

**Final Report for Publication**

**Concerted Action on**

**Transport Pricing Research Integration**

**CAPRI**

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# Table of Contents

Page:

<b>1. OBJECTIVES OF THE CAPRI PROJECT AND MEANS USED TO ACHIEVE THE OBJECTIVES .....</b>	<b>1</b>
1.1 OBJECTIVES OF THE CONCERTED ACTION .....	1
1.2 MEANS USED TO ACHIEVE THE OBJECTIVES .....	1
1.3 STRUCTURE OF THIS REPORT .....	2
<b>2. INDEX OF RELATED PROJECTS .....</b>	<b>3</b>
2.1 INTRODUCTION .....	3
2.2 RESEARCH PROJECTS WITHIN THE EUROPEAN 4TH FRAMEWORK PROGRAMME .....	3
<b>3. PRICING PRINCIPLES .....</b>	<b>6</b>
3.1 THE BASIS FOR PRICING.....	6
3.2 THE COSTS IMPOSED BY THE USE OF TRANSPORT INFRASTRUCTURE .....	6
3.3 RELEVANT COST CATEGORIES .....	7
3.4 WIDER CONSIDERATIONS IN THE DETERMINATION OF PRICING POLICY .....	8
3.5 THE NEED FOR DIFFERENTIATION OF PRICES .....	9
<b>4. VALUATION OF EXTERNALITIES .....</b>	<b>10</b>
4.1 DEFINITION AND RELEVANCE TO PRICING.....	10
4.2 CATEGORIES OF EXTERNALITY .....	10
4.3 VALUATION METHODS.....	11
4.4 REGULATORY POLICY .....	13
4.5 EMPIRICAL VALUES OF EXTERNALITIES .....	13
<b>5. ROAD PRICING.....</b>	<b>14</b>
5.1 THE OBJECTIVES OF ROAD PRICING.....	14
5.2 WHICH FORMS OF ROAD PRICING EXIST? .....	14
5.3 ACCEPTABILITY AND IMPLEMENTATION .....	15
5.4 EVIDENCE ON LIKELY IMPACTS .....	17
<b>6. PRICING OF RAIL AND OTHER PUBLIC TRANSPORT.....</b>	<b>18</b>
6.1 INFRASTRUCTURE PRICING .....	18
6.2 PRICING OF PUBLIC TRANSPORT SERVICES .....	21
6.3 EVIDENCE OF LIKELY RESULTS.....	22
<b>7. PRICING OF AIR TRANSPORT .....</b>	<b>23</b>
7.1 PRICING OF AIR TRAFFIC CONTROL SERVICES .....	23
7.2 PRICING OF AIRPORT SERVICES.....	23
7.3 PRICING OF AIRLINE SERVICES.....	25
<b>8. LIKELY OUTCOMES OF INTRODUCING MORE DIFFERENTIATED PRICES ....</b>	<b>26</b>
8.1 IMPACTS ON PRICES .....	26
8.2 IMPACTS ON TRAVEL DEMAND .....	27
8.3 MAKING THE CASE FOR PRICING REFORM .....	28
<b>REFERENCES.....</b>	<b>29</b>

## ANNEXES

- A General Economic Principles of Pricing Transport Services**
- B Valuation of Transport Externalities**
- C Road Transport Pricing Issues**
- D Public Transport Pricing Issues**

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## **Executive Summary**

The Concerted Action on Transport Pricing Research Integration (CAPRI) was commissioned to facilitate the exchange of information and results from research projects dealing with the pricing of transport. The project ran from January 1998 to December 1999.

The key objectives of CAPRI were:

- to aid dissemination of research results to Member States and other parties;
- to present a syntheses of research findings;
- to facilitate discussion and debate of research findings; and
- by identifying areas of agreement and disagreement, to attempt to build up a consensus on the policy implications of this research.

In addition to drawing on the reports of pricing-related projects in the European Commission's 4<sup>th</sup> Framework Programme, research evidence was put forward by researchers and civil servants from the EU, Norway, Switzerland, the USA and a number of Accession Countries. The implications of the synthesis of research findings were extensively discussed in four meetings during the course of CAPRI.

Conclusions are grouped according to six themes:

- A. Recommendation for pricing principles – for infrastructure use by all modes;
- B. Recommendations on valuations of externalities;
- C. Road pricing – urban and inter-urban;
- D. Rail and other public transport;
- E. Air transport; and,
- F. Conclusions on likely impacts of implementing efficient pricing.

These six sets of conclusions are now discussed in turn.

## **A. Recommendations for Pricing Principles - for Infrastructure Use by all Modes**

- A1. an understanding of marginal social costs should form the basis for the development of pricing policy** since under marginal social cost pricing users pay the costs that they cause through additional infrastructure use, and thus economic efficiency is maximised.
- A2. revenue contributions in addition to marginal costs may be justified** – to meet governments’ and private operators’ revenue needs, and to take account of equity considerations.
- A3. prices based on short run marginal costs should incorporate all significant cost categories** – including:
- *operating costs* (except those costs borne by the individual user);
  - *infrastructure wear and tear*;
  - *congestion costs* (except those costs borne by the individual user);
  - *opportunity cost for the use of capacity* (when other users are displaced);
  - *accidents* (except those costs borne by the individual user);
  - *noise*;
  - *air pollution*; and,
  - *global warming*.
- A4. prices should vary more according to location and travel time** – reflecting the characteristics of the above cost categories. However, changes to existing mechanisms should only occur when the benefits from more variable pricing exceed the costs of implementing more complex systems.
- A5. These pricing principles should be applied evenly across all passenger and freight modes of transport** – and, in addition, in related sectors such as energy.

## **B. Recommendations on Valuation of Externalities**

- B1. Externalities *within* the transport sector are of equal relevance as externalities that are caused *outside* the transport sector** – it is the impact of one individual/ organisation’s behaviour on other individuals/organisations that is important for pricing, not whether the cost is within or outside the transport sector as a whole.
- B2. All of the key externalities can be valued and incorporated in the development of pricing structures** – although substantial uncertainty exists in relation to cost estimation, in principle there is no reason to exclude any of the cost categories listed under “Pricing Principles”.
- B3. Evidence of external benefits from increased private use of transport infrastructure is weak** – in contrast to public transport, where external benefits arise due to increased demand resulting in improved service levels to the benefit of other public transport users.
- B4. External costs of congestion, scarcity and accidents should be valued using willingness to pay approaches** – and it is essential that the internal element that the user already ‘pays’ is separated from the price-relevant external element.
- B5. Valuation of air pollution is best undertaken by the impact pathway approach** – that incorporates emission, dispersion and dose-response relationships, with valuation of the final impacts on health, buildings, crops etc.
- B6. Human health impacts should be valued using the years of life lost approach** – and not on the “value of a statistical life” method. Ideally, quality life years lost should be taken into account.
- B7. Regulatory policy may often be more powerful than pricing policy in the control or reduction of some categories of environmental emission** – particularly for aspects such as noise, where in some circumstances the marginal costs are very low.
- B8. At present there is no consensus on the values that should be placed on emissions of global warming gases** – thus, values used in pricing should be based on political decisions about target emission levels.

## C. Road Pricing – Urban and Inter-Urban

- C1. More differentiation in road charges by time period and area is necessary** – externalities are severe in congested urban and inter-urban situations where travel patterns are heavily peaked by time of day, day of week or season of the year.
- C2. Comparative analysis of the performance of road pricing versus the performance of other transport strategies is essential** – existing mechanisms or policies often have under-exploited potential. It is also important that the level of technological sophistication is also justified, relative to more basic road pricing schemes.
- C3. Low levels of political and public acceptability imply the need for a *staged* implementation strategy** – beginning with simple systems with low charge levels, and introducing more complex charging systems over time.
- C4. To increase acceptability, revenue from road pricing should be earmarked for specific spending programmes** – for activities such as public transport, additional infrastructure expenditure, improving environmental conditions in towns, etc. However, both economic viability and public support will be undermined if revenue raised is not spent wisely.
- C5. Increased choice can result in increased acceptability** – enhancing alternative modes in urban areas, retaining free parallel inter-urban routes, and allowing variation in charges by time of day all increase choice and improve acceptability.
- C6. Modelling studies for urban and inter-urban road pricing indicate that proposed price changes can induce small but significant changes in behaviour** – small changes in behaviour can make a major contribution to the reduction of congestion and other externalities.
- C7. In contrast, demonstrations of urban road pricing often suggest that unacceptably large price changes may be needed to influence behaviour** – however, these magnitudes of response should be treated with caution as they may underestimate price sensitivities - although these demonstrations have provided valuable evidence on behaviour, their short-term focus and use of compensation to volunteer participants who chose not to use their car (as opposed to charging those who did) affects the results obtained.
- C8. The main impact of more variable road charging is likely to be travel at different times or by different routes by the same mode** – user's first preference will often be to continue to use their vehicle, but in a different way (different departure time, route etc.).

## D. Rail and Other Public Transport

- D1. There is strong evidence of declining costs in the railway industry so that marginal cost pricing will often lead to deficits** – declining costs particularly result from economies of density.
- D2. Where governments are unwilling/unable to fund deficits, “second best” pricing options should be considered** – two part tariffs for track access are likely to be appropriate, particularly when services are franchised; however, this access price structure may be difficult where on-track competition is proposed.
- D3. Efficient pricing of rail and other public transport, including internalisation of externalities, is likely to require greater peak/ off-peak differentials** – and also an element of government funding, particularly for short-distance urban services.
- D4. The scarcity value of train paths may be found by auctioning paths off** – but in practice there are many difficulties with this approach, and it may be more practical to allow negotiation of path allocation and prices between service providers and infrastructure managers.
- D5. Congestion costs may be estimated with simulation models, or measured ex-post** – there is reason to suppose that the former approach will be more reliable.
- D6. Improving service quality and investment in infrastructure may be the most important measures for increasing modal shares** – as opposed to internalisation of externalities for all modes via the pricing mechanism. This is particularly the case for freight transport.



## E. Air Transport

- E1. Pricing to take account of environmental pollution at high altitudes could in principle be integrated in air traffic control charges** – however, institutional relationships and transactional costs may in some circumstances mean that kerosene taxation would achieve internalisation of these externalities more effectively.
- E2. An auction process for airport slots is likely to be the most efficient way of allocating slots when property rights are allocated** – as an alternative to fixing prices to take into account the opportunity cost of slots
- E3. Environmental pricing can be based on kerosene consumption and/or landing and take-off operations** – while the first pricing option has to be based on unified EU rules, the second one can be organised on a more decentralised basis according to the local/regional context. As a general rule, the environmental costs should be allocated to the polluters.
- E4. Pricing policy development for the air sector requires more research** - to determine cost structures and hence appropriate pricing mechanisms. The exception to this is the extensive literature on slot allocation procedures.

## F. Conclusions on Likely Impacts of Implementing Efficient Pricing

- F1. Pricing based on marginal costs may result in price *reductions* for some modes as well as price rises for some others** – internalisation of externalities does not necessarily imply lower travel demand, or a shift to modes that are viewed as more environmentally sustainable– because current levels of taxation and charging have to be taken into consideration.
- F2. For inter-urban passenger travel in uncongested conditions, it is likely that road-based modes are over-priced** – due to the combination of existing charging and taxation systems.
- F3. Inter-urban passenger travel by rail is often over-priced** – despite generally low taxation to account for externalities, current fares are often in excess of the marginal cost of providing additional services.
- F4. For inter-urban freight transport, evidence suggests that there is often significant under-charging for both road and rail-based modes** – even in uncongested conditions. The outcome of efficient pricing applied across modes is likely to be fairly neutral in terms of mode shares, however.
- F5. Urban transport by means of road-based modes is typically dramatically under-charged** – implying that efficient pricing will have the greatest impact in reducing externalities in urban areas.
- F6. The need for radical pricing reform has to be made on a case-by-case basis** – in over half of the situations examined in European pricing projects the case for new pricing systems was not established, relative to the potential performance of existing pricing measures.
- F7. More variable pricing is likely to result in more dramatic changes *within* modes, than in switching of trips *between* modes** – greater differentiation of prices by time of day/ vehicle or engine type/ location is likely to change how users make use of their existing (and currently preferred) mode. For example, the dominant impacts of more variable charges by time of day/ location are likely to be greater departure time and route adaptation, as opposed to switching between modes.

# 1. Objectives of the CAPRI Project and Means Used to Achieve the Objectives

## 1.1 Objectives of the Concerted Action

The CAPRI project was commissioned to facilitate the exchange of information and results from research projects dealing with the pricing of transport. The key objectives were:

- to aid dissemination of research results to Member States and other parties;
- to present a syntheses of research findings;
- to facilitate discussion and debate of research findings; and,
- by identifying areas of agreement and disagreement, to attempt to build up a consensus on the policy implications of this research.

## 1.2 Means Used to Achieve the Objectives

The Commission invited all Member States to nominate two experts to serve on the Concerted Action's committee, which would consider and debate the syntheses of research findings. Experts from some other countries (including Estonia, Hungary, Norway, Switzerland, and the USA) and organisations (such as ECMT, IATA, IRU, UIC, UITP) were also invited to specific meetings.

Four main meetings of the committee were held over the course of two years. Papers relating to specific aspects of transport pricing were prepared for consideration at each of the first three of these meetings. The last meeting took the form of a conference which presented the findings of the project to a wider audience. The programme of meetings is shown in Table 1.1

**Table 1.1: Summary of Committee Meetings**

Meeting date	Reports Discussed
May 1998	<ul style="list-style-type: none"><li>• Outline of the Concerted Action</li><li>• General Economic Principles of Pricing Transport Services</li></ul>
November 1998	<ul style="list-style-type: none"><li>• Valuation of Transport Externalities</li><li>• Road Pricing (Urban)</li></ul>
May 1999	<ul style="list-style-type: none"><li>• Road Pricing (Inter-urban)</li><li>• Public Transport Pricing</li></ul>
November 1999	<ul style="list-style-type: none"><li>• Overall Conclusions from CAPRI on Transport Pricing</li></ul>

The main reports presented to the committee are included as Annexes A-D of this report.

### **1.3 Structure of this Report**

Chapter 2 of this report summarises the main projects whose findings contributed to CAPRI. Chapters 3–7 summarise the outcomes of the syntheses of research and subsequent discussions at the meetings. Chapter 8 presents overall conclusions on the likely implications of more differentiated pricing in the transport sector.

## **2. Index of Related Projects**

### **2.1 Introduction**

The Green Paper “Towards Fair and Efficient Pricing in Transport” (CEC, 1998) and, subsequently, the White Paper “Fair Payment for Infrastructure Use” (CEC, 1999) placed transport pricing high on the policy agenda. Whilst these papers advocated pricing based on marginal cost principles, there were concerns regarding: how this approach to pricing might be operationalised; what pricing instruments should be employed; what the price levels should be; what the impacts of such prices would be; and how such prices should relate to budgetary constraints and financing needs. The research projects commissioned as part of the European 4th Framework Programme and covered within the CAPRI project address this range of issues and have, therefore, assisted CAPRI in coming to a number of conclusions which inform the development of EU transport pricing policy. This section/chapter outlines the basic details of the key projects that have contributed to CAPRI.

### **2.2 Research Projects within the European 4th Framework Programme**

4<sup>th</sup> Framework project information, including contact details that enable the individual project’s final reports to be requested, may be found at [www.cordis.lu/transport](http://www.cordis.lu/transport).

The main 4<sup>th</sup> Framework projects that CAPRI drew evidence from, were:

#### **EUROTOLL (European Project for Toll Effects and Pricing strategies)**

This project sought to validate the effectiveness of pricing measures in 14 cases. The project centres on using road pricing as a congestion management tool.

#### **QUITS (Design and testing of an integrated methodology for the valuation of the quality of transport and systems and services in Europe)**

This project used a bottom-up approach to quantify the internal and external quality of transport. The study methodology was validated for multiple modes for three corridors: Frankfurt-Milan, London-Lille, and Munich-Patras.

#### **PETS (Pricing European Transport systems)**

This project gives practical advice on what the consequences of implementing efficient prices will be in terms of volume of traffic, choice of mode and environmental consequences. The pricing scenarios tested included: (i) marginal cost pricing; (ii) marginal cost pricing subject to a budget constraint; and, (iii) full internal and external cost recovery. The project also examines the relationship between deregulation and pricing. It involves five case studies - Channel crossing, crossing of the Alps, Oslo-Gothenburg, Finland, and the Tagus River crossing, Lisbon.

#### **TRANSPRICE (Transmodal Integrated Urban Transport Pricing for Optimum Modal Split)**

This project addresses a wide range of transport demand management measures (ring tolling, area pricing, parking pricing combined with access restrictions etc.) with an

additional emphasis on how pricing may be integrated across a number of transport modes and related facilities. The indicators of success are primarily the efficiency (in terms of how it affects mobility demand and traffic congestion) and public acceptance. The test sites are York, Leeds, Madrid, Athens and Como.

**TRENEN II STRAN (Models for Transport, Environment and Energy, version 2; Strategic Transport Policy analysis)**

This project analysed different combinations of pricing and regulatory instruments in order to identify optimal combinations to solve environmental, energy and pure transportation problems. It involved six urban case studies - Amsterdam, Athens, Brussels, Dublin, London and Mestre - and three regional case studies - Belgium, Ireland and Italy. The TRENEN model maximises a weighted sum of the consumer and producer surpluses, tax revenues and external effects by selecting a set of policies under constraints.

Other pricing-related projects that were not drawn on extensively, usually because the research was ongoing at the time of the CAPRI project, but which may be of relevance are:

**AFFORD (Acceptability of Fiscal and Financial Measures and Organizational Requirements for Demand Management)**

This project aims to identify practical measures to implement marginal cost pricing in urban areas both in the short and long term. The project examines the institutional, economic (including equity) and public and political acceptability issues affecting the implementation of these measures and ways to overcome any identified constraint or problem. It involves six case studies - Athens, Dresden, Edinburgh, Helsinki, Oslo and Madrid.

**CONCERT-P (Cooperation for novel City Electronic Regulating Tools)**

This project aims at producing guidelines for the development and implementation of European and local policies on pricing and access restriction, based on the assessment of the efficiency and acceptability of related transport demand management measures (integrated pricing and restraint measures, time-dependant and vehicle-based tolling, pollution-based pricing etc.). Their impact on urban traveller behaviour and travel demand patterns was modelled and evaluated through partial demonstrations in Bologna, Hannover, Marseilles, Dublin, Thessaloniki, Barcelona, Trondheim and Bristol.

**FISCUS (Cost Evaluation and financing Schemes for Urban Transport systems)**

This project sought to evaluate total transport costs (internal and external) in view of comparing costs between public transport and private car use. The research also looked at cost allocation practices in urban areas with a view to identifying feasible and effective means to finance urban transport systems.

**PATS (Pricing Acceptability in Transport systems)**

This project defines a priori measures to increase the acceptability of marginal cost based pricing in transport based on an analysis of the reactions and comments to the Green and White Papers on pricing. These measures are tested and enhanced

empirically using citizen surveys in six countries and focus group discussions in four countries. The implications of the suggested measures are assessed using modelling techniques.

**PRIMA (Capabilities of advanced traffic management tools)**

This project studies the acceptance issue for road pricing schemes that have been implemented or where non-acceptance has resulted in rejecting the scheme. The project also looks at technological specifications and design issues.

**PROFIT (Private operation and financing of trans-European networks)**

This project is focused on public-private partnerships for Trans-European Transport Networks. Its aim is to bridge the gap between financial profitability and socio-economic feasibility.

### **3. PRICING PRINCIPLES**

#### **3.1 The Basis for Pricing**

Pricing principles for transport markets stem from more general economic principles which apply to all markets. Therefore, the general pricing principles outlined here should be applied evenly across all passenger and freight modes of transport – and, in addition, in related sectors such as energy. This section considers these general principles and what consensus there exists about them, before more mode/market specific issues are considered in subsequent sections of the report. The main issue of principle relates to the choice of pricing rule or structure to be adopted, although there are also issues of principle regarding how the pricing rule should be implemented. Annex A contains a full discussion of pricing principles.

In a market economy, prices fulfil several functions in parallel. Firstly, the price mechanism is the best way to ensure that a limited supply of a good is made accessible to those who value it most. By raising prices until the total demand equals the available quantity, the consumers with the highest willingness to pay for the good receive the good (the tax and benefit system can be used to address income inequalities and enable lower income groups to express their willingness to pay). Secondly, prices act as signals to consumers about the costs associated with particular goods or services. Consumers then base their demand decisions upon these price signals. Thirdly, in competitive markets firms will generally only succeed if their prices are kept low. In this way the price mechanism provides all producers with incentives to develop cost-reducing production techniques.

#### **3.2 The Costs Imposed by the Use of Transport Infrastructure**

When car drivers, rail operators or other transport vehicle users use transport infrastructure they impose a series of costs; firstly on themselves, e.g. in terms of fuel costs, secondly on the infrastructure, e.g. in terms of wear and tear, and thirdly on society, e.g. in terms of congestion to other users. If prices are to act as signals to users then they should reflect these use-related costs. If prices reflect the additional cost to society of the production of an extra unit of that good (the marginal social cost) then consumers will only demand that extra unit and producers will only produce that extra unit if consumers are willing to pay for the additional cost incurred to society. Therefore, when prices are set according to marginal social cost only goods that are worthwhile, from society's point of view, are produced - this is known as allocative efficiency.

Thus, an understanding of marginal social costs should form the basis for the development of a pricing policy in which users pay the costs that they cause through additional infrastructure use, and thus economic efficiency is maximised.

Sunk costs, such as the cost of laying a railway, do not vary, cannot be fully redeemed at a later point by selling assets and are not relevant for the purposes of promoting the efficient use of infrastructure, though these costs do need to be met somehow. Sunk costs should not, however, be confused with fixed costs which do not vary with output



but which can be avoided or redeemed at a later point. Hence, fixed costs are part of the opportunity cost of supplying a good, as are variable costs that vary continuously with the quantity of output.

There is a distinction between short-run marginal social costs and long-run marginal social costs. Where production capacity can be optimally adjusted to take account of changes in demand short-run and long-run marginal social cost are the same as each other; this is, however, rarely the case in most transport markets where demand is often peaked and investment lumpy.

Short-run marginal social costs are defined for a given production capacity and will equal the additional operating and external costs associated with the production of an additional unit of output (i.e. vehicle km). Capacity costs must be paid regardless of output levels and hence are not included in short-run marginal cost. In contrast, long-run marginal social costs also capture the costs of altering capacity levels to facilitate the production of an additional unit of output. Marginal costs will not reflect sunk costs and will be based on future or avoidable costs.

In the long-run, all inputs including production capacity can vary. However, when investment is 'lumpy' in nature or difficult to adjust because of slow planning procedures, or when demand fluctuates over the year or within a day, pricing at the long-run marginal cost becomes problematic. Indeed, either demand exceeds capacity and is not rationed efficiently by the price system or demand is smaller than capacity and demand is curbed by prices that are too high. Therefore short-run marginal social cost pricing is, in general, the preferred starting point for developing a pricing policy which maximises economic efficiency.

### **3.3 Relevant Cost Categories**

A key element of marginal social costs is the marginal external costs. These are those additional costs imposed on society by a person making an additional journey which are not accounted for by that person. If prices do not reflect external costs, consumers receive signals to the effect that these costs are not a burden to society; clearly this is not the case. The polluter pays principle is, with respect to taxation, well established in policy circles. It is important that the tax is linked as closely as possible to the origin of the external effect – often emissions - rather than to general production levels. This is necessary to give producers the incentive to reduce external effects whenever the abatement cost is smaller than the avoided external damage.

Prices based on short-run marginal costs should incorporate all significant cost categories – including:

- infrastructure wear and tear;
- operating costs (except those costs borne solely by the individual user);
- congestion costs (except those costs borne solely by the individual user);
- opportunity cost for the use of capacity (when other users are displaced);
- accidents (except those costs borne by the individual user);
- noise;

- air pollution; and,
- global warming.

Therefore, efficient pricing requires information about all costs and, where they can be shown to exist, benefits of additional travel. In general external benefits are not present in transport markets; benefits are usually internal and are captured by demand. However, external benefits do exist in public transport markets, where additional use leads to higher frequency services, benefiting existing users.

### **3.4 Wider Considerations in the Determination of Pricing Policy**

Prices which are closely based on short-run marginal costs do not necessarily ensure that costs are fully recovered. Indeed, an approach based on short-run marginal cost may lead to either deficits or surpluses in a market. Where surpluses exist, the most efficient use of the net revenue may be to lower existing labour taxes.

The reform of pricing and taxes may bring about new investment needs for transport - besides the obvious need for charging equipment. Each of these projects should be judged on its own merits taking into account the cost of public funds. Earmarking the revenue from externality taxes to these investments is not desirable from a theoretical point of view; there need be no link whatsoever between the size of the revenue and the need for investment. However, earmarking may be a necessary condition to achieve acceptability, but the pricing reform would then not be worthwhile unless the revenue is still spent on projects with adequate benefits.

Any major reform of taxes and prices of transport will have impacts on the distribution of income. It is important to compute this impact correctly, taking into account gains in time and the use of extra revenue. In order to win sufficient public acceptance and support, it will be important to bear the needs of potential 'winners and losers' in mind when considering the use of the resulting revenue, e.g. for the purposes of reducing labour taxes.

Pricing based on short-run marginal cost may also lead to financial deficits. In this situation, there are three possible alternative strategies to financing the deficit whilst minimising the loss of efficiency:

- Firstly, the government could provide a lump sum subsidy to an operator that has been selected on the basis of an auction (competitive tendering) and that is required to price at marginal social cost;
- Secondly, prices could be set to cover costs but in accordance with the Ramsey principle which suggests that prices still be based on marginal cost but with mark-ups which are higher for goods whose demand is less responsive to price changes; and,
- Thirdly, prices could be devised which comprise a variable component per unit consumed, based on marginal cost, and a fixed component - also called an entry charge - to cover the deficit. This two-part tariff is an example of a potentially more sophisticated multi-part tariff.

Hence, if subsidy is not available, revenue contributions in addition to marginal costs may be justified – to meet governments’ and private operators’ revenue needs, and to take account of equity considerations.

### **3.5 The Need for Differentiation of Prices**

Current pricing signals are not efficient. The most striking inefficiency in most transport markets is the lack of differentiation in pricing to reflect the different social costs of travel. We know that efficient prices require that customers are confronted with the social cost of a trip. Yet drivers travelling in the rush hour pay more or less the same price as those who travel in the off-peak period. The price of a bus or train ticket is often the same in peak and off-peak periods. There is insufficient incentive to travel in the off-peak period. Similarly people driving highly polluting cars pay more or less the same rate per kilometre as those driving less polluting cars. Again, there is insufficient incentive to use less polluting cars. Given this pricing structure, it is no surprise that too much travel occurs in the peak period, too much pollution is generated, or that too many accidents occur.

When short-run marginal costs fluctuate strongly, it is important to inform the customers about the expected future profile of prices. Customers should take their investment decisions (in durable goods, housing etc.) on the basis of a correct anticipation of future prices. Some type of weighted averaging of short-run marginal costs over sub-periods or over different types of demand conditions (e.g. energy demand under differing weather conditions etc.) may be necessary. However, it is important that prices remain responsive to costs.

Therefore, prices should vary more according to location and travel time – reflecting the characteristics of the previously mentioned cost categories. However, changes to existing mechanisms should only occur when the benefits from more variable pricing exceed the costs of implementing more complex systems.

## **4. Valuation of Externalities**

### **4.1 Definition and Relevance to Pricing**

Externalities arise when the social or economic activities of one economic agent have an impact on the welfare of another economic agent, without that impact having been taken into account by the first agent. Specifically, they occur when changes in welfare resulting from economic activities are not reflected in market prices. If monetary values can be placed upon externalities then they can, at least in theory, be incorporated into the pricing mechanism; in this way they will then be taken into account by all economic agents. Monetary valuation of externalities is therefore directly relevant for transport pricing purposes. Annex B provides more detailed information on valuation of externalities.

Externalities may be classified as technological or pecuniary. The difference is in their respective effects, which are limited to changes in prices in the case of pecuniary externalities, while they induce a modification of utility or production functions in the case of technological externalities. Only technological external effects lead to market failure and require political intervention, while pecuniary externalities do not introduce any inefficiency.

Externalities that are negative and entail a cost for the economic actors affected by the externality are called external costs. Good or positive externalities that entail a benefit are called external benefits. This document concentrates on the valuation of negative externalities, as external benefits from transport infrastructure use are considered to be negligible with the exception of the benefits to public transport users due to frequency improvements caused by increases in demand.

The externalities analysed here relate to the use of transport infrastructure, as opposed to the provision of transport infrastructure. Externalities of infrastructure provision should rather be accounted for (and internalised) within the cost/benefit calculations carried out as part of a project appraisal, to allow public authorities to evaluate various infrastructure investment options.

Externalities resulting from transport infrastructure use may impact both upon agents within and outside the transport sector. However, externalities within the transport sector are of equal relevance as externalities that are caused outside the transport sector – it is the impact of one individual/ organisation's behaviour on other individuals/organisations that is important for pricing, not whether the cost is within or outside the transport sector as a whole.

### **4.2 Categories of Externality**

The main categories of externalities considered are: congestion, accidents, air pollution, noise, water pollution, and climate change. For these categories quantitative results with a degree of reliability that is sufficient for valuation purposes are available. While other externalities like visual intrusion, loss of biodiversity and ecosystem damages are also relevant, these impacts are not examined in detail since

no reliable empirical monetary valuation studies are available. Thus, the economic valuation of these impacts requires further research.

Congestion is common to many different transport markets: urban road and transit travel; queuing costs to park; airline and shipping slots at ports. For pricing purposes, however, it is the marginal external congestion cost – that is the increase in time and operating costs to other transport users from a decision to travel an extra kilometre - which is relevant. Efficient pricing requires a charge equal to this marginal external congestion cost, correctly estimated at the level of traffic at the most efficient price. This is the rationale behind urban road pricing and it has already been applied successfully in airport pricing.

Measuring external accident cost is a complex matter. The principle is, however, reasonably straightforward. Unless individual drivers face correct economic incentives, it is likely that the level of road safety will remain too low. A decision by a car driver to drive an extra unit distance may well increase the risk of unprotected road-users being involved in an accident. If this is the case, drivers may not have to consider this increase in risk in decision making. The extent to which this increase in risk is ‘internal’ or ‘external’ to drivers is complicated by insurance systems. External accident costs exist for private transport and for public transport.

Transport is responsible for noise and water pollution, as well as emissions of numerous and varied air pollutants: greenhouse gases, which may increase global warming, as well as other pollutants, which have been linked to impacts on human health, building materials, crops, forests, fisheries and wider eco-system functioning. Assessing external pollution costs per vehicle kilometre is not easy. While much uncertainty surrounds these estimates, it is now well established that some modes of transport are more responsible for pollution than others. Similarly, some types of fuels generated more emissions of the more dangerous pollutants. It is equally clear that current tax policies do not sufficiently differentiate between the dirty and clean modes and vehicles. It should be stressed that external pollution costs are associated with both private and mass transit modes.

All of these key externalities can be valued and incorporated in the development of pricing structures. Although substantial uncertainty exists in relation to cost estimation, in principle there is no reason to exclude any of the cost categories described above.

### **4.3 Valuation Methods**

Costs can be calculated by using either bottom-up or top-down approaches. Bottom-up studies are based on micro data, specifically related to individual routes, or trips. Top-down studies calculate average values for a whole transport network at the national or regional level, and subsequently allocate the resulting costs to specific routes or trips. External costs can show enormous variations depending on the time and place of the

activity. In the cases of air and water pollution, for instance, the same concentration of pollutants creates higher external costs in densely populated areas than in less densely populated areas. As for congestion, its severity, and therefore the amount of time lost, heavily depend on the time of day, day of week etc. at which travel occurs. Therefore, the bottom-up approach is recommended for pricing purposes.

In the absence of market prices, the economic value of an externality can be calculated by measuring individuals' willingness to pay, either by direct, stated preference, or indirect, revealed preference, methods. In stated preference methods, the value of a non-market good is derived from people's answers to explicit questions asked about their willingness to pay. Many studies use the contingent valuation method, based on surveys that describe a specific situation with a certain level of environmental quality and ask the respondents for their willingness to pay for a specified improvement, or their willingness to accept compensation for a worsening. Revealed preference approaches are indirect methods based on the observation of people's behaviour in actual markets where the external effect to be valued has an influence on their choice. Indirect methods include hedonic pricing, the calculation of travel cost, avoidance cost, lost production and lost income.

In nearly all major external cost of transport studies, an impact pathway approach incorporating dose-response functions is used to quantify the physical environmental impacts of air pollution. In a first step, physical emissions and impacts from transport activities are estimated with emission and diffusion models. In a second step, monetary values are placed on the resulting physical effects by using the relevant direct or indirect valuation methods (contingent valuation, hedonic pricing, travel costs, lost production etc.).

Transfers of costs and benefits from one context to another should be made carefully: criteria of transferability should be considered, and, most important, the transfer procedure should be made transparent. Values derived from inter-urban transport should not be used for urban routes, and vice versa. And, of course, values derived from other sectors (e.g. energy) cannot be used for the calculation of transport externalities without careful consideration of whether conditions are comparable.

When impacts - such as climate change - have a global and inter-generational dimension, questions of intra- and inter-generational equity are raised and should be reflected in the valuation of external costs (e.g. by time-variant discount rates and equity weighting).

External costs of congestion, scarcity and accidents should be valued using willingness to pay approaches – and it is essential that the element internal to the user is separated from the price-relevant external element.

Air pollution human health impacts should be valued on the years of life lost approach – and not on the “value of a statistical life” method, which is specific to the value of a prevented casualty. Ideally, quality life years lost should be taken into account.

#### **4.4 Regulatory Policy**

Regulatory policy may often be more powerful than pricing policy in the control or reduction of some categories of environmental emission – particularly for aspects such as noise, where in some circumstances the marginal costs are very low. In the case of noise, it may be that little reduction will be achieved by marginal cost pricing, but that regulatory measures to achieve major reductions may still be worthwhile.

#### **4.5 Empirical Values of Externalities**

A relatively high level of uncertainty exists about the numerical estimates of the monetary value of most transport externalities. This is due to both the intrinsic complexity of the physical phenomena involved and the corresponding uncertainty attached to their representation, as well as to the limitations of the valuation techniques themselves. This clearly highlights the need for further research and empirical testing. In particular, there is no current consensus on the values that should be placed on emissions of global warming gases. However, politicians do take decisions about the degree of reduction of greenhouse gases that should be targeted, and these imply an opportunity cost attached to increased emissions in that they must be offset by actions to keep within the target. In this situation, values used in pricing should be based on political decisions about target emission levels.

Nevertheless, ranges of illustrative values can be derived. It is widely agreed that the total external costs of transport are substantial and require further political action. However, total numbers should be interpreted cautiously due to methodological problems of aggregating micro-data under *ceteris paribus* assumptions.

## **5. Road Pricing**

### **5.1 The Objectives of Road Pricing**

Road pricing refers to paying directly for the use of roads. The case for road pricing arises out of concerns that road users, when making decisions about whether and how to travel, do not take account of all of the additional costs they impose on society. Pricing which fully reflects these external costs is one way of providing appropriate signals to road users for them to base their decisions on. As referred to in Chapter 3, the most appropriate pricing policy for achieving this is through prices making use of information on short-run marginal social cost. In addition, road pricing is also seen as a possible financing instrument for new road or public transport infrastructure. Annex C contains a full discussion on these, and related, road pricing issues.

Whilst road users currently face a variety of taxes and charges, these tend not to be very closely related to use or the incidence of externalities. External costs are severe in congested urban and inter-urban situations where travel patterns are heavily peaked by time of day, day of week or season of the year. Therefore, more differentiation in road charges by time period and area is necessary to fully reflect the incidence of road use externalities.

### **5.2 Which Forms of Road Pricing Exist?**

Road pricing may take several forms. The main types of road pricing system are:

- real-time congestion pricing - with charges varying according to traffic conditions, area and time of day (in principle the higher the level of congestion the higher the charge);
- time-based pricing - charge being proportional to the time spent travelling within a specified area;
- delay-based pricing - a variant of time-based pricing, whereby charges are directly related to the time spent queuing or in slow-moving traffic conditions;
- distance-based pricing - charge is directly related to the distance travelled within a specified area;
- cordon pricing - charges applied at points crossing a cordon (usually around the city centre), where charging could be one-way (e.g. for inbound traffic only) or two-way (with differential charge levels by direction);
- area licensing - charging is applied to vehicles in a specified area at specific periods of the day. Once an area licence is bought, the additional cost of a trip is effectively zero; and,
- combinations of the above.

A key aspect of the alternative systems is their ability to reflect the costs that an individual driver imposes. This should be compared to the alternative systems' relative costs. There are, however, a number of issues involved in selecting a road use pricing system, namely:



- the cost of the system;
- the ease of implementation;
- the ability to reflect costs – e.g. to apply differential charges by time of day, vehicle/ engine type, direction of travel; and,
- the public and political acceptability of the system.

Clearly in terms of developing a pricing strategy, there may be a trade-off between a sophisticated system which effectively internalises costs imposed and a simpler system which may be easier to implement and gain acceptance for. This may result in a strategy that is staged over time. The Singapore experience provides a good example of this – having moved in 1998 from an area licensing scheme to an electronic scheme with charges varying by half hour time periods.

Comparative analysis of the performance of road pricing versus the performance of other transport strategies is essential – existing mechanisms or policies often have under-exploited potential. It is also important that the level of technological sophistication is also justified, relative to more basic road pricing schemes.

### **5.3 Acceptability and Implementation**

A principal barrier to the implementation of road pricing has been the low level of public and political acceptability of the concept. People generally regard road space as a “free” good, therefore there will be strong emotional resistance to any attempt to charge directly for it. Hence, much attention has been placed upon making road pricing more acceptable.

One means of improving the acceptability of a road pricing system is to give users incentives and privileges. One possible incentive would be to charge a lower tariff (or no charge at all) for cars with high occupancy (say with 3 or 4 people in the car). This way acceptability of the system by high occupancy vehicle users is secured from the outset. However, the mere fact of high occupancy implies a relatively low charge per passenger. Another approach is to combine road use charging with parking charging, thus giving the right to park free for those that pay the charge or, looking at it another way, to levy the parking charge other than at the point of use. The integration of parking charges and road use charges in this way may be expected to contribute to higher public acceptability.

Acceptability and the ability to influence driver behaviour may suggest that the road use charge level should be clear before travel is undertaken. With real-time congestion pricing and time-based road use pricing if severe congestion occurs, the user not only will suffer in terms of extensive delays but his road use charge will go up as well. A pragmatic approach here may be to cap the maximum level of charge that can be levied at a certain location or time of day.

With time-based and delay-based pricing unpredictability of charge levels may also lead to lack of acceptability from road users. Such forms of pricing may also encourage speeding or dangerous driving.

Distance-based pricing, cordon pricing and area pricing, however, offer easy and clearly understood bases for charging road users. The charge level is known (or can be easily calculated by the user) before the trip is made. Distance-based pricing however, may lead to users selecting the minimum distance route to minimise the charge and this may lead to transfers to alternative, less suitable routes. Cordon pricing is considered to be an effective and practical form of road use pricing. The charges can be clearly identified by the user yet differential charging may be applied by time of day and direction of travel. Cordon pricing could be implemented by several cordons (e.g. central, inner and outer) and be extended to include screenlines (depending on city structure). The automatic debiting and electronic tolling technology already available makes cordon pricing technically feasible. Area pricing is easy to understand and can be implemented without sophisticated technology. However, it has to use a flat rate that is not related to the amount of travel. Therefore, for any given time period, differentiation can only be applied at crude level.

Implemented schemes show that complex pricing systems can work effectively and achieve public acceptance; examples from US experience include dynamic systems where the charge varies according to traffic levels, and charges that are fixed but vary by the half or quarter hour.

In general, however, low levels of political and public acceptability imply the need for a staged implementation strategy – beginning with simple systems with low charge levels, and introducing more complex charging systems over time.

As a further means of increasing acceptability, revenue from road pricing could be ear-marked for specific spending programmes – for activities such as public transport, additional infrastructure expenditure, improving environmental conditions in towns, etc. However, both economic viability and public support will be undermined if revenue raised is not spent wisely.

Increased choice can result in increased acceptability – enhancing alternative modes in urban areas, retaining free parallel inter-urban routes for inter-urban travel, and allowing variation in charges by time of day all increase choice and improve acceptability. It should be remembered, though, that acceptability should take account of the views of both car users and non-car users; if only car users are interviewed, it will be unsurprising that findings are negative.

In most EU countries, with the exception of Italy, Britain, Greece and France, the legal foundations for road pricing do not exist. They must, therefore, be created, either through the national or regional government (depending on the country). Hence in relation to urban road pricing, the powers do not necessarily lie with the city authority. There may follow a conflict of interest, the decision makers for such laws that are superior to the city may also represent those sections of the population that live in the surroundings of the city who would be the main losers from any form of urban road pricing system (if the revenue raised were distributed within the city). Therefore from

the legal point of view one may count on a difficult and lengthy decision process for the creation of the legal foundations for urban road pricing.

#### **5.4 Evidence on Likely Impacts**

In Norway, special area entry permits are being used in Oslo, Bergen, and Trondheim. Although they are primarily used to raise revenues, there is evidence that there has been some impact on the overall traffic levels in the controlled area. In Oslo, the car traffic reduction is estimated as 8-10%. A form of area pricing system has been in use in Singapore since 1975 with considerable success. From 1998, this was adapted to an electronic charging system.

Modelling studies for urban and inter-urban road pricing indicate that proposed price changes can induce small but significant changes in behaviour (e.g. a 5 to 10% demand reduction) – small changes in behaviour can make a major contribution to the reduction of congestion and other externalities. In some studies a small reduction in demand has been shown to result in the marginal external cost of congestion falling to 20% of the pre-charge level.

In contrast, demonstrations of urban road pricing often suggest that unacceptably large price changes may be needed in order to influence behaviour. However, these magnitudes of response should be treated with caution - although these demonstrations have provided valuable evidence on behaviour, their short-term focus and use of compensation to volunteer participants who chose not to use their car (as opposed to charging those who did) affects the results obtained. In some volunteer exercises, compensation levels have only returned a proportion of the “money saved” by the volunteer and have also been uncertain and paid out at the end of the trial period; this has affected the volunteers’ perception of compensation in relation to “real money”.

The main impact of more variable road charging is likely to be travel at different times or by different routes by the same mode – the user’s first preference will often be to continue to use their vehicle, but in a different way (different departure time, route etc.).

## **6. Pricing of Rail and other Public Transport**

### **6.1 Infrastructure Pricing**

With rail systems, pricing for the use of both infrastructure and of services needs to be taken into account (Annex D). The issue of charging mechanisms for the use of rail infrastructure has become increasingly important as a result of a trend towards rail reform, in particular the requirement, under EC legislation, of all Member States to separate infrastructure from operations - initially in terms of accounting.

A number of different objectives for infrastructure charges may be identified. A set of objectives identified at a recent European conference of Ministers of Transport (ECMT Round Table 107, 1998) meeting and those reflected in the Commission's White Paper on Fair Payment for Infrastructure Use are as follows:

- promoting efficient use of the infrastructure;
- promoting efficient investment in and development of the infrastructure;
- recovering the costs of providing the infrastructure, including adequate funding for investment;
- promoting efficiency of operators, for instance through facilitating competition; and,
- harmonisation of the terms of competition between modes.

Whilst these objectives all reflect a desire to obtain maximum value to society from the rail system, not all contribute equally to that higher objective and not all can be adequately fulfilled with a single policy instrument. There are trade-offs to be made.

There is general agreement that the most important objective should be efficient use of the infrastructure, although this should be achieved in the way which least damages other objectives, in terms for instance of incentives for efficient development of the network and the scope for promoting competition amongst train operators.

The basic principles for the efficient use of infrastructure are that, in the absence of capacity constraints, operators willing to pay the extra costs they impose by their use of the infrastructure should be allowed to use it, whilst in the presence of capacity constraints the capacity should go to the operator and type of traffic for which it has the most value. This of course does presuppose that what the operator is willing to pay represents the social value of the train, so that any external benefits or costs have already been taken account of by taxes or subsidies from the government. The issue of capacity is an important one and arises due to the difficulties and time lags involved in altering railway capacity in the short term. If it were possible to reduce or increase the capacity of railway infrastructure quickly and flexibly in direct response to demand variations then it would be possible to identify both the additional cost imposed by an extra train using the infrastructure and the additional cost associated with expanding the capacity of the infrastructure in response to that extra train. However, indivisibilities and other time lags involved in railway investment mean that quick and flexible adaptation of railway infrastructure is impossible, making this a difficult basis on which to develop an approach to pricing.

The approach to pricing which results is one based on an understanding of short-run marginal social cost, in other words to base charges on the incremental cost of use of the existing infrastructure by the train concerned. This would cover the wear and tear cost, plus any costs imposed on other services in terms of delays or retiming to accommodate the train concerned. In the presence of a capacity constraint, this cost would have added to it the value of any train which could not be run as a result of lack of capacity (this only really becomes an issue where there is more than one train operator; with only one operator such costs are internalised). In conjunction with this kind of approach to pricing, the appropriate means of adapting the capacity of the infrastructure would be to do so in accordance with the outcome of social cost-benefit analysis of alternative schemes.

It is relatively straightforward to estimate the marginal cost in terms of wear and tear and accelerated renewals of additional train services. Unplanned delays caused to other operators may be charged for by the ex post payment of compensation, as under the Railtrack performance regime in Britain (OPRAF, 1996), or by ex ante prices developed by means of simulation using models such as the MERIT model of Railtrack. The modelling approach is claimed to be superior, as it identifies the full congestion cost of additional trains on the network, including the impact of reduced recovery possibilities from delays with other causes. Actual measurement, on the other hand, is confined to delays directly caused by the train in question. Extra pollution will also result.

The most attractive method of estimating the value of any train which could not be run as a result of lack of capacity is, in theory, to “auction” scarce slots. There are many practical difficulties however, including the complicated ways in which slots can be put together to produce a variety of types of service, and the possibility of lack of adequate competition to ensure a competitive price. In practice it is therefore usually accepted that any degree of price rationing of scarce slots will have to be on the basis of administered prices rather than bid prices, although it might be possible to allow for a degree of ‘secondary trading’ in which slots change hands between operators at enhanced prices, and/or to organise a degree of bidding for pre-packaged sets of slots.

Therefore, the most efficient pricing policy for rail infrastructure will be based on short-run marginal social cost, including wear and tear costs, congestion costs and the scarcity value of paths when capacity constraints are binding. Congestion costs may be estimated from simulation models, or measured ex post. There is reason to suppose that the former approach will be the more reliable. The scarcity value of paths may in principle be found by auctioning paths off, but in practice there are many difficulties with this approach. The most workable alternative is to permit negotiation of path allocation and prices between service providers and infrastructure managers.

There is strong evidence of declining costs in the railway industry so that pricing based on short-run marginal social cost will often lead to deficits – declining costs particularly result from economies of density. Where governments are willing and able to fund these deficits through subsidy to the infrastructure, charges to operators should reflect the opportunity cost/shadow price of those public funds. Where governments are unwilling or unable to fund these deficits, ‘second best’ pricing

options should be considered, including Ramsey pricing and two-part tariffs. The application of Ramsey pricing to an intermediate good such as transport is, however, not straightforward; it is the effect on the prices and service patterns in the final market that matter, and that is difficult to predict and appropriately allow for. Two-part tariffs are likely to be appropriate in this situation, with the fixed part reflecting the avoidable cost imposed by the operator concerned plus some allocation of joint costs. Such a two-part tariff exists for the franchised passenger operators in Britain (ORR, 1994), and a similar type of tariff was subsequently negotiated by the major freight operator (ORR, 1997).

The attraction of two-part tariffs is that the fixed part may be related to ability to pay, but still leave the operator free to raise the necessary cash in the way that loses them the least traffic, without the distorting effect on service levels that a surcharge on the charge per train kilometre has. The difficulty is that if the fixed part is the result of a tariff, it almost inevitably favours large operators against small (even if there is a fixed charge per route kilometre, as in France and Germany, it favours the operators who have a lot of traffic on the particular route, although it is not as damaging to the prospects of entrants as a large fixed charge for an entire network, as in Britain). The question arises of how to determine a fixed charge for new operators that will not discourage them from entry if they are more efficient than existing operators but will conversely not give them an advantage over existing efficient operators. The theoretical answer again is well known but difficult to implement - it is to charge them an amount equal to any surplus over avoidable costs that they take away from existing operators (Baumol, 1983). In the absence of the necessary knowledge to implement this, it may be reasonable to allow entrants to choose between paying on the same two-part tariff as incumbents (with the fixed part being a charge per route kilometre, so that overall size per se does not give the incumbent an advantage on any particular route) or paying the average cost per train kilometre paid by the incumbent. This at least represents the level of surplus that on average the incumbent is required to earn. It is broadly the approach recommended by Coopers and Lybrand (1998) and now being adopted in Germany. Franchising, by promoting efficiency in operations through competition for the market, may be a better means of overcoming the problems posed by use of two-part tariffs.

An approach recommended by NERA (1998) and endorsed by the Commission in its proposed Directive, is to identify sections of infrastructure where capacity is constrained and to charge the long-run average incremental cost of expanding capacity. However, this is a very difficult concept to measure (the cost of expanding capacity varies enormously according to the exact proposal considered, and it is not easy to relate this to the number of paths created, since they depend on the precise number and order of trains run). However, this appears to be a popular approach and is under consideration, for instance, in both Britain (ORR, 1998) and France.

Given the difficulties with all these approaches, it may be that the best way of handling the issue is to permit direct negotiation between operators and the infrastructure manager over the price and allocation of slots, including investment in new or upgraded capacity. It is appreciated that it is difficult to ensure that this does not lead to the abuse of monopoly power, particularly when the infrastructure manager and the operator are part of the same company. An independent regulator is certainly

needed but their job is far from easy. Whichever of the above systems of charging is implemented will leave an issue as to the incentive given to infrastructure providers to adapt the quantity and quality of the infrastructure to future needs. This is perhaps most readily addressed via the 'two-part' tariff approach, whereby changes in the infrastructure required by operators or subsidy providers may be reflected in changes in the fixed element of the two-part tariff. Again, it would seem difficult to do this in any way other than by the negotiation of a commercial contract between the two parties.

## **6.2 Pricing of Public Transport Services**

In contrast with infrastructure pricing, relatively few studies deal with the principles to be adopted in the pricing of rail and other public transport services. The marginal cost of handling additional rail traffic comprises the additional operating costs plus any additional infrastructure costs; providing that one of the above recommended approaches to infrastructure pricing has been adopted the latter will be appropriately reflected in additional charges paid by the train operator for use of the infrastructure, as will external costs such as environmental effects. However, it also includes the marginal cost imposed on other rail users. Where increased traffic leads to a more frequent service, this effect will be negative (Jansson and Lindberg, 1998).

The marginal cost of carrying extra traffic will probably be lowest where it is possible to increase capacity simply by operating longer trains. Even if more trains have to be operated however, their extra cost will partly be offset by resulting improvements in the timetable for existing customers. This effect is likely to be greater for passengers than freight, and for short distance services than long, since any inconvenience of not having a train at exactly the desired time is a greater part of generalised cost the shorter the journey. The marginal cost of additional capacity is obviously likely to be greater in the peak, when capacity is fully utilised, than in the off peak when it is not. Charging extra for scarce infrastructure slots will reinforce this difference between peak and off peak charges.

A pure marginal cost pricing approach would therefore differentiate between peak and off peak, as well as between other determinants of marginal cost such as the quality of rolling stock and on-board services provided. To the extent that the financial performance of such a regime is unacceptable, price differentiation is likely to be the appropriate way forward. In the freight sector, it is possible to differentiate to a high degree, since many customers are large enough to make it worth negotiating an individual price. Provided that any infrastructure charges are appropriate, this may leave little case for further subsidies for rail freight services except on second best grounds. For passenger services, differentiation can take place in terms of origin, destination, class and time of travel, person type (e.g. pensioner, child, family group) and when the booking was made (at least in terms of longer trips where booking ahead may be reasonable). But such differentiation will almost inevitably be cruder than for freight, because it is not feasible to negotiate a separate price with each passenger. It will be cruder for short distance than long distance services, because it is less worth the costs of administering a more complicated system for short journeys.

The same situation applies broadly for other scheduled public transport modes. For instance, for buses, when traffic increases there is a choice between operating larger buses (if this is feasible) and more frequent services. In the former case the marginal cost to the operator is well below the average cost. In the latter, marginal operating cost may equal average (there is less convincing evidence for economies of density when service frequencies are increased for bus than for rail), but there is a benefit to existing passengers from a more frequent service. The problem of the peak is again typically very important.

Therefore, efficient pricing of rail and other public transport services, including internalisation of externalities, is likely to require greater peak/ off-peak differentials – and also an element of government funding, particularly for short-distance urban services.

### **6.3 Evidence of Likely Results**

Case studies carried out as part of a series of European research projects have analysed the potential results of implementing a variety of pricing reforms. Results vary across countries. However, despite the context-specific nature of case study findings, some general messages emerge for rail and other public transport pricing.

The passenger transport case studies suggest that reform of prices for urban rail services in line with an approach based on marginal cost would involve only a slight increase on current prices. Moving to more optimal prices for peak buses would, however, involve substantial increases as compared with current prices, since external costs are greater. Overall, implementation of prices based on marginal cost might generate small reductions in the total volume of urban travel.

At the inter-urban level, the main effect of the pricing policies is to induce minor shifts from air and road to rail transport. These shifts become stronger when policies are integrated and infrastructure development is combined with economic incentives for internalisation of environmental costs.

The freight transport case study results suggest some benefit to rail from full internalisation of costs on other modes, but improvement of rail service quality is more important than increasing road transport costs in boosting the rail share of the market. Infrastructure improvements should be combined with environmental charges in order to generate greater benefits for rail and intermodal passenger transport.

Therefore, efficient pricing, including internalisation of externalities, is likely to benefit rail and other public transport, particularly in the urban peak. In off peak, and non-urban conditions, the outcome is less predictable, depending on the existing level of taxation and subsidy of the various modes.

Interestingly, improving service quality and investment in infrastructure appear to be the most important measures for increasing modal shares – as opposed to internalisation of externalities for all modes via the pricing mechanism. This is particularly the case for freight transport.



## **7. Pricing of Air Transport**

### **7.1 Pricing of Air Traffic Control Services**

The air transport market is subdivided into three segments: air traffic control services, airport services and airline services. Different cost/demand regimes apply for each segment which give rise to different theoretical and practical pricing schemes. These issues are discussed in depth in Annex D.

In the past decades air traffic control in the European Union has been a bottleneck factor, responsible for substantial delays of aircraft movements. In the course of reorganisation of air traffic control in Europe, involving a reduction in the number of air control organisations, a strengthening of the co-ordination by Eurocontrol, co-ordination with military air control, modernisation of technical equipment, application of new telecommunication technologies and commercialisation of air control organisations, the efficiency of air control has significantly increased. According to the expectation of most experts flight control will, subject to investment in air traffic control, not be a constraining factor for the growth of air traffic in the following decades.

The pricing of control services is now organised, basically, according to a club-principle: The air control service companies allocate the full cost of the service (according to accounting principles set by ICAO and Eurocontrol which are applied in 27 European countries) to the airlines which use the service. The price for a single aircraft movement is dependent on the type of aircraft and the flight distance. Prices reflect the estimated average costs including capital costs and are strictly bound to a cost ceiling. If a financial surplus occurs it has to be paid back within two years. In the Green Paper on the Finance of Air Traffic Control Infrastructure the Commission has underlined the principle of cost orientation of charges.

Congestion and externality pricing based on the marginal cost principle is presently not applied to air traffic control services, although the Commission in their Green Paper express some preference for this type of charging. The re-organisation of the air traffic control regime in form of a club structure and the establishment of the self-financing system have contributed to move demand and supply for air control services in the right direction. Pricing to take account of environmental pollution at high altitudes could in principle be integrated in air traffic control charges – however, institutional relationships and transactional costs may mean that kerosene taxation would achieve internalisation of these externalities more effectively.

### **7.2 Pricing of Airport Services**

Airport services include runway provision, parking, cleaning, ground transportation and passenger handling. At the main airports the runway capacity is the dominating bottleneck factor such that airport slots are defined as time units of runway capacity which allow for one aircraft to either land or take-off. The allocation and management of these slots is, therefore, extremely important.

Due to the history of air traffic the main airports are dominated by the formerly designated national carriers. This has enabled them to exert a strong influence on the slot allocation process, reducing the potential for competitive bidding and representing a barrier to new entrants. Slot prices at many airports are regulated by public authorities, but if price setting is left to the market then the market power of the big airlines can dominate. The Commission has taken some steps to limit the monopoly power of incumbent airlines in the context of approval for international alliances, e.g. Frankfurt, London Heathrow and Copenhagen airports which are dominated by LH, BA and SAS.

As in the case of air traffic control, the fixed capital cost element - runways, gates and other fixed installations - plays a dominant role and leads to a high proportion of the fixed cost block. The problem arises of how to allocate this cost to the users, i.e. the aircraft. Pricing based on short-run marginal cost pricing might result in deficits for the airport authority, because fixed costs are not considered. A Ramsey pricing scheme, which adjusts marginal cost values through (inverse) demand elasticities, is one way of covering fixed costs (Morrison, 1985). An alternative method would be through use of multi-part tariffs. These consist of at least two pricing elements which address different user characteristics and which are indirectly linked to the costs that result from these characteristics. A number of authors have shown that this pricing principle under certain conditions is optimal for producers and consumers (Oi, 1971; Shibley, 1986; Willig, 1978). Levine (1969) proposed landing fees on airports based on two components, the first of which is based on the cost of runway (footprint pressure) and the second on the congestion situation (time of the day, type of runway used). This can guarantee that revenues cover total cost and that enough incentives are generated to allocate the activity to the appropriate time of day and runway.

Airport slot pricing is confronted with a mix of short-term and long-term contracts such that a differentiated scheme applies. While the long-term segment is characterised by individual negotiations, leading to a package of pricing elements (multi-part tariffs), the short-term segment can be treated according to short-run marginal cost rules. However, instead of fixing prices on the base of marginal cost calculations an auction process for slots might be more efficient.

Auctioning of slots can be classified into short and long term slot contracts. Grampp (1968) and Levine (1969) provided first proposals for short term slot auctions. Grether, Isaac and Plott (1979) proposed a two stage slot allocation mechanism consisting of a computerised, sealed bid one-price option and an after market. Mills (1990) suggested a slot auction scheme for the Sydney airport. He proposed peak and off-peak charges which should reflect the operating costs at the airport as well as social costs. Airlines would bid for slots in addition to these posted charges in a non-discriminatory sealed bid auction to prevent collusion. A similar approach has been applied by Kwong (1988) for the Kaitak airport at Hong Kong.

Long-term slot contracts have been proposed by Wolf (1991) or Janda (1993). They suggest to orientate the contract duration at the current gate lease contracts. Another possibility is to link lease contracts to the time of depreciation for an aircraft. Further advanced from the theoretical point of view seems to be the suggestion of Scicon

(1991) who proposed the market high bridge option. It consists of a first price sealed bid option of slot lease contracts. These were proposed to have duration of seven years. An after market was allowed. It was proposed to convert 20% of all grandfathered slots to leases per year. After five years every slot would have been auctioned-off once. After a two-year gap, the next auction round of the first portion of the slots would be started.

Some airports apply environmental pricing based on noise or NO<sub>x</sub> emissions. This is done in a way that a part of internal airport cost is allocated using environmental indicators as levy variables. It does not mean that the external cost of noise or air pollution are actually allocated.

Environmental pricing might be based on three leverage points: kerosene consumption, air traffic control pricing by flight segment and landing/take-off operations. While the first two pricing options have to be based on unified EU-rules, the third one can be organised on a more decentralised basis according to the local/regional situation (subsidiarity principle). As a general rule, the environmental costs should actually be allocated to the polluters.

### **7.3 Pricing of Airline Services**

In the course of the three deregulation packages for the European air transport sector the traditional price regulations on the base of IATA agreements have been removed. This has resulted in a much higher price flexibility and a wide range of prices, which are highly differentiated and dependent on demand characteristics. The cheapest fares are in most cases about a third of the standard fares, but restricted to weekend travel or advance booking.

It is difficult to identify a cost base for the individual price setting behaviour of companies. One can assume that the companies apply some type of network-wide cost/revenues analysis and set the prices according to their long, medium or short-term strategic objectives. This means that, at one end of the spectrum, “charging what the market will bear” is applied, whilst at the other end of the spectrum prices may be set below even marginal cost so as to facilitate market entry and attract frequent flyers to the bonus system.

Monopolistic competition can be found in many parts of the air-traffic market. Whether or not this disturbs dynamic efficiency is dependent on the organisation of slot allocation and the contestability of the market, i. e. the competitive situation between the big airline alliances and the access conditions for new entrants to come into the market.

## **8. Likely Outcomes of Introducing more Differentiated Prices**

### **8.1 Impacts on Prices**

The existing range of pricing policies in most Member States is so varied that it is difficult to generalise about the likely effects of pricing reforms designed to reflect marginal social cost. Pricing based on marginal costs may result in price reductions for some modes as well as price rises for some others because current levels of taxation and charging have to be taken into consideration. Evidence on the potential impacts of pricing reforms has been gathered from a number of European research projects that have undertaken modelling and demonstration work as part of case studies on pricing reform.

For inter-urban passenger travel in uncongested conditions, it is likely that road-based modes are over-priced – due to the combination of existing charging and taxation systems. For example, the PETS case studies suggest that existing prices for inter-urban car broadly reflect and perhaps exceed marginal social cost including all externalities. It is common to find that inter urban rail and road-based public transport are overpriced, despite generally low taxation to account for externalities. Current fares are often in excess of the marginal cost of providing additional services due to full cost recovery targets in the presence of economies of scale. This forms the main case for a realignment of prices to favour rail transport. The same result may not apply to air transport, however, because of its much higher level of external cost.

For inter-urban freight transport, evidence suggests significant under-charging in many cases for both road and rail-based modes – even in uncongested conditions. Inter-urban road freight is also likely to suffer from distortions due to the variety of pricing regimes in operation in different Member States. The benefits of internalisation for rail freight are again limited by the finding that rail is often underpriced as well.

Urban transport by means of road-based modes is typically dramatically under-charged, particularly in congested conditions. The well known phenomenon of serious underpricing of the car mode is reflected in the results of the PETS and TRENEN urban case studies.

Therefore, pricing reform to reflect marginal social cost in passenger transport would, in general, involve a decrease in prices for inter-urban road and rail transport and increases in the price of urban road-based transport, in particular the private car.

Pricing reform to reflect marginal social cost in freight transport would lead to increases in prices for both road and rail. In addition, these pricing reforms would result in a substantially greater degree of differentiation and variation in transport prices.

## 8.2 Impacts on Travel Demand

Internalisation of externalities does not necessarily imply lower travel demand, or a shift to more “sustainable” modes of transport, since prices may increase or decrease for the different modes.

As referred to above, existing prices for inter-urban car broadly reflect and perhaps exceed marginal social cost including all externalities. Simply internalising externalities will, therefore, not necessarily benefit public transport modes even though they may have a much lower level of external cost than road, because of the existing levels of taxation on road transport.

The outcome of efficient pricing applied across modes in the freight transport sector is likely to be fairly neutral in terms of mode shares as evidence suggests significant under-charging for both road and rail-based modes.

The under-charging of road-based modes in urban areas implies that efficient pricing will have the greatest impact in reducing externalities in urban areas. Modelling and demonstration work as part of the TRANSPRICE project confirmed that road use pricing is an effective way of changing modal split from private car to public transport and park & ride. Modelling tests for five cities taking part in the TRANSPRICE project produced city centre traffic reduction of 5-20%, with associated environmental benefits. In the case of Athens where both demonstration and modelling were carried out, a reasonably close result between the two sources was found.

Parking pricing provides an effective way for restraining car trips (assuming that enforcement can be maximised), but less so than road use pricing options for which enforcement levels are expected to be higher than past experience with parking pricing.

High occupancy vehicle lane pricing options have marginal impacts on modal split. Modal split impacts from integrated ticketing are small, but could be significant over time. Smartcard integrated payment systems can support trans-modal pricing measures and can have small but significant modal split impacts on their own. Mode share and travel demand levels in inter-urban and urban situations and both for passenger and freight modes.

### 8.3 Making the Case for Pricing Reform

An understanding of marginal costs should form the starting point for development of an efficient pricing system for transport infrastructure and services, with second best departures from it - two-part tariffs and/or price differentiation according to the elasticity of demand - where necessary to meet budget constraints or equity considerations. Simple allocations of total cost are not generally adequate as an estimate of the costs associated with infrastructure use or provision of scheduled public transport services.

The marginal costs of transport vary strongly over time and over space while present transport prices do not. This means there are important opportunities for pricing reform. In urban areas the major pricing inefficiency is car prices that do not include the external congestion costs. Efficient transport pricing also requires a reform of public transport prices. Once car use can be priced efficiently, there are no reasons not to make public transport pay its marginal social cost. Public transport fares should therefore be differentiated between peak and off peak and also include marginal external costs.

Further extension of deregulation and commercialisation may not benefit rail transport in terms of the relative level of price compared with other modes as - while the process has led to substantial reductions in terms of prices in road freight and air transport - it has tended to raise prices for bus and rail. The explanation is in terms of the very different starting points in terms of pricing policies and subsidies between the modes. However, the effect on quality of service is also very important for mode split.

Acceptability is a key issue. Pricing reform is more likely to be acceptable where alternatives are offered, and where the revenue is ear-marked. However, the most efficient use of revenues may often be to reduce other distorting taxes (e.g. taxes on labour) and use of revenue to pursue uneconomic projects would negate most of the benefits of pricing reform.

The need for radical pricing reform has to be made on a case-by-case basis – in over half of the situations examined in European pricing projects the case for new pricing systems was not established, relative to the potential performance of existing pricing measures.

More variable pricing is likely to result in more dramatic changes within modes, than in switching of trips between modes – greater differentiation of prices by time of day/ vehicle or engine type/ location is likely to change how users make use of their existing (and currently preferred) mode. For example, the dominant impacts of more variable charges by time of day/ location are likely to be greater departure time and route adaptation, as opposed to switching between modes.

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