0.97	0.62	0.77	0.56	0.64

Note: Rounding accounts for apparent inconsistencies in totals.
Source: ECMT Task Force estimates.

Table D5. **Expected use-charges in urban areas (including congestion)**

	Passenger car			Freight transport		
	Gasoline	Diesel	LPG	Van	Truck	Weighted average
Percentage of total covered by use-charge (as against fixed charge)						
Infrastructure	100	100	100	100	100	100
Accidents	100	100	100	100	100	100
CO_2	100	100	100	100	100	100
NO_x + VOC	100	100	100	100	100	100
Particulates	100	100	100	100	100	100
Noise	100	100	100	100	100	100
Use-charges	(ECU/1 000 p-km)			(ECU/1 000 t-km)		
Infrastructure	25	25	25	305	19	27
Accidents	15	15	15	138	3	7
CO_2	5	5	5	66	5	7
NO_x + VOC	2	2	2	32	8	9
Particulates	0	3	0	32	2	3
Noise	7	7	7	63	14	15
Total	54	57	53	635	51	68
Use-charges (ECU/v-km)						
Infrastructure	0.045	0.045	0.045	0.061	0.150	0.101
Accidents	0.028	0.028	0.028	0.028	0.028	0.028
CO_2	0.009	0.009	0.008	0.013	0.039	0.025
NO_x + VOC	0.003	0.004	0.003	0.006	0.064	0.033
Particulates	0.000	0.005	0.000	0.006	0.018	0.011
Noise	0.013	0.013	0.013	0.013	0.113	0.058
Total	0.098	0.103	0.096	0.127	0.411	0.256
Use-charges (ECU/litre of fuel)						
Infrastructure	0.56	0.69	0.45	0.61	0.50	0.53
Accidents	0.35	0.43	0.28	0.28	0.09	0.15
CO_2	0.12	0.13	0.08	0.13	0.13	0.13
NO_x + VOC	0.03	0.06	0.03	0.06	0.21	0.17
Particulates	0.00	0.08	0.00	0.06	0.06	0.06
Noise	0.16	0.19	0.13	0.13	0.38	0.30
Total	1.22	1.58	0.96	1.27	1.37	1.34

Note: Rounding accounts for apparent inconsistencies in totals.
Source: ECMT Task Force estimates.

Table D6. **Expected fuel charges in rural areas (no congestion)**

	Passenger car			Freight transport		
	Gasoline	Diesel	LPG	Van	Truck	Weighted average
Percentage of total covered by fuel charge						
Infrastructure	50	50	50	50	30	41
Accidents	50	50	50	50	50	50
CO_2	100	100	100	100	100	100
NO_x + VOC	100	100	100	100	100	100
Particulates	–	–	–	–	–	–
Noise	100	100	100	100	100	100
Use-charges	(ECU/1 000 p-km)			(ECU/1 000 t-km)		
Infrastructure	13	13	13	153	6	11
Accidents	8	8	8	69	2	4
CO_2	5	5	5	66	5	7
NO_x + VOC	1	1	1	16	4	4
Particulates	0	0	0	0	0	0
Noise	1	1	1	12	3	3
Total	28	27	27	316	19	29
Use-charges (ECU/v-km)						
Infrastructure	0.023	0.023	0.023	0.031	0.045	0.041
Accidents	0.014	0.014	0.014	0.014	0.014	0.014
CO_2	0.009	0.009	0.008	0.013	0.039	0.025
NO_x + VOC	0.001	0.002	0.001	0.003	0.032	0.016
Particulates	0.000	0.000	0.000	0.000	0.000	0.000
Noise	0.003	0.003	0.003	0.003	0.023	0.012
Total	0.050	0.049	0.048	0.063	0.153	0.108
Use-charges (ECU/litre of fuel)						
Infrastructure	0.28	0.35	0.22	0.31	0.15	0.22
Accidents	0.17	0.21	0.14	0.14	0.05	0.07
CO_2	0.12	0.13	0.08	0.13	0.13	0.13
NO_x + VOC	0.02	0.03	0.01	0.03	0.11	0.09
Particulates	0.00	0.00	0.00	0.00	0.00	0.00
Noise	0.03	0.04	0.02	0.02	0.08	0.06
Total	0.62	0.76	0.48	0.63	0.51	0.57

Note: Rounding accounts for apparent inconsistencies in totals.
Source: ECMT Task Force estimates.

SUMMARY OF DISCUSSIONS ON INTERNALISATION OF THE SOCIAL COSTS OF TRANSPORT AT THE ANNUAL ECMT HEARING OF INTERNATIONAL ORGANISATIONS OF 26 MARCH 1996

INTRODUCTION

The 1996 Annual ECMT Hearing of International Organisations was given over entirely to the issue of internalising transport's social costs, following the interest shown in the issue at previous hearings and given its importance in public debate on transport. Eighteen organisations participated in the hearing, representing the full range of transport interests. Several of them are preparing detailed papers on issues relating to social costs. The following organisations were present at the hearing, and the International Federation of Pedestrians provided written material.

Central Commission for the Navigation of the Rhine
European Civil Aviation Conference
European Cyclists' Federation (ECF)
European Federation for Transport and Environment (T&E)
European Transport Safety Council (ETSC)
International Federation of Trade Unions of Transport Workers
International Federation of Transport Executives
International Organisation of Motor Vehicle Manufacturers (OICA)
International Road Federation (IRF)
International Road Transport Union (IRU)
International Touring Alliance/International Automobile Federation (FIA)
International Transport Workers' Federation (ITF)
International Union for Inland Navigation
International Union of Combined Road-Rail Transport Companies (UIRR)
International Union of Public Transport (UITP)
International Union of Railways (UIC)
Permanent International Association of Road Congresses (PIARC)
Union of Industrial and Employers' Confederations of Europe (UNICE)

Delegates to the hearing were asked to give their views on two documents presented by the ECMT Task Force on the Social Costs of Transport and included in the present report: a glossary of terms and definitions and a paper summarising estimates of the magnitude of externalities. They were also asked to comment on the policy proposals emerging from the work of the Task Force. Delegates were asked particularly for their views on the following points:

1. The existence of external effects.
2. The treatment of external benefits.
3. The relationships between internalisation policies, infrastructure costs and public service obligations.
4. The validity of the order of magnitude estimates of externalities summarised in the Secretariat paper.
5. The selection of appropriate instruments for internalisation.
6. Measures to deal with congestion.

The three papers presented were generally welcomed by all delegates as contributing to clarification of the political debate on the social costs of transport and helping establish a more objective framework for policy discussions.

The paragraphs that follow present the views expressed at the hearing, concentrating on issues of most relevance to the report in preparation for ECMT Ministers. Some comments have been added with a view to drawing conclusions from the debate, but judgements on individual points made have been avoided in this summary. A draft of the paper was circulated following the hearing and the resulting written comments are incorporated in this final version.

TRANSPORT POLICY

A number of delegates, particularly those representing industry, welcomed efforts towards establishing an objective framework for examining social costs. This, in their view, equates largely with designing a comprehensive transport policy, for which they expressed a need. For some, internalisation should be the basis for future transport policy.

Delegates agreed that it is important to consider internalisation policies in conjunction with efforts to improve the competitiveness of transport services and the economy as a whole, and in the context of ensuring a level playing field with regard to financing and fiscal policies for competition between transport modes.

It was noted that internalisation of transport externalities will require not only price adjustment but also regulatory measures. Reducing accidents, congestion and pollution should also be addressed in the wider policy context, and some participants emphasised support for public transport.

EXISTENCE OF EXTERNAL COSTS AND BENEFITS

All participants accepted the existence of external costs and the principal that transport users should bear the responsibility for reducing environmental and other externalities. External benefits were discussed and a consensus with few exceptions emerged that, providing the large social benefits derived from transport are accounted for in infrastructure project planning and in public service obligations, they can be regarded as otherwise irrelevant to the management of infrastructure use (FIA disagreed).

THE DYNAMIC ASPECT OF EXTERNALITIES

The magnitude and extent of externalities changes over time with technological innovation and traffic trends. OICA's projections suggest that within 20 years air pollution from passenger cars will decrease to levels that do not warrant intervention, and a number of other organisations believe that regulation driven technological advances will result in acceptable air quality in the medium term. Most other forecasts suggest that growth in traffic will outweigh technological gains and that emissions will continue to represent a significant externality despite technological progress. In either case, the dynamic aspect implies that periodic review should be part of internalisation policies and that charges should be calculated in relation to critical pollution loads.

REGULATORY *VERSUS* ECONOMIC INSTRUMENTS

A number of industry representatives expressed a preference for command and control regulation over economic instruments for the implementation of environmental protection policies. The success of existing regulations in reducing emissions of air pollutants from vehicles was cited in support of this view. The question of whether economic instruments might provide a less costly and more efficient alternative or complement to future stricter regulations was, however, only indirectly addressed. T&E argued that regulations alone would be insufficient in the face of traffic growth and that the hidden costs of regulations are high.

ETSC highlighted the importance of ensuring that measures aimed at internalisation affect individual decisions as directly as possible. For this reason fuel taxes tend to be more efficient than annual road fees, and insurance based on individual risk factors is more efficient than taxes for internalising accident costs. ETSC pointed out, however, that economic instruments that can directly affect individual decisions sufficiently are not yet available in many instances, and in these cases regulations will be more effective.

The IRU sees no polarisation between regulations and economic instruments but believes that greater differentiation in charges related to externalities is needed. In particular, operators of relatively clean vehicles should not be asked to pay the same charges as those for more polluting vehicles.

ENFORCEMENT

UIC pointed out the importance of enforcing existing regulations on safety, vehicle performance, speed limits and driving hours as perhaps the greatest contribution to reducing externalities. OICA underlined the importance of regular vehicle maintenance and inspection at appropriate intervals.

EXISTING CHARGES FOR ROAD TRANSPORT

OICA presented the results of studies that suggest that the overall sum of current taxes and charges on road transport yields revenues greater than the estimated costs of related externalities; and with expected improvements in pollution control over the next 15 years the difference will increase. This would imply that internalisation measures should aim primarily at restructuring systems of charges and taxation. The IRU commented that in these circumstances it will be difficult to ask road users to pay higher prices. Several industry representatives identified increased investment in road infrastructure as the priority, rather than better demand management through internalisation.

FUEL CHARGES

UITP suggested that increasing fuel taxes is unlikely, on its own, to have a significant effect on traffic as road users are accustomed to frequent increases. This implies distance and time based charges will be more effective, especially at tackling congestion.

PUBLIC SERVICE OBLIGATIONS

T&E suggested that the fact that 40 per cent of EU citizens do not have access to private cars implies governments have an obligation to provide access to public transport, whether rail or various forms of road transport.

ADDITIONAL MEASURES

T&E suggested that incentives for scrapping polluting vehicles and incentives for better driver behaviour were important to complement regulations and the economic instruments discussed in the papers presented.

CONGESTION

Some of the organisations represented do not consider congestion to be an externality. The IRU considers it rather a question of traffic management. UITP argued that regardless of whether congestion should be defined as an externality, measures to manage peak demand are urgent since the costs of congestion, according to some studies (notably the EU green paper, ‘‘Towards Fair and Efficient Pricing of Transport’’), are higher than other externalities and exacerbate air pollution, noise, accidents and barrier effects in urban areas. UITP would prefer to see demand managed through pricing rather than rationing but also advocates wider use of parking restrictions and bus lanes.

OICA rejected proposals for charging for congestion, claiming it is mainly a responsibility of local authorities that have failed to invest in sufficient infrastructure. It conceded, however, that charging could make a useful short term contribution to traffic management where no other solution exists. OICA pointed out the difficulties in introducing urban road pricing systems. Both OICA and UNICE supported infrastructure investment as the main response to congestion.

PIARC has studied the likely impact of congestion pricing and reports positive results. UITP pointed out that congestion charging can not be considered double charging as it is designed to reduce congestion not complement congestion. The overall result should be a reduction in costs to road users if congestion charging is successful.

SUPPRESSION OF TRANSPORT MODES

ECF argued that the inadvertent suppression of non-motorised transport modes represents a significant externality overlooked in most analysis. Bicycling has declined in some places due in part to dangerous and polluted road conditions that rule out cycling for journeys where it would otherwise be the preferred and most efficient option.

INTERMODAL COMPETITION

Despite a widespread impression that internalisation policies will lead to some shifts from road to rail transport, a number of participants cited studies suggesting internalisation would result in steeper increases in costs for rail services than for road users. OICA and UNICE pointed out that major modal shifts should not be expected since for the majority of cases no viable alternative to road transport exists. Even the doubling of road tolls in sensitive corridors such as Alpine valleys would not result in a shift to rail without investment in the rail system, as combined transport systems are saturated. UNICE pointed to a combination of underinvestment and poor interoperability as the main constraint on railway competitiveness.

ACCIDENTS

ETSC pointed out that most studies significantly underestimate accident externalities because as many as 40 per cent of serious injury accidents, and a much higher proportion of accidents that do not involve serious injuries, are not reported to the police agencies that normally compile the statistics.

ETSC warned of a danger that using motorway tolls as an internalisation instrument would transfer traffic to roads with much poorer safety characteristics. For this reason it advocates fuel charges rather than tolls for internalisation. Clearly internalisation measures will have to be designed carefully and in concert with other transport policy objectives.

VALUATION METHODOLOGIES

Though ECMT work on valuation methodologies was not presented to the hearing, a number of comments were made on the subject. Several participants noted that studies based on willingness to pay methodologies tend to overestimate externalities in certain cases. Others suggested that the approach is likely to underestimate environmental damage, in particular related to the greenhouse effect.

Cost-benefit analysis is based on similar evaluation techniques. The ITF stressed that the choice of a conservative approach to introducing internalisation instruments in transport pricing (i.e. adopting them only gradually) must not be allowed to undermine the place of estimates of external costs and benefits in project appraisal and planning decisions.

IMPACT OF INTERNALISATION MEASURES AND ISSUES OF FAIRNESS

UIRR asserted that aspects of the existing structure of taxation and charges in transport reflect the influence of lobbies more than logic. It called for a reworking of taxation systems to reinforce, rather than undermine, market forces.

The IRU declared that it would be prepared in principle to agree to internalisation of road infrastructure costs if every user and every transport mode were subject to the same policy. The IRF is ready to accept infrastructure and congestion pricing on two conditions: that the income generated is used to benefit road users (including through improved environmental protection measures); and that other utilities (rail, water, electricity, etc.) are subject to infrastructure charges according to the same principles. More generally a consensus emerged that internalisation measures could be acceptable providing satisfactory guarantees are given that this will not result in a significant increase in tax burdens on transport service users and providers or in the economy as a whole. FIA believes governments will face a major credibility problem in attempting to convince the public that internalisation is not simply an excuse to increase taxation.

A number of organisations stressed the importance of ensuring that internalisation policies do not have unacceptable impacts on employment and productivity. OICA expressed fears of a major effect on GDP and inflation and the IRU explained that even small increases in charges would have a major impact on the road haulage industry because of the tight profit margins which characterise the industry. T&E believes internalisation measures will have little or no effect on overall competitiveness, as increased charges at some times and locations will be compensated by a general increase in road haulage efficiency.

These concerns need to be addressed in developing policies aimed at internalising the social costs of transport. To avoid a political backlash, fears must be allayed through commitments to ensure that: *i)* internalisation is primarily based on shifting the structure of charges rather than increasing overall levels of taxation, and *ii)* particular subsectors are not unfairly penalised. Overall, greater transparency in charging for the use of transport infrastructure is needed and governments must make greater efforts to inform users of the rationale for existing charges.

NEXT STEPS

There was some division on what steps should be taken towards internalisation of transport's social costs. The position of OICA and UNICE is that no action needs to be taken, though OICA can accept internalisation measures if they are part of a coherent transport policy and if they do not result in net additional taxation. UNICE believes that the competitiveness of European business must be improved through creation of the conditions for increased competition in transport services before internalisation is addressed. All other organisations represented appear to believe that more differentiated and variable systems of charging are required and that acceptable internalisation policies can be developed given the safeguards described in the previous section. Many organisations, including UIRR, ITF and T&E, believe that even though the estimates of externalities are imprecise, they provide a sufficient basis for taking a first step towards internalisation, and that the need to do this is clear.

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GLOSSARY

(Italicised terms are also glossed separately.)

Accident insurance — Voluntary or mandated insurance against the risks of accidents (property and health). The premiums partly internalise external costs.

Average costs — Total costs in a period, divided by the quantity (output) produced/consumed in that period. Long term average costs include a share of fixed costs (*e.g.* costs associated with expansion of infrastructure).

Barrier effect — Separation of adjacent areas by road or rail infrastructure, causing negative impact on human beings (*e.g.* restricted access to shopping or recreation) or on flora and fauna (*e.g.* constriction of habitat). Also called *separation* or *severance effect*.

Club good — A good that can be consumed only by a limited number of users (club members), as opposed to a *public good* (consumable by everyone) or one from whose consumption everyone can easily be excluded. Road use is a club good.

Consumer surplus — Measure of the net benefits from consuming a certain quantity of a good/service; also a measure of how much a consumer would be willing to pay for the consumption of a good, over and above the market price.

Contingent valuation method — *Valuation* technique which asks people directly how much they are willing to pay/to accept for improving/deteriorating environmental quality. Based on the *stated preference* approach, it is the only method that allows the estimation of *existence value*.

Cost-effectiveness — Minimising the costs of achieving a given (*e.g.* environmental) objective/target; a "*second-best*" efficiency criterion, often used when a full cost-benefit analysis is not feasible.

Defensive expenditures — *Valuation* technique wherein a value for environmental quality is inferred from people's (voluntary) expenditures aimed at improving their situation.

Dis-benefit / Dis-utility — Cost to an individual of an external effect (private dis-benefit); or the aggregate of such costs in an economy (social dis-benefit).

Earmarking — Tying revenues received to a specific use (*e.g.* financing road network expansion), also known as *hypothecation*.

Efficiency — Generally used here to mean efficient allocation of scarce resources, in the broad sense. At the margin, resources should be used by the individual who is willing to pay the most for them (*i.e.* marginal social cost equals marginal social benefit).

Elasticity — Proportional change in demand in response to a price increase or decrease (price elasticity); or reaction in total demand after an increase/decrease in income (income elasticity).

Environmental effectiveness	Environmental benefit that a given policy generates, considered in isolation from the economic costs that may result from implementing the policy.
Equity	Criterion that may entail modifying a political decision so as to achieve a particular distribution of incomes in the economy through, for instance, subsidies to public transport for low income groups or to achieve regional development objectives.
Existence value	Economic value which people attribute to something purely for its existence (no consumption is foreseen); can only be estimated via the *contingent valuation* method.
Externality (external cost)	Economic cost not normally taken into account in markets or in decisions by market players.
(Full) fuel cycle	Complete fuel cycle; the discovery, depletion (mining), processing, transport and use of an energy resource.
Hedonic pricing	*Valuation* technique which infers a value for environmental quality from rent or property price differentials.
Human cost	Value attributed to human life in excess of the average economic output produced by an individual.
Hypothecation	Tying revenues received to a specific use (*e.g.* financing road network expansion), also known as *earmarking*.
Internalisation	Incorporation of an *externality* into the market decision making process through pricing or regulatory intervention. In the narrow sense, internalisation is achieved by charging polluters (for example) with the damage costs of the pollution generated by them, in accordance with the *polluter pays principle*.
Marginal costs	Costs related to a small increment in demand (*e.g.* an extra vehicle-kilometre driven). Long term marginal costs include the capacity expansion needed to service increased traffic demand.
Opportunity costs	Costs which arise when a particular project restricts alternative uses of a scarce resource (*e.g.* land use for infrastructure precludes alternative uses such as recreation). The size of an opportunity cost is the value of a resource in its most productive alternative use.
Pareto efficiency (=P. optimality)	State of equilibrium where no one's welfare can be further improved without decreasing someone else's (after V.F.D. Pareto, 1848-1923).
Pecuniary externality	External effect that is actively and voluntarily processed through markets and thus need not be addressed by government action.
Polluter pays principle	Political/economic principle stating that polluters should pay the full environmental costs of an activity. Some experts extend the principle to state that users that should pay the full social costs of an activity, but this is not universally accepted.
Prevention cost approach	Technique for estimating *externalities* whereby the cost of preventing damage is used as a proxy for the cost of the damage itself for society.
Productivity	Output divided by the inputs needed to produce that output, in value terms.
Public good	Good/service for which property rights are not defined. Without government intervention, environmental goods (*e.g.* clean air) are usually treated as public.

Progressivity/Regressivity	Impact of government policy on income distribution; progressive/regressive effects occur when poor households spend a smaller/larger proportion of their income for a particular measure (*e.g.* a tax) than do richer households.
Relative price	Price of a good/service relative to one or several other goods (*e.g.* transport prices relative to a "basket" of all other goods/services produced in the economy).
Revealed preference	*Valuation* technique wherein consumers' choices are revealed in the marketplace (*e.g.* by the purchase of a good).
Risk approach	Technique for estimating *externalities* whereby external costs are inferred from premiums for risk factors (*e.g.* the cost of insurance, or of risk diversification).
Second-best (option, policy)	One that does not correspond to the theoretically optimum solution but is the best of the available non-optimal policies/measures.
Separation or severance effect	Separation of adjacent areas by road or rail infrastructure, causing negative impact on human beings (*e.g.* restricted access to shopping or recreation) or on flora and fauna (*e.g.* constriction of habitat). Also called *barrier effect*.
Shadow price	The marginal opportunity cost of the use of a resource (*i.e.* the loss of benefits if this resource cannot be used for the next best purpose).
Social costs	The sum total of internal (private) and *external* costs.
Social cost-benefit analysis	Systematic estimation of all costs and benefits of a project that are relevant to society. Includes both *technological externalities* and *pecuniary externalities,* as long as the latter are not merely redistribution of income.
Stated preference	*Valuation* technique wherein monetary estimates are derived from hypothetical statements by individuals about their preferences, typically relying on a questionnaire approach; an example is the *contingent valuation method.*
Tax	A government-imposed levy whose size may or may not be related to the pre-tax price of a good/service.
Technological externality	External effect that is not actively or voluntarily processed through markets, resulting in economic inefficiency; occurs when some firm or individual uses an asset without paying for it (or when one productive activity changes the amount of output or welfare which can be produced by some other activity using a given amount of resources). Negative technological externalities reduce the amount of output or welfare an economy can produce with a given allocation of inputs.
Toll	Special charge levied at a particular point where vehicles pass (tunnel, motorway, etc.).
Traffic volume	Measure of transport activity, expressed in, for example, *vehicle-kilometres* or tonne-kilometres.
Transport mode	Category of means of transport (road, rail, aviation, shipping, etc.).
Unit costs	Costs per unit of a good/service or per unit *traffic volume*.

Use-charge Any charge related directly to actual use of transport; a variable charge (as opposed to, say, vehicle and sales taxes, which are fixed charges). The term is preferred here because "user charge", which is frequently employed in the literature in this sense, can be misinterpreted out of context.

Utility Benefit received by an individual through consumption of a good/service or through the existence of that good/service (private utility); or the aggregate of private utilities in an economy (social utility).

Valuation Process of estimating the economic value of a certain quantity of a good/service; generally expressed in monetary terms.

Vehicle-kilometre One kilometre travelled by a single vehicle.

LIST OF ABBREVIATIONS

ABS	advanced braking system
CO_2	carbon dioxide
COP-3	Third Conference of the Parties to the UN-FCCC held in Kyoto in December 1997
dB(A)Leq	decibel(s) equivalent continuous noise level
ECAC	European Civil Aviation Conference
ECMT	European Conference of Ministers of Transport
ECU	European currency unit(s)
EU	European Union
EUR 17	EU countries plus Norway and Switzerland
GDP	gross domestic product
GPS	global positioning system
GRP	general road pricing
ha	hectare(s)
HGV	heavy goods vehicle
ICAO	International Civil Aviation Organisation
LPG	liquefied petroleum gas
LRMC	long-run marginal costs
NO_2	nitrogen dioxide
NO_x	nitrogen oxides
O + M costs	operating and maintenance costs
p-km	passenger-kilometre(s)
PM_{10}	particulate matter (10 microns or less in diameter)
PPP	purchasing power parity
PSO	public service obligation
SRMC	short-run marginal costs
t-km	tonne-kilometre(s)
TSP	total suspended particulates
v-km	vehicle-kilometre(s)
UCPTE	Union for the Coordination of Production and Transmission of Electricity
UN-FCCC	United Nations Framework Convention on Climate Change
URP	urban road pricing
VOCs	volatile organic compounds
WTP	willingness to pay

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