Transport Research Knowledge Centre

FINANCING, PRICING AND TAXATION
THEMATIC RESEARCH SUMMARY

Directorate-General for Mobility and Transport

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Thematic Research Summary:

Financing, pricing and taxation

Prepared by Marco Valerio Salucci and Zuzana Šitavancová

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Foreword

This report has been produced as a part of the activities of the TRKC (Transport Research Knowledge Centre) project of the Sixth Framework Programme.

The role of TRKC, as its predecessor project EXTR@Web, is to collect, structure, analyse and disseminate transport research results. It covers EU-supported research, as well as research financed nationally in the European Research Area (ERA) and selected global research programmes. The main dissemination tool used by TRKC is the public web portal at www.transport-research.info.

The approach to dissemination of results of the research projects, adopted by the TRKC team, includes the following three levels of analysis:

- Project Analysis, which provides, project by project, information on research background, objectives, results, technical and policy implications;
- Thematic Analysis, which pools findings of research projects according to a classification scheme based on into thirty themes, fixed for the life time of the TRKC project; the product of this analysis activity is the set of Thematic Research Summaries (TRS); the present document belongs to this set;
- Policy Analysis, which pools findings of research projects according to combinations of themes based on ad-hoc policy priorities, which are agreed with DGMOVE of the European Commission and the representative group of research users.

The present Thematic Research Summary deals with the themes of transport financing and transport pricing and taxation. The aim is to provide the reader with a structured guide to the results of research projects carried out mainly in the European Research Area (ERA). The report is intended for policy makers at the European, national and local levels, as well as interested readers from other stakeholders and from the academic and research communities.

Disclaimer

The analysis in this report is under responsibility of the TRKC project team; it does not represent the official viewpoint of the European Commission; it has not been approved by the coordinators of the research projects reviewed.

Executive summary

This thematic research summary on financing, pricing and taxation aims to provide the reader with a synthesis of results of completed European research projects related to that theme. The first part includes a brief overview of the scope of the theme and summarises the main policy developments at EU level relevant to the theme. The second part contains a synthesis of the main findings and policy implications from research projects and identifies the implications for further research. Research results are presented according to two sub-themes: Financing Tools and Pricing and Taxation.

The research projects for which the synthesis is provided are European EU-funded and national projects that are completed and with results publicly available. The EU projects have been funded under the Sixth Framework Programme. Projects that had been reviewed in the related report produced within the predecessor project EXTR@Web are only briefly summarised in the background section of each sub-theme.

In the sub-theme concerning **Financing Tools,** research has analysed harmonisation of guidelines for project assessment for trans-national projects in Europe. This includes the provision of a consistent framework for monetary valuation based on the principles of welfare economics, contributing in the long run to consistency with transport costing. Research has aimed at developing a scientifically sound approach to the funding of large transport infrastructure investments in the EU, most particularly the TEN-T projects. Different mechanisms are explored for the funding of these investments. The one which has received highest attention is the creation of an EU transport infrastructure fund financed by pricing mark-ups on transport activities.

In the sub-theme concerning **Pricing and Taxation**, research has analysed case studies to improve the level of knowledge of transport costs and the estimation of marginal social costs for all main transport modes, and has proposed improvements to the methodological and data collection procedures in order to use transport accounts for monitoring pricing policies. Research has also identified barriers and investigated issues concerning public acceptance of pricing schemes. New insights into differentiated charging as an efficient way of managing transport demand have been provided and investigations on the appropriate degree of complexity in transport charges have been made. Finally, concepts for interoperable pricing systems have been developed.

Abbreviations and acronyms used

AC	Average Cost
AFITF	Agence de Financement des Infrastructures de France
ASECAP	Association Européenne des Concessionaires d'Autoroutes et d'ouvrages à Péages
ASFINAG	Autobahnen- und Schnellstrassen- finanzierungs-aktiengesellschaft
CBA	Cost Benefit Analysis
CEC	Commission of the European Communities (= EC)
CEN	Comité Européen de Normalisation (European Committee for Standardization)
CTP	Common Transport Policy
DGMOVE	Directorate-General for Mobility and Transport (new EC Directorate-General from 2010)
DGTREN	Directorate-General for Energy and Transport (former EC Directorate-General up to end of 2009)
DSRC	Dedicated short-range communications
EC	European Commission (= CEC)
EETS	European Electronic Toll Service
EIB	European Investment Bank
ERA	European Research Area
ERDF	European Regional Development Fund
EU	European Union
EUR	Euro
FHTF	Federal Highway Trust Fund
FP5	Fifth Framework Programme
FP6	Sixth Framework Programme
GDP	Gross Domestic Product
GNSS	Global Navigation Satellite System

HGV	Heavy Goods Vehicle(s)
HICP	consumer price index
IPR	Intellectual Property Right(s)
ISO	International Organization for Standardization
ITS	Intelligent Transport Systems
MC	Marginal Cost
MSCP	Marginal Social Cost Pricing
NPV	Net Present Value
OBE	On Board Equipment
P&R	Park and Ride
PIC	price index for construction costs
PPP	Purchasing Power Parity
PP	Priority projects
PT	Public Transport
RCI	Road Charging Interoperability
RUC	Road User Charging
SUSTDEV	Sustainable Development Global Change and Ecosystems
TEN-T	Trans-European transport network(s)
TRKC	Transport Research Knowledge Centre
TRS	Thematic Research Summary
UK	United Kingdom
US	United States
VAT	Value Added Tax
VOC	Vehicle Operating Costs
VTTS	Value of Travel Time Savings

Table of Contents

1. Introduction

This report provides a structured review of the research relating to transport financing and to transport pricing and taxation, carried out in transport research projects throughout the European Research Area (ERA). This report covers two of the thirty themes in the classification scheme adopted by the TRKC project. The scheme, and the two themes which together make up this report, are shown in the table below.

Table 1. The classification scheme adopted in TRKC

Sectors
✓ passenger transport ✓ freight transport
Geographic
✓ urban transport ✓ rural transport ✓ regional transport ✓ long-distance transport ✓ EU accession issues
Modes
✓ air transport ✓ rail transport ✓ road transport including walking and cycling ✓ waterborne transport ✓ innovative modes ✓ intermodal freight transport
Sustainability policy objectives
✓ economic aspects ✓ efficiency ✓ equity and accessibility ✓ environmental aspects ✓ user aspects ✓ safety and security
Tools
✓ decision support tools ✓ **financing tools** ✓ information and awareness ✓ infrastructure provision including TENs ✓ integration and policy development ✓ Intelligent Transport Systems (ITS) ✓ regulation/deregulation ✓ land-use planning ✓ transport management ✓ **pricing and taxation** ✓ vehicle technology

This scheme was adopted to enable search facilities in the TRKC portal, and to ensure comprehensive coverage of research results and appropriate policy analysis in the Thematic Research Summaries (TRS). Definitions for each theme are found on the TRKC portal at www.transport-research.info.

In the predecessor EXTR@Web project, TRSs were produced for 28 out of the thirty themes (resulting from merging of some themes into a single TRS). The TRKC project is producing first versions of TRS for themes for which a critical mass of project results is available by February 2010, with certain groups of themes for which fewer project results are available being merged (including this one on financing, pricing and taxation).

The TRS “pricing and taxation and financing tools” produced in the predecessor project EXTR@Web (EXTR@Web, 2006), had reviewed research from European projects belonging to the Fifth Framework Programme (FP5) and national projects. The report here adds new projects to the analysis reported on in that report. The new projects are mainly European projects from FP6.

The research reviewed in this report does not represent the entire range of research dealing with transport financing and transport pricing and taxation carried out in Europe. The report focuses on research from those projects, which have prepared documentation on their results available to the TRKC team after the issue of the EXTR@Web report (EXTR@Web, 2006). A summary of the research, reported on in the EXTR@Web report, is also included to make the reader aware of a more complete range of research, which has dealt with the theme.

The report is organised as follows. Sections 2 and 3 set the scene. **Section 2** includes a brief analysis of the scope of the theme. **Section 3** provides an overview of the policy priorities at EU level, which underpin the research objectives. The sources for this section are principally European Commission documents, which have set the policy agenda such as white papers, green papers, and communications, as well as EU legislation such as directives, regulations and decisions.

Section 4 reports on the results from specific research projects. The section is structured according to sub-themes to make the broad area of research, which has dealt with transport financing and with transport pricing and taxation, more manageable. For each sub-theme, the research objectives and findings are reported on. A special focus is given to the policy implications of research results. **Section 4** is concluded with an overview of the gaps and topics for future research which could be identified by the projects. Sources for Section 4 are documents available from the projects and reporting on achievements, essentially the project final reports and selected deliverables. Section 4 is organised according to two sub-themes, one deals with financing issues, one with pricing and taxation issues.

The **Annex** includes the list of the research projects that have been reviewed in the report. Links to the projects' websites are included. In several cases these websites make the project documentation available to the public. This may include final reports and project deliverables.

2. Scope of the theme

2.1 Financing

Financing tools involve options to bridge the gap between the financial profitability of transport projects and their socio-economic viability by facilitating and promoting ways to finance the operation of transport projects. In addition, financing tools are the instruments that provide the needed capital upfront for the construction or renewal of infrastructure. Financing tools are funding mechanisms that can be divided into two major categories:

- cash management tools; and
- credit enhancement and/or investment tools.

Specific examples of approaches addressing issues about financing tools for transport projects are the following:

- assessment of positive and negative impacts resulting from new financing principles;
- financing schemes for transport systems operations;
- socio-economic financial and risk analysis framework;
- provision of capital for investment; and
- financing to cover construction/renewal costs.

Current pricing instruments for transport often result in on-going financial deficits and/or generate insufficient capital funds to finance, what are sometimes major, investment needs. The traditional, and in many places the prevailing, means of financing these on-going deficits and investment needs is through public budgets. However, this is increasingly subject to criticism as other sectors of public concern place competing demands on public budgets. These criticisms have created a pressure to identify alternative means of generating project finance, both to cover capital investment needs and to cover current costs, including the costs of servicing the capital.

Whilst capital may be provided by either the public or the private sector, private finance is not in general an option for covering current costs. For this the options are user charges, public budgets, value capture and cross subsidy. This immediately illustrates the importance of looking at funding packages rather than individual instruments, as private finance always needs to be associated with other sources of funding to service the capital.

A key factor in the introduction of private capital into public transport is the sharing of risks. Commercial profit is dependent on the investment time, interest rates and risk management. Because of the long time periods involved, these risks may be very high.

2.2 Pricing and taxation

Pricing is a central tool for resource allocation in the view of economists but a more general definition of it refers to measures of making up the price for certain commodities and services.

Pricing and financing are closely linked, as pricing represents one of the most important methods of raising capital for the financing of works, acquisition of equipment/rolling stock, etc. In the context of transport, pricing has another equally important role, since it can be a key mechanism for influencing the demand for travel for each mode of transport, in order to achieve transport policy goals, such as economic efficiency and environmental sustainability.

Taxation is a system or regulation of imposing tax on the consumers for the consumption/purchase of certain commodities and services. Taxes levied on transport are, with rare exceptions, either related to the right of access or to the use of the infrastructure, and are a simple and practical instrument for raising public revenues. In the context of transport, both pricing and taxation could act as management measures to regulate the transport market in addition to the purpose of raising revenues.

Issues relevant to pricing and taxation are reflected in the following objectives of research:

- develop methodologies to determine charges levied with the aim of internalising the external costs of transport, in order to secure more efficient use of the transport network and environmentally sustainable transport;
- develop a more detailed understanding of transport costs on which to base transport prices;
- identify barriers for the implementation and public acceptance of pricing and taxation instruments;
- evaluate the effects of new charging principles, pricing schemes and tolls on modal split, traffic volumes and trip patterns;
- develop an interoperable electronic toll system for road transport in European countries.

3. Policy context

3.1 Financing

According to the 2001 European Transport Policy White Paper (CEC, 2001), a large number of political measures and instruments such as financial tools will be needed to launch the process which, over the next 30 years, will lead to the kind of a sustainable transport system set out in the White Paper. These include the adequate funding of transport infrastructure needed to eliminate bottlenecks. The Mid Term Review of the 2001 White Paper (CEC, 2006) has underlined that user charges should contribute more to the financing of the most commercially viable parts of the transport networks. Also it is stated that public-private partnerships should be used more as they can accelerate the implementation of projects, increase value for money and ease pressure on public finances.

The legal basis for establishing Trans-European Networks (henceforth TEN) in the areas of transport, energy and telecommunications infrastructure can be found within articles 154-156 of the Treaty establishing the European Community. TENs are regarded as central to the establishment of a European internal market and guarantee optimal economic and social cohesion, to the benefit of both economic operators and communities.

The contribution of the Common Transport Policy (CTP) to the achievement of TEN-T (Trans-European Networks – Transport) relies on three pillars:

- the preparation of guidelines covering the objectives, priorities and measures aimed at identifying projects of common European interest;
- the adoption of measures aimed at favouring the interoperability of networks;
- support to specific projects, with feasibility studies, loan guarantees and interest-rate subsidies.

The Commission and the Member States coordinate the interventions. The Commission can also cooperate with third parties to promote projects and ensure the interoperability of the networks.

According to the recent Green Paper on the TEN-T (CEC, 2009a) the TEN-T are composed of 95,700 km of roads, 106,000 km of rail (of which 32,000 km are high-speed links), 13,000 km of inland waterways, 411 airports and 404 sea ports. Furthermore, substantial funds are being invested in the TEN-T to expand this capacity further. The Motorways of the Sea are a key element of TEN-T (CEC, 2005; CEC 2007a). Today plans are under development to link the TEN-T with neighbouring European and African countries (CEC, 2007b).

In order to focus the Community's efforts and resources on key interventions, a list of priority projects (PPs) was identified in 1996 subsequently updated in 2004 and now including 30 PPs. This approach was chosen as a result of the large amount of financing necessary to complete the entire TEN-T.

However, a number of issues still hinder the ability of the policy to deliver results efficiently and within the timescale originally scheduled, such as (CEC, 2009a):

- in some cases, public and political opposition to construction of new transport infrastructure, often on environmental grounds;
- limited transparency in the selection of projects;
- a lack of financial resources both at Community and Member State level;
- poor management, monitoring and coordination of interventions; and
- the technical complexity of some projects (often due to border crossings).

While the Community's direct involvement in the financing of TEN-T projects has been increasing in recent years, the Community's budget is still unable to entirely cover the necessary investment costs. The majority of the burden falls thus on Member States, which often themselves suffer from funding constraints and have other priorities at the State level.

To date only four of the PPs have been completed from an original list of 14 priority projects (planned to be completed by 2010).

The selection and funding of such infrastructure projects has predominantly been the responsibility of the individual Member States, although most of them contain (often multiple) cross-border sections. The main existing European Community sources of funding for the TEN-Ts are the TEN-T budget line itself, the Cohesion Fund and the European Regional Development Fund (ERDF). Although not the only cause of delays in the implementation of the TEN-Ts, under the current funding procedures, by the end of 2003 only three of the 30 priority projects had been completed, only a quarter of cross-border funding had been found and 20 years would be needed to complete the priority axes at the current rate of investment. The 2009 TEN-T Green Paper (CEC, 2009a) states that the management of all available budgetary resources needs to be better coordinated.

At the Member State level, the German federal model of infrastructure procurement bears most resemblance to a potential European structure of a true transport infrastructure fund. Several countries also have recent experience with national transport infrastructure funds (such as ASFINAG in Austria and AFITF in France) from which useful lessons can be drawn for the formation of a European fund. The private sector is, in addition, together with the EIB, a potentially important source of finance for the TEN-Ts.

The main example of federal funding of transport infrastructure projects is the US. The Federal Highway Trust Fund (FHTF) was set-up to finance the National System of Interstate Highways using highway user tax revenues. The original system was completed by 1992. The Fund is mainly financed by dedicated taxes on motor fuel, collected by a federal agency. The federal matching grants, on average 80% of the total costs, are paid out by the agency based on technical criteria of the projects. This leaves the actual project selection to the states. While the federal set-up in the US differs from the EU system, some important lessons can be drawn with regard to how an EU fund should be organised.

Current EU policy allows for tolls on Heavy Goods Vehicles (HGV) (Eurovignette) and rail infrastructure charging but does not extend as far as full marginal social cost pricing on all modes.

3.2 Pricing and taxation

In the 2001 White Paper on transport policy (CEC, 2001), charging for infrastructure is recognised as one instrument, together with fuel tax, for integrating infrastructure costs and external costs, and thus replacing existing transport system taxes. The White Paper stressed that while transport may be too heavily taxed it is above all badly and unequally taxed as users are all treated alike, irrespective of the infrastructure damage, bottlenecks and pollution they cause. The consequence is a considerable distortion of competition both between transport operators and between modes of transport. Infrastructure charging, based on the “user pays” and “polluter pays” principles, is advocated as a particularly effective means of managing congestion and reducing other environmental impacts, and fuel tax as a means of controlling carbon dioxide emissions.

The principles of infrastructure charging had been discussed in the Green Paper “Towards Fair and Efficient Pricing in Transport” (CEC, 1995), in the White Paper “Fair Payment for Infrastructure Use: a Phased Approach to a Common Transport Infrastructure Charging Framework in the EU” (CEC, 1998), and in the series of reports of the High Level Group produced in 1998 and 1999.

In the road sector, the Directive 1999/62 on the charging of HGVs for the use of certain infrastructures (the Eurovignette Directive) recognised the “user pays” principle by allowing Member States to levy distance-based charges (tolls) to recover the cost of construction, maintenance and operation of infrastructure.

The proposal of the Commission (CEC, 2003) for a new Directive amending the Eurovignette Directive 1999/62 aimed to change the framework for tolls and vignettes for goods vehicles over 3.5 tonnes, with the introduction of a higher differentiation including: distance travelled, accident and environmental costs, congestion levels by time period, local population density, vehicle emission classes. In addition, the proposal provided the methodologies for the calculation of the different toll components.

The road charging Directive subsequently approved in 2006 (Directive 2006/38) represents the first step towards taking account of external costs: it will allow a greater variation in tolls to reflect congestion, and toll variations to reflect the pollution caused by vehicles. The Directive makes provision for Member States to be able to increase tolls with a “mark-up” on roads in particularly sensitive mountainous regions. The income from these mark–ups must be used to fund alternative transport infrastructure in that corridor or zone. The new Directive also establishes the principles for calculating tolls and limits frequent user discounts, to ensure that they are fair, proportionate, transparent and non-discriminatory.

In the rail sector, as a follow up of the infrastructure charging debate, the Directive 2001/14 on rail infrastructure charging has required marginal social costs to be used as the basis of charging, whilst permitting supplementary charges where necessary for cost-recovery purposes. The provisions for infrastructure charging of rail transport are compulsory while in the road case they are not. Directive 2001/14 is interpreted differently by the various Member States. This has generated a wide range of different systems of rail infrastructure charges.

In 2006 the Commission was asked by the Parliament to prepare a communication which should provide a general framework for the internalisation of external costs. The preparatory work has led to the issue of a handbook on the estimation of external costs in the transport sector based on a review of best practice (CE Delft et al., 2008). This handbook is intended to serve as the basis for future calculations of infrastructure charges.

The communication on the strategy for internalisation of external costs has been issued in July 2008 (CEC, 2008a). The strategy sets out how external costs can be internalised in all modes of transport. Social marginal cost charging is set as principle for internalisation as this will provide the users with the right signals. It is recognised that the EU has already started to internalise external costs. This is accomplished by existing rules on minimum tax levels for motor fuel, although most maritime and aviation uses are exempt. In addition, the Commission has proposed to include aviation in the EU Emissions Trading System (ETS) and to incorporate a CO_2 component in registration and annual circulation taxes for cars.

In the road sector the strategy on internalisation proposes an amendment to the Directives on infrastructure charging for HGVs (Directives 1999/62 and 2006/38). This proposal is outlined in a separate document (CEC, 2008b). According to the existing Directives toll rates may be varied according to vehicle emission standards or congestion levels but under a constraint of revenue neutrality. Except for few cases, this option has not been exerted because of the complexity for infrastructure operators to adjust their charging structure to the demand response in a way that keeps revenues constant. Thus the existing Directives do not enable Member States to apply optimal pricing. This means that sufficient incentives cannot be put in place for operators to modernise their fleet with cleaner vehicles and to adapt their route planning and logistics towards more sustainable practices.

The proposal for amending the existing Directives (CEC, 2008b) enables Member States to integrate in tolls an amount which reflects the cost of air pollution and noise pollution caused by traffic. During peak periods it also allows tolls to be calculated on the basis of the cost of congestion imposed upon other vehicles. The current scope of the existing directives is extended beyond the TEN-T to avoid inconsistent pricing schemes between major corridors and other inter-urban roads.

The strategy for internalisation (CEC, 2008a) addresses other modes too. The Directive 2001/14 allows internalisation of external costs in the rail sector. In the case where this would lead to an increase in revenues for the infrastructure manager internalisation is allowed only if there is an equivalent increase for competing modes. The strategy notes that the proposed revision of the directives 1999/62 and 2006/38 on HGVs will make it possible to internalise costs in road transport and therefore in rail transport.

For inland waterways the strategy announces the internalisation of all external costs in the sector following the NAIADES Communication, and, for maritime, where internalisation has yet to begin, it commits the Commission to suggest acting if the International Maritime Organisation does not agree concrete measures to reduce greenhouse gas emissions. Commission suggestion for action may include integrating the maritime sector into the EU's Emission Trading System.

The 2009 Commission's Communication on sustainable future for transport (CEC, 2009b) states that internalisation charges to complement revenues from energy taxation are likely to be necessary in any event, since excise duties on oil derivatives will presumably decline with wider diffusion of vehicles running on alternative sources of energy. The 2009 action plan on urban mobility (CEC, 2009c) has announced a study on the efficiency and effectiveness aspects of various pricing solutions, including implementation issues such as public acceptability, social consequences, cost recovery, availability of ITS tools and how urban pricing policies and other green zone arrangements can be effectively combined.

The Directive 2003/96 on harmonisation of energy taxation has laid down a series of minimum rates of excise duty on energy products. Above these minimum rates Member States are free to set their national excise rates at levels they consider appropriate. The practical consequence in the road sector has been that the rates for commercial diesel differ a lot from one Member State to another. Since operators competing on the same markets do not all enjoy the same possibilities of purchasing low-tax fuel, "tank tourism" creates distortions of competition between different categories of hauliers: hauliers who can benefit from low taxed fuel have increase their share of the market at the expense of hauliers forced to pay higher fuel taxes.

Therefore the Commission put up a proposal to amend the energy tax directive (CEC, 2007c). The Commission proposed to increase in two steps the minimum rate of excise duties. The proposal furthermore foresaw that in any given Member State, the rates applicable to non-commercial diesel and to unleaded petrol must not be less than that applied to commercial diesel. Otherwise, non-commercial diesel and unleaded petrol would be treated more favourably than commercial diesel.

The energy taxation Directive 2003/96 provides Member States with the option of applying a reduced rate of excise duty to pure or blended bio-fuels. According to this Directive international air transport and maritime transport are exempted from fuel taxation. The Commission is proposing to remove the exemption existing for international air transport.

In the air sector, on the premise that in the absence of a framework regulating the essential features of airport charges, basic requirements in the relationship between airport management bodies and airport users may not be met, a Directive on airport charges (Directive 2009/12) was adopted with the objective to set common principles for the levying of airport charges at Community airports.

Regarding interoperability of road toll systems the Directive 2004/52/EC had set the framework for a European Electronic Toll Service (EETS), by which road users only subscribe to a single contract with an EETS provider in order to pay the charges related to any charging scheme requiring an on-board unit. The detailed definition of the EETS, including technical, procedural and legal issues and a schedule for implementation, has been set in a European Commission decision adopted in October 2009.

4. Research findings

4.1 Introduction

The research synthesised in this report deals with two sub-themes, as shown in the figure below.

The first sub-theme deals with financing tools. It focuses on harmonisation of guidelines for project assessment for trans-national projects in Europe. This includes the provision of a consistent framework for monetary valuation based on the principles of welfare economics, contributing in the long run to consistency with transport costing. Research has aimed at developing a scientifically sound approach to the funding of large transport infrastructure investments in the EU, most particularly the TEN-T projects.

The second sub-theme deals with pricing and taxation. In this area, research has offered new insights into knowledge and estimation of transport costs. Barriers to the implementation of pricing schemes and differentiation of charging schemes have also been investigated. Finally, interoperable road pricing systems have been developed.

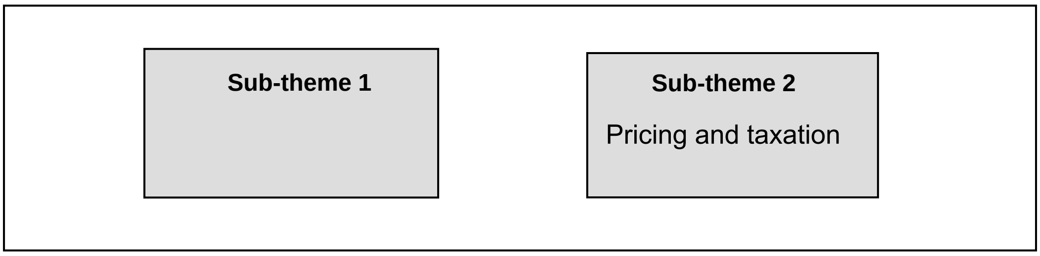

Table 2 below shows the EU-funded projects, which have dealt with each of the sub-theme. Further details of projects listed in this table are given in the Annex. The Table includes:

- projects which had been synthesised in the EXTR@Web TRS and which are briefly summarised in the background of the following sub-sections;

- completed projects which are synthesised in this TRS and for which the following sub-sections report on research objectives, research results, policy implications and implications for further research;
- projects which are still on-going or which, although completed, have not yet made results publicly available.

Table 2. Projects relevant to the theme

Sub-theme	Contributing projects
1. Financing tools	Projects covered in this report: HEATCO, FUNDING Projects covered in the EXTR@Web report: Alternative urban transport funding: Cost-benefit analysis of alternative public trans-port funding in four Norwegian cities; Funding tomorrow's transport systems; New models for funding of transport infrastructure services Other FP6 projects with results not yet available: *ENACT*
2. Pricing and Taxation	Projects covered in this report: CATRIN; CURACAO; DIFFERENT; GRACE; IMPRINT-NET; ARENA (SE); Express buses in the Stockholm congestion charging trial (SE). Projects covered in the EXTR@Web report: CUPID; DESIRE; IMPRINT EUROPE; MC-ICAM; PROGRESS; RECORDIT; TELEPAY; UNITE; D3 (CH); SVI 1999/317 (CH); SVI 2000/442 (CH); UG346 (UK); Multi-modal freight model for distance-based HGV charging (UK), RCI. Other FP6 projects with results not yet available: *ENACT; ASSET*

4.2 Sub-theme 1: Financing tools

4.2.1 Background

Research on financing tools reported in the Thematic Research Summary produced in EXTR@Web (EXTR@Web, 2006) included primarily national projects. The difficulty of mobilising capital is one of the main obstacles to carry out infrastructure projects. Transport infrastructure funding in Europe takes place against a backcloth of a multitude of different institutional setups and at different levels of decision making. At the national level there is a wide variety of approaches to the procurement of infrastructure including infrastructure funding agencies and private sector involvement. One of the project reviewed dealt with the institutional and financial reforms on funding transport systems, including road infrastructures, in Switzerland. Another project investigated funding of public transport services in cities in Norway.

The EU-funded research reviewed in EXTR@Web (2006) had addressed the funding of European infrastructure projects but only indirectly. Insights on the optimal use, from a welfare viewpoint, of the revenues from social marginal cost pricing schemes have been provided. Options for use have included earmarking to infrastructure investment.

4.2.2 Research objectives

A first strand of research has proposed harmonised guidelines for project assessment for trans-national projects in Europe (HEATCO, 2006a; HEATCO, 2006b). This includes the provision of a consistent framework for monetary valuation based on the principles of welfare economics, contributing in the long run to consistency with transport costing. These guidelines have been developed, based on latest research results on the different aspects of transport project appraisal and on an analysis of existing practice in the EU countries and Switzerland. Case studies on four TEN-T projects were selected, the proposed assessment methodology applied and compared with the national methodologies and outputs.

At the European level the Member States are the movers of nearly all strategic transport infrastructure investment, with the EU institutions holding both a political influence and the capability to contribute via the funding mechanisms at its disposal. Another strand of research has aimed at developing a scientifically sound approach to the funding of large transport infrastructure investments in the EU, most particularly the TEN-T projects.

Different mechanisms are explored for the funding of these investments. The one which has received highest attention is the creation of an EU transport infrastructure fund financed by pricing mark-ups on transport activities.

The economics of infrastructure funds and the mark-up method are first explored conceptually (FUNDING, 2006a). The conceptual phase leads to the formulation of a limited number of alternative scenarios for a European infrastructure fund and for the use of mark-ups (FUNDING, 2006b). Modelling is used to assess taxation scenarios which could be used to finance the infrastructure fund (FUNDING, 2006c).

For the infrastructure fund three questions are examined: how to spend the resources of the infrastructure fund (what type of projects, subsidies or loans), how to finance the operation of the fund (contributions out of general budget or earmarked taxes on transport) and what decision rules to use for the fund (political body versus agency, accountability issues). These questions are explored using economic theory (political economy, risk pooling, and network spillovers) but we also draw upon experience with infrastructure funds and mark-ups in EU, US and World Bank.

4.2.3 Research results

The HEATCO project recommends using the following definition of capital costs of the infrastructure investment:

- construction costs, including materials, labour, energy, preparation, professional fees and contingencies;
- planning costs, including design costs, planning authority resources and other planning costs;
- land and property costs, including the value of the land needed for the scheme (and any associated properties), compensation payment necessary under national laws and the related transactions and legal costs;
- disruption costs, e.g. the disruption to existing users to be estimated using the same values of time as are used for travel time savings arising from the scheme;

Furthermore the cost assessment should be based on the following two general principles;

- costs should be attributed to the project year in which the resources become unavailable to alternative uses;

- it is necessary to distinguish between costs incurred before and after the decision whether to go ahead with the project or not; and retrievable and non-retrievable costs.

As the cost-benefit analysis only concerns costs that will be incurred due to the decision to go ahead with the project, non-retrievable costs incurred prior to the decision should not be included in the cost-benefit analysis. The residual value is an item in the appraisal which captures the net benefits beyond the formal evaluation period. If the evaluation period is longer than the lifetime of a certain part of the infrastructure, reinvestments are necessary. If the evaluation period is shorter than the lifetime of another part, the residual value of this part has to be taken into account. In the cost-benefit analysis, the capital costs of the infrastructure are reduced by the net present value of the residual value of the infrastructure. HEATCO recommends a pragmatic approach for estimating the residual value, which includes:

- determination of the fixed lifetime of the infrastructure - or its sub-components
- determination of a depreciation profile

A range of recommended lifetimes for road and rail projects is provided by HEATCO.

The HEATCO approach includes as well the costs of maintenance, operation and administration and the changes in infrastructure costs on existing network. The distinction between (short run) fixed costs and the variable costs (costs that vary with traffic use) are determined on the basis of national accounts/statistics and a general classification of cost categories. In order to estimate these costs, it is recommended - for pragmatic reasons - to assume that the marginal costs per vehicle can be approximated by the average variable costs and that average variable costs/marginal costs are constant (and not for instance increasing with traffic).

One of the major purposes of the four TEN-T Case Studies was to test if the methodology and its applications in to the practice. This is the case, since the HEATCO methodology was successfully applied in all four cases. No major difficulties were reported on scientific, methodological or technical problems related to application of the HEATCO guidelines. Problems observed were rather of practical nature, such as difficult access to relevant information and applicability of data. All these problems would have occurred as well with any other methodology to be used for investment appraisals.

Another purpose of the Case Studies was to show the major differences in European appraisal methodologies compared to HEATCO. The most important differences can be summarised as follows:

- Market prices vs. Factor Costs - Some national appraisal methodologies use market prices for the assessment of costs. The HEATCO guidelines recommend the use of factor costs. The difference between the two approaches is that factor prices reflect the production costs since they do not include taxes and subsidies. Comparing the two approaches, market prices are significantly higher than factor costs. In the researched countries market prices are 18%-34% higher than factor costs. Since it is only a unit of account, the outcome of the appraisal is not influenced, however.

- The social discount rate - The social discount rate indicates how much future consumption a household is ready to give up consuming now. Future costs and benefits are discounted with this rate in order to calculate the Net Present Value. A high discount rate requires a fast return on investment and thus has a high time preference. The discount rates used in Europe differ considerably. It is at 3% in Germany, 3.5 in the UK, 5% in Italy and 6% in Denmark. HEATCO recommends the use of National values and sensitivity testing at 3%. Sensitivity calculations show, that the choice of the discount rate has a strong impact on the project output.
- The appraisal period - The appraisal period determines over which period costs and benefits have to be taken into account. HEATCO recommends appraising the project during planning and construction and then another 40 years. The appraisal period in Denmark amounts to 50 years and in the UK 60 years. Direct effects of the appraisal period on the NPV have not been assessed, however it can be concluded that a longer appraisal period tends to result in higher benefits.
- Adjustment of costs with Purchasing Power Parity - From the European perspective the comparison of projects in different countries is of utmost relevance. Thus, HEATCO recommends PPP adjustments to take into account the different purchasing power of the population affected. Since the adjustment with PPP affects cost as well as benefits, the BCR will remain unchanged, while the NPV varies. The PPP adjusted NPV in UK and Denmark is 11% and 17% lower than the non-adjusted value, while in Greece an adjustment with PPP increases the NPV by 27%.
- Share of benefits - The Case Studies also provide the opportunity to make an international comparison of transport investment appraisals using a comparable methodology for projects, which are very different in nature. The analysis reveals that the Value of Time plays a dominant role in the appraisals. However, if the producer surplus is deducted more than 90% of total user benefits and externalities are generated by VTTS and VOC. While VTTS seems to be crucial for all appraisals, environmental effects only comprise a small share of the benefits: They range between -1% and +11% of all benefits. The reduction of accidents contributes with 0 to +16% to the overall benefits.

The recommendations relating to accounting procedures are:

- Factor costs should be the unit of account. This requires measures expressed in market prices - which include indirect taxes and subsidies – to be converted to factor costs.
- All unit values should be expressed in a common price base year of 2002 but that this base year should be adjusted regularly, according to data availability in future years. This entails conversion from current prices to constant prices.
- In order to convert current price measures to constant price the price index for construction costs (PIC) should be used for construction costs whilst the consumer price index (in the EU measured by the HICP) should be used for user benefits and externalities.
- Changes in prices relative to changes in the general price level should be accounted for by adjusting specific prices on the basis of how the long run average trends in these prices differ from the long run trend in the general price level.
- Changes in the future value of a resource should be fully reflected in the unit value(s) related to that resource, on the basis of national GDP growth rates.
- Unit values should be expressed in base year nominal exchange rate EUR and in purchasing power equivalents. Where use of nominal EUR and PPP-equivalent EUR give different recommendations using the CBA decision-rule, the choice of which exchange rate to use will be dependent on the preference of the decision-maker.

The conceptual investigation of the economics of infrastructure fund has first addressed pricing and investment decision on parallel and serial networks, with and without regulatory intervention (FUNDING, 2006a). In parallel networks, where parallel links fall into different countries, transit traffic shifts to the link where cost is lower. This acts as disincentive for a country to invest. User pricing will give incentives with competition between the parallel links preventing tolls from becoming too high. In serial networks with adjacent links falling into different countries the problem is the potential for excessively high user prices because each country charges a monopoly margin without taking into account the revenue reduction for the other country.

Another issue which has been explored conceptually is the relationship between cost structure, pricing and subsidies (FUNDING, 2006a). A marginal social cost pricing (MSCP) is not always sufficient to cover the cost of an infrastructure project. There are three ways to cope with this problem. Either the user of the infrastructure project pay more (internal mark-up), the infrastructure is financed by letting the whole transport sector (even those who do not use the specific infrastructure) contribute (external mark-up), or non transport money from the general budget is used.

The so-called cost recovery theorem, based on a few simplifying assumptions, states that the ratio between optimal user charges and the capacity cost is equal to the degree of scale economies in capacity expansion, which may be as low as 0.2 while for road can be close to 1. An internal mark-up (price above MSCP) to finance the investment project will lead to a welfare loss due to overpricing of the infrastructure use. If, in addition, there is an underpriced existing substitute for this project (typically road or air traffic for a rail project), there will be an additional welfare loss since part of the users that decided not to use the overpriced mode anymore will switch to the underpriced mode and increase the existing inefficiency.

Surveys of European and US experience of infrastructure funds have been carried out (FUNDING, 2006a). At the EU level the main existing European Community sources of funding for the TEN-T are the TEN budget line itself, the Cohesion Fund and the European Regional Development Fund (ERDF). At the national level the German federal model of infrastructure procurement bears more resemblance to a potential European structure for an infrastructure fund and has therefore been analysed in detail. The main federal planning instrument in Germany is the federal infrastructure master plan. This includes a list of priority projects for investments ranked according to the results of a project appraisal. A quota system is then applied for the distribution of investments between the states. The federal government is responsible for providing federal motorways and trunk roads while the states administer them.

Several EU countries have established transport infrastructure funds via financing agencies as a means of managing and providing infrastructure financing independent of public budgets. Prominent examples have been set up in Austria (ASFINAG), in Germany (VFIG) and in France (AFTIF). While ASFINAG is responsible only for motorways, VFIG and AFTIF have been set up with a view to financing multi-modal projects. ASFINAG obtains capital from the market with the loans being guaranteed by the Austrian State. The refunding of the investments is done via the user charges which are set by federal government. The agency is, however, involved in the selection of projects for investment, in contrast to VFIG and AFTIF who are not.

Also a review of the infrastructure funding system in the US has been carried out (FUNDING, 2006a). In the US, the Federal Highway Trust Fund (FHTF) was set-up to finance the National System of Interstate Highways. The Fund is mainly financed by dedicated taxes on motor fuel, collected by a federal agency. A great part of the FHTF funds has since been used to finance other transport-related projects than interstate highways. The federal agency does not choose the funded projects: it only confirms that the project can receive federal funding if it complies with the criteria. This leaves the actual project selection to the states.

About every five years the Congress approves a new set of legislation defining the appropriation formulas for the disbursement of the funds. The formula takes into account factors like the state's length of road network, the number of motor vehicles in the state and the annual contributions of the state to the FHTF. The Congress does not decide on the project selection of the FHTF funds. However, the Congress representatives have developed a practice of requiring an increasing number of "earmarks" or "demonstration projects", i.e. additional projects from other federal funds that they require as a condition for their approving vote for the legislation package. This increasing practice of "pork barrelling" (the appropriation of government spending for localised projects, secured primarily to bring money to the district of an elected politician) has increased the total transport budget and made the transport expenditures less efficient.

Based on the results reported on above, different scenarios have been developed for funding the TEN-T projects (FUNDING, 2006b). A first scenario has moderate subsidy, a second scenario has high subsidy. A third scenario is as the moderate scenario but with in addition an equity component as countries with relatively low GDP receive an extra subsidy. Subsidy comes from EU and Member States. The EU contribution would be financed by an infrastructure fund while the Member States are required to provide a matching grant. The remaining investment costs are covered by user charges.

The magnitude of the subsidy is differentiated by transport mode in the light of the cost recovery theorem, being different the returns to scale in capacity costs. As the main reason to have the EU involved in subsidising investment costs is the spill over of benefits when there are many foreign users, it is suggested making the EU subsidy share proportional to the share of foreign users. The EU infrastructure fund would be financed with extra charge on all traffic flows and contributions from Member States. In the high subsidy scenario an important share has to come from extra charge on the road sector as this sector has the largest market share.

Subsequent research (FUNDING, 2006c) has assessed the welfare costs of financing the total EU and Member State subsidies for TEN-T projects by raising money from the transport sector. Different taxation scenarios which can be used to finance the infrastructure fund under the moderate and high subsidy scenarios above have been developed. These include additional road tolls, flat or differentiated in various ways (by vehicle type, time period, geographical area and country), and an additional fuel tax for all modes.

The TREMOVE[1] model has been used to quantify welfare for the different scenarios. Welfare results from summing up consumer and producer surplus, external costs, and tax revenues for the government. First the total extra tax revenues needs have been estimated for the moderate and high subsidy scenarios. Then the welfare cost of 1 EUR levied via additional transport taxation has been estimated for 2010 and 2020. The welfare cost is defined as the ratio of additional tax revenues plus welfare loss to additional tax revenues.

The result is that this cost is close to 1 in both scenarios with all different types of taxation considered. For the most differentiated road toll we have the best performance with a welfare cost slightly lower than 1 indicating a welfare gain.

4.2.4 Policy implications

The guidelines for project assessment and transport versus costing in Europe have been developed by analysing:

- the national assessment practice in the EU Member States
- newest research results e.g. on projects developing methods for impact assessment, taking into account the recommendation and advice from the participants of two HEATCO workshop and the results of a survey to substantiate values for assessing noise annoyance and time costs.

It is important to illustrate how monetary data can be expressed in a way such that all monetary inputs into the TEN-T project appraisal process are expressed in consistent forms with each other. This consistency can be brought about by adopting:

- a common unit of account (to account for taxes and subsidies),
- a common price base year for prices and values,
- a common currency.

In general, transport benefits, revenues and costs accrue at the level of Member States or regions within states and therefore most infrastructure decisions are properly decisions for Member States (or more locally within Member States). In such cases there is no justification for EU intervention in decisions or funding for such infrastructure provided EU rules regarding competition, procurement, single market etc are observed.

Research on the economics of infrastructure funding (FUNDING, 2006a) has suggested solutions for cases of serial networks crossing two or more countries: the excessive charge problem can be overcome by cooperative solutions between two price setters or by attributing the concession for the pricing to one only infrastructure manager.

[1] www.tremove.org

The survey of European experience on infrastructure funding (FUNDING, 2006a) has highlighted issues which need to be tackled when introducing new schemes for funding TEN-T projects. In particular a few recommendations for the set up of an infrastructure fund at European level have been proposed.

- Clear rules are necessary to determine whether transport infrastructure is eligible for funding, and the involvement should be restricted to projects that clearly fulfil trans-boundary transport functions benefiting EU objectives in order to avoid over subsidisation and excessive involvement in regional transport infrastructure investments.
- There needs to be a clear division of responsibilities between the European and the Member State level with control mechanisms installed over the whole procurement process to protect the interests of the financing actors.
- An infrastructure fund promises more flexibility and higher stability of the investment budget than funding from general budgets. Currently there is no autonomous funding mechanism for cross-border infrastructures of European interest.
- A future funding organisation is likely to contain elements of grant contributions from government as well as funding from user charges and private sector involvement in financing and project delivery. The clear assignment of the powers and responsibilities of the parties within the model is crucial to efficient delivery.
- There is a need not only for financial but also for organisational co-ordination of cross-border infrastructure procurement. First steps towards this have been taken by the introduction of European co-ordinators for the TEN-T priority axes.
- The setup of an infrastructure fund needs to consider carefully whether a multimodal approach is taken, revenues from user charges are earmarked and directly transferred to the fund, and whether the fund can borrow money from the capital market.
- In the case of the private participation, rules are necessary to determine who bears the risk of cost overruns; experience shows that privately owned companies (and in particular railway network companies) need planning security and this issue must be considered in the financing rules of a fund.
- Private involvement in infrastructure provision requires support in the form of long-term commitment of the public partner.
- Assuming that the larger airports can recover their costs through user charges, privatisation of airports may require close monitoring and regulation of charges to prevent abuse of monopoly powers. Subsidising airports at the

local and regional levels needs to be closely monitored to prevent market distortions.

The main implication which could be derived from the survey of the interstate highway funding system in the US (FUNDING, 2006a) is that the share of the EU level in the financing of transport investments should be limited and tied to the non-local benefits: this is the major safeguard against pork barrel politics and could avoid that Member States claim every year their share of the budget.

4.3 Sub-theme 2: Pricing and Taxation

4.3.1 Background

A first strand of research on pricing and taxation reported in the Thematic Research Summary produced in EXTR@Web (EXTR@Web, 2006) was concerned with investigations to better understand transport costs and consequently to support a more efficient definition of pricing policy by developing pilot accounts for all transport modes and marginal cost estimations based on case studies. In particular, research developed a methodology for calculating internal and external costs of intermodal freight transport.

Another strand of research focused on the analysis of pricing policies with a view of developing recommendations for implementing the required pricing reforms for a fair and efficient pricing. In particular, barriers to the implementation of pricing schemes and public acceptance issues were analysed and possible way for overcoming them proposed.

A further strand of research presented and analysed case studies concerning the development/demonstration of transport pricing schemes and systems. More specifically, research reviewed integrated urban transport pricing schemes, based on the concept of marginal-cost pricing, a set of best designs for future inter-urban road pricing schemes for heavy vehicles, and an interoperable electronic toll system actually implemented in real traffic in several European countries. Research also studied the technical, legal and commercial feasibility of a payment system through mobile phones.

A final strand of research reviewed economic instruments. Starting from the analysis of costs of intermodal transport, an assessment of the reform of the taxation system in the

European countries was performed with a view of increasing competitiveness of intermodal transport compared with road transport. Furthermore, research has assessed the impacts of a bonus-malus system for cars in terms of CO_2 emission reductions and the short-term impacts of fuel price increases on fuel sales and car purchase decisions.

4.3.2 Research objectives

The development of fair and efficient pricing policies requires in-depth knowledge of transport costs as well as of the mechanisms of cost formation in order to correctly quantify the marginal social costs of a mode of transport and encourage a fair competitiveness between modes with a view of developing sustainable transport systems. In this respect, a first group of research objectives has concerned with the analysis of case studies in order to improve the level of knowledge and estimation of marginal social costs for road, rail, air and waterborne (CATRIN, 2009; GRACE, 2008; IMPRINT-NET, 2008) transport and has provided guidance on methods for determining charges (GRACE, 2008; IMPRINT-NET, 2008). Furthermore, research has also provided suggestions to improve the methodological and data collection procedures for using transport accounts to monitor the implementation of pricing policies in an enlarged Europe (GRACE, 2008).

A critical aspect of pricing policies concerns their successful implementation. As a consequence, another group of objectives has addressed issues concerning the implementation of fair and efficient pricing schemes. In particular has identified barriers and investigated issues concerning public acceptance (IMPRINT-NET, 2008; GRACE, 2008; CURACAO, 2009). Research has also provided new insights into differentiated charging as an efficient way of managing transport demand, externalities and equity aspects (DIFFERENT, 2008), and has made investigations on the appropriate degree of complexity in transport charges (GRACE, 2008). Finally, in Stockholm, a congestion charging trial has been implemented as a way of managing transport demand (Express buses in the Stockholm congestion charging trial).

A final group of objectives relates to the development of interoperable road pricing systems. One of the objectives of the European Commission is the creation of an interoperable road charging system and the Directive 2004/52/EC (CEC, 2006) establishes the conditions for the development of a European Electronic Toll Service (EETS), which ensures the interoperability of electronic road toll systems in the Community. In this respect research has been conducted to develop an open and integrated framework for road charging interoperability (RCI, 2008), as well as to develop and demonstrate an interoperable road user charging system for HGVs (ARENA, 2008).

4.3.3 Research results

4.3.3.1 Knowledge and estimation of transport costs

Research has investigated and reviewed issues on transport cost categories and their assessment for all main transport modes.

Research has shown that there are many methodological approaches for estimating marginal costs, which strongly depend on data availability and the transport mode considered (GRACE, 2008). In general a good level of knowledge has been achieved for road, rail and air modes costs and their assessment, while there seems to be no clear relationship between charges and infrastructure costs for waterborne transport. However, it is still necessary to develop a consolidated approach to the estimation of wear and tear costs for road transport, wear and tear and scarcity costs for rail transport, and congestion costs at airport for air transport. It is also necessary to overcome the difficulties in estimating environmental costs of waterborne transport (IMPRINT-NET, 2008).

The situation-specific nature of most external costs implies that their accurate estimation can only be performed considering every set of circumstances which determine their generation. Consequently, research has attempted to generalise transport cost estimations by trying to understand how circumstances affects costs. This has required the examination of a series of case studies covering different transport modes and cost categories. An important output of these research activities has been the creation of a user-friendly software tool which permits to calculate reasonable estimations of external costs for different combinations of circumstances (GRACE, 2008).

Road transport costs

The costs affecting interurban road transport are classified as belonging to one of the following: infrastructure, accident, congestion, and environmental. All examined econometric studies for estimating infrastructure costs have obtained slightly non linear curves with average cost elasticities[2] generally less than 1 (IMPRINT-NET, 2008; CATRIN, 2009). Furthermore the elasticity of renewals has always been found to be greater than the elasticity of maintenance, and the elasticity of maintenance greater than the elasticity of operation, and the elasticity for operation costs is more or less equal to zero (GRACE, 2008). The analysis the pattern of marginal cost curves is more controversial, since most studies found decreasing cost curves (IMPRINT-NET, 2008; CATRIN, 2009), but there were also cases of increasing cost curves (IMPRINT-NET, 2008). Research has shown that marginal costs considerably vary with traffic density and infrastructure quality (CATRIN, 2009). Many case studies show that the elasticity decreases when traffic volumes increase. It was also found that the methodology for estimating maintenance costs is more developed compared to that for estimating renewals costs (GRACE, 2008).

Research has highlighted that the large potential for econometric analysis for assessing marginal costs and elasticity is hindered by limited availability of data (CATRIN, 2009). Accident costs are based on the statistical value of human life, whose value has been confirmed to be about 2 million Euros by new research, even though variable from country to country. It is still a controversial issue whether congestion costs are internal or external. Furthermore, the methods used to estimate marginal external costs differ from country to country and the reasons are still not clear (IMPRINT-NET, 2008). However, the analysis of case study has shown that the main reasons for such a high variability in road congestion costs can be ascribed to different definitions of “optimal” tolls and the ways they are calculated, different characteristics of the cities which affect the result (e.g. the level of congestion, the availability and attractiveness of alternative modes, the drivers’ tolerance of congestion, and the capacity of the network to absorb additional demand), different estimation of externalities (maybe as a consequence of different values attributed to time and resources), differences in the models used for cost estimation (GRACE, 2008).

Research has found that there is an operational consistent framework for estimating marginal environmental costs of interurban transport, which are lower than those of urban transport because of the lower density of emission sources and receptors. Emission both from vehicle operation and fuel provision must be considered (IMPRINT-NET, 2008). Furthermore, case studies in urban areas have shown that driving parameters of environmental costs are wind speed and population density for air pollution, and population density along the route and average distance of traffic from buildings for noise. Finally, a

[2] Cost elasticity with respect to traffic output is given by $e = MC/AC$, where MC is the marginal cost and AC is the average cost.

factor has been estimated using the impact pathway approach[3] to compare the sensitiveness of Alpine regions to that of "flat" regions. The result has been that external costs in Alpine regions are significantly greater (e.g., in Alpine Regions air pollution costs are 5 times higher in road transport, 3.5 times in rail transport, noise costs 5 times higher in road and 4 times in rail transport, the maintenance costs are 4.5 times higher for road transport and 1.4 times higher in rail transport) (GRACE, 2008).

Rail transport costs

The results of studies on econometric analysis to estimate marginal wear and tear costs for different national railways show some convergence. However, a number of studies found that costs variable with traffic falls as traffic density increases, and differences between countries makes it difficult to benchmark their marginal costs. Furthermore, the distinction between maintenance and renewals costs and the way they are considered in modelling differs from country to country (IMPRINT-NET, 2008). Case studies found that the elasticity for rail infrastructure cost is lower than the elasticity for road (GRACE, 2008). Research has shown that marginal costs considerably vary with traffic density and infrastructure quality (CATRIN, 2009).

As for scarcity costs, there is a lack of a consolidated approach for their estimation. However, some studies made some attempts to estimate scarcity costs on particular corridors in order to determine a corresponding scarcity charge, which should be paid even if the slot is not used (especially for freight traffic where slots are often reserved but not used). Rail is a relatively environment-friendly mode. However, research has been and is being made to estimate air and noise pollution costs. Research has found that mark-ups for environmental costs are perceived as only being a way Member States use for abusively raising revenue. Another important aspect greatly affecting the total cost estimation is how assets are valued. Sometimes assets are very old and it is necessary to ensure that mark-ups on marginal cost are fairly calculated (IMPRINT-NET, 2008).

Waterborne transport costs

Research has developed a simulation tool for estimating marginal costs (more precisely infrastructure costs for using locks in the port, crew cost on the vessel, operating and

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[3] This approach was developed within the ExternE (Externalities of Energy) project series. Environmental benefits and costs are estimated by following the pathway from source emissions via quality changes of air, soil and water to physical impacts, before being expressed in monetary benefits and costs" (source: www.externe.info).

maintenance cost, accident costs, noise and air pollution costs) when a vessel calls and leaves a port. It has been found that these costs increase with vessel size and that marginal infrastructure costs are only a tiny fraction of total marginal costs and can be only ascribed to the use of lock (GRACE, 2008). In general, inland waterway transport does not pay for using rivers, but pays for using, for example, locks, canals, and ports (IMPRINT-NET, 2008).

Safety and accident costs have been found to be estimate as a sort of congestion or scarcity cost, because, for example, the presence of a ship carrying dangerous goods in a lock reduces the available capacity of the lock itself. However, for the inland waterway mode, the marginal costs are mostly affected by environmental costs, which can be reduced by introducing new more environment-friendly technologies for engines and hulls. Noise emissions (especially for mooring ships and at night) and waste disposal are perceived as an important environmental impact.

There are debates about the necessity of accounting for congestion costs, because currently there are not problems of congestion at European locks (IMPRINT-NET, 2008), except for particular locks and bridges where waiting times are significant and can increase rapidly when traffic intensity increases (GRACE, 2008), or rare cases in which unexpected events cause large queuing up of ships (IMPRINT-NET, 2008). Nonetheless, a methodology to estimate congestion and scarcity costs has been developed; it takes into account congestion at locks and bridges, and scarcity on waterways (GRACE, 2008).

Air transport costs

The infrastructure costs for air transport concern airport. Capital costs, which are fixed costs, are the most important. Also labour costs (mostly for security, maintenance and ground handling) can be considered relatively inelastic. These costs differ from country to country within the EU. However, the reference costs for pricing the use of air infrastructure are long run marginal costs, which account for capacity and operating expenditures. The main environmental costs relate to noise and polluting emissions, global warming and congestion. Research has found that the estimation approaches for noise and air pollution currently used at airports, in general based on avoidance rather than damage costs, lead to an inappropriate estimation of the social impact.

The estimation of congestion and scarcity costs needs to be improved. The relation between congestion and scarcity is complex, because congestion is not only driven by the use of slots, but also by demand (airlines push airports to exploit capacity till the upper limit to accommodate as much demand as possible). Research is currently focusing on identifying feasible mechanisms for creating a market for slots in order to solve scarcity problems. The assessment of costs relating to global warming and climate change is subjected to several uncertainties (IMPRINT-NET, 2008). An econometric model has been developed to assess air marginal costs and applied to 3 case studies. The results have been large variations in marginal costs. Furthermore, most airports operate in the area of increasing returns to scale, and this means that efficient charges will be below average cost if externalities are not considered. It has also been found that substantial parts of external costs relating to environmental impacts are not usually internalised in taxes or charges (GRACE, 2008).

Transport accounts

Transport accounts provide information on total social costs and revenues for the main transport modes at different levels of disaggregation (e.g. network types, user groups, transport means, etc.). Starting from the results obtained by previous work[4], research has improved the methodological and data collection procedures in order to use transport accounts for monitoring pricing policies. Suggestions have been made to split infrastructure costs in fixed and variable and accident costs in internal and external, as well as to organise databases so that network information is separated according to capacity utilisation levels and by population density. Also simplified updating procedures have been proposed in order to improve the efficiency of this monitoring tool. Furthermore, recommendations and guidelines to produce transport accounts for the new Member States have been developed, and issues on the development of transport accounts at regional level have been addressed (GRACE, 2008).

4.3.3.2 Implementation of fair and efficient pricing

Research has analysed current charging practices and their impacts for the main transport modes (IMPRINT-NET, 2008). The general conclusion has been that there is a need for further research for the analysis of the impacts of pricing policies, especially for the waterborne mode (IMPRINT-NET, 2008). The market structure greatly affects the results of pricing schemes for the rail mode, since it has been found that the level of success of pricing reforms in terms of user behaviour changes increase with the level of competition

[4] UNITE (Unification of accounts and marginal costs for Transport Efficiency) project. FP5 - GROWTH - KA2 - Sustainable Mobility and Intermodality.

between private operators. As for the road transport mode, the impact of pricing schemes in terms of modal shift towards more sustainable modes has been found to be not significant (IMPRINT-NET, 2008). The main barriers to pricing reforms have been ascribed to institutional/political context (possible shortcomings in the regulative framework), acceptability (especially in relation to the efficient use of revenues), technology/interoperability (in relation to the collection and provision of correct information to ensure the efficient implementation of pricing schemes in line with the social marginal cost approach) (IMPRINT-NET, 2008).

Research has particularly focused on analysing urban road user charging (RUC) practices, especially when used as a demand management tool in urban areas, providing a state of the art report and identifying barriers and ways of overcoming them (CURACAO, 2009). Efficiency, reduction of environmental impacts and raising revenue are the most important objectives among those that are most likely to be pursued by cities when implementing pricing schemes.

RUC policy is more effective if implemented in combination with measures aiming at encouraging the use of public transport (PT), reallocating road space and planning land use, because doing so it has been found that is possible to improve the acceptability of RUC and reduce its impacts on the most negatively affected, even though the effects naturally depend on the specific city context. There is increasing evidence that distance-based pricing is the most efficient compared to cordon and area-based pricing schemes, and the technological developments are making more affordable the devices required for its implementation. However, many cities still continue to use conventional pricing schemes.

The effectiveness and acceptability, the two opposing objectives of RUC, strictly depends on charge specifications such as level of charge, variations by vehicle type, location and time of day, and exemptions and discounts. The success of RUC also depends on the behavioural response of transport system users, but there is still little empirical evidence of this aspect especially for second order effects (such as changes in vehicle ownership and fleet composition, changes in the location of economic activity, homes and jobs). The increasing evidence collected of methods used to predict impacts of RUC has highlighted the low reliability of conventional prediction methods because of the high complexity of urban RUC.

Urban RUC aiming at reducing traffic have typically achieved reduction between 14% and 23%. The impacts on speed and congestion have shown higher variability. On the basis of the limited evidence collected, the impacts of RUC on the urban economy appear to be very low. Acceptability remains the main concern when implementing RUC and can be improved using complementary policy instruments, providing alternatives, appropriately using revenue from RUC as well as discounts and exemptions. Collected evidence show that acceptability is likely to be low before the implementation and increase after implementation.

The way RUCs are implemented and the legislative and political context vary from city to city, and the timing of implementation must be within an electoral cycle. Cities should be encouraged to monitor and evaluate impacts of implemented RUCs, because it is crucial not only for improving the specific schemes, but also to increase the body of empirical evidence on urban RUC, which can support other cities to define successful RUCs in their specific context (CURACAO, 2009).

The analysis of the case studies has shown and quantified the benefits that the implementation of urban RUC permit to achieve, as a demand management instrument, in terms of reduction in congestion levels, in environmental impacts and in number of accidents, and positive financial and economic impacts (CURACAO, 2009).

Also national research has investigated the possibility of using congestion charging as a way of managing transport demand (Express buses in the Stockholm congestion charging trial). The trial, implemented in Stockholm, consisted in a combination of three measures: congestion charging, reinforced PT (12 new bus express routes) and additional P&R facilities. The objective was to provide a high quality service to regular and new PT patronage and reduce pressure on train capacity. The expected result of the introduction of the 12 new bus express routes together with the congestion charges, was that most passengers using the new buses would be former PT passengers and that most new PT passengers would have gone by rail if the new buses would have not been implemented.

The actual results were as follows. Even though most residents had a realistic perception of PT in their living area, and were sufficiently informed on the existence of the new direct bus services, the perceptions of travelling times to terminals in the city were not so good, and fewer inhabitants even chose to go by car to inner city. During the trial the percentage of respondents using PT has increased by between 5 to 10 percentage points according to zones, but only a few respondents declare that they had changed because of the congestion charge. A slight change in attitude has been assessed by the end of the trial especially among the PT passengers: fewer respondents agreed that travel by car should be made easier. Those going by direct buses were more pleased with travel time, punctuality and comfort than those using various rail services. The most important performance for the respondents was punctuality. No significant preference for train or bus has been assessed (Express buses in the Stockholm congestion charging trial).

Research activities have been carried out to identify the conditions for a fair and efficient implementation of pricing differentiation in transport and to study user reaction (DIFFERENT, 2008) in theoretical and practical terms. At the theoretical level, a number of hypothesis have been made for the optimal level of differentiation of infrastructure charges, based on both the normative and positive theory of transport economics as well as behavioural theories of psychology. Setting these hypotheses against empirical facts and figures derived from case studies, it has been found that copybook implementations and of pricing schemes are rare, but rather they are a compromise between different aspects and approaches and that there is an optimal degree of differentiation beyond which differentiation is counterproductive. Furthermore, it has been found that there is always some political influence on pricing structures (which, consequently, must be considered in the design of pricing schemes), and that objective of pricing, cost structure and demand of infrastructure use are key factors when designing pricing schemes (and therefore essential for differentiation) (DIFFERENT, 2008).

The analysis of the case studies on pricing differentiation in transport produced interesting results. The general result is that pricing is effective contrary to what transport economics asserts. This general result stems from the consideration of two aspects across transport modes: the first aspect is concerned with the effects of price changes on travel behaviour and mode choice; the second aspect relates to the effects of differentiation on travel behaviour and mode choice (DIFFERENT, 2008).

The evidence gathered from case studies shows that price changes do affect travel behaviour and mode choice in the case of interurban road transport. As for the rail mode, limited data availability due to the current regulatory upheaval has not permitted to get a clear picture of the situation. In the case of air transport, evidence shows that the effects of changes in take-off and landing fees on the behaviour of airlines are rather limited, however, considering that the contribution of these fees to the total costs of airlines is rather small, this result is not surprising. In spite of the good availability of case studies on ports, the picture of effects of price changes is not clear (DIFFERENT, 2008).

From the evidence collected from case studies, differentiation does affect travel behaviour and mode choice, but its extent strongly depends on the specific transport mode and circumstances. In the case of interurban road transport, pricing differentiation on the basis of axle weight and emission classes showed clear effects. Also in the case of urban transport significant effects of pricing differentiation could be detected. As already said before, the limited availability of data in the case of rail transport did not permit to draw clear conclusions.

As for air transport, the Spanish case studies show that peak-load pricing produce welfare effects, but also that current institutional constraints impede their exploitation. The Hamburg case study concerning noise charges showed no effect at all (this might be due to the special political circumstances at the time these charges were implemented). The case of London show that there is relatively little competition between airports, and, therefore, price differentiation does not appear to be a competitive parameter for airports. In the case of maritime transport, port dues only contribute to a small extent to the overall voyage costs of shipping companies, and consequently the picture is similar to that of the airport case studies (DIFFERENT, 2008).

Surveys were carried out in the UK, Germany and Greece to explore user response to complexity in road user charges and identify optimal levels of complexity in road user charges. Optimal levels of complexity are the result of a trade-off between the theoretical advantages of highly differentiated charges and the practical problems caused by such differentiation. The results of the surveys have been used to calibrate a modelling package used to test the performance of different charging regimes with different degrees of complexity.

The core components of this modelling package were the SATURN assignment model, a charge estimation model and a demand response module (logit models were used to predict responses to complex charges, while a conventional elasticity model was used instead for predicting responses to simple charges) (GRACE, 2008). A result of the modelling exercise has been that complex charging regimes produced larger revenues and greater reductions in externalities than any of the simpler regimes but produced lower benefits. This underperformance in terms of benefits of the complex regime has been ascribed to the fact that it was based on link-specific charges which, on the one hand, reduce congestion, but on the other hand induce drivers to choose longer routes thus increasing in vehicle operating costs. In this context, the users' response to optimal charges will not be efficient, because they do not perceive their current operating costs correctly (GRACE, 2008).

Research has used the TREMOVE[5] modelling tool to assess social and economic impacts in three marginal social cost pricing reform scenarios sharing the hypotheses of abolition of all existing transport taxes, charges and subsidies and non-road modes covering their variable and marginal external environmental and noise costs, but differing in that: the first scenario implement fuel taxes together with a flat rate kilometre charge for HGVs; the second scenario implement for all vehicles kilometre charges differentiated by country and vehicle type; the third scenario introduces kilometre charge differentiated in time and space.

A first result has been that it using only fuel tax (first scenario) to address all externalities of cars and motorcycles requires dramatic increases in fuel taxes and generates large revenues, but no appreciable advantages in terms of welfare. The implementation of a kilometre charge for cars and trucks as main pricing instrument (second scenario) generates slightly less revenues than the introduction of fuel tax only, but welfare increase. The implementation of pricing reforms with spatial and temporal differentiations[6] (third scenario) produces similar results to the second scenario but slightly less in absolute numbers. Overall transport volumes decrease almost the same (10.7%, 11%, 10.8% for the first, second and third scenario respectively). Furthermore, it has been found that higher welfare gains are obtained by reducing external accident costs, external congestion costs and by appropriately using the extra tax revenues (GRACE, 2008).

Research has also simulated the economic impacts on the Swiss economy caused by regionally differentiated pricing strategies which take into account the higher costs of transport in sensitive areas like the Alps. The conclusion has been that a regionally differentiated marginal social cost pricing scheme is more beneficial (for both the Alpine region and the rest of Switzerland) than currently used pricing regimes (GRACE, 2008).

The problem of the asymmetric information in the implementation of marginal social cost pricing has also been addressed. This problem consists in that the marginal external cost

[5] www.tremove.org

[6] The implementation of area and time based pricing regimes increases transaction costs (billing, enforcement etc.), but this is not yet considered in the welfare computation (GRACE, 2008).

at the member country level are unknown at the EU level, and, consequently, a member country, in order to raise revenue, may charge through traffic for more than the real social marginal costs (differently from EU, which is interested in ensuring in all its extension pricing regime based on social marginal cost). In order to prevent Member States from misusing marginal external cost, the EU can use different policy instruments, whose effectiveness depends on whether the external costs affect the volume of traffic or not. These instruments are: an incentive mechanism (financial reward) to induce member countries to provide correct information, which might be difficult to implement politically; the imposition of a toll cap based on the EU estimate of the marginal external costs (this is likely to result in a non perfect pricing); a cap based on the average infrastructure expenditures for road (If the composition of through and local traffic are homogeneous and average infrastructure costs are constant, this policy instrument should generate in principle optimal pricing, but, in case this composition differs the instrument does not work properly, because through traffic or local traffic would be overcharged because they would pay a disproportionate share of the infrastructure costs).

The first two instruments are effective in case of external costs which do not affect volume of traffic (e.g. air pollution costs), the last two instruments works for external costs which affect volume of traffic (congestion costs) (GRACE, 2008).

4.3.3.3 Interoperability of road pricing systems

The Directive 2004/52/EC has established the conditions for creating interoperable electronic road toll systems in Europe also identifying technical, procedural and legal issues. Starting from these specifications, research has defined, implemented and demonstrated a high-level architecture for road charging interoperability in collaboration with the standardisation committees CEN and ISO, and the ASECAP[7] tolling operators and the “Stockholm Group”[8] (RCI, 2008).

This architecture (called RCI), based on DSRC and GNSS technologies, has adopted the

[7] ASECAP (Association Européenne des Concessionaires d’Autoroutes et d’Ourages à Péage - European Association with tolled Motorways, Bridges and Tunnels) is a European Organisation whose mission is “to promote toll as the most efficient tool to finance the construction, operation and maintenance of motorways and other major road infrastructures” (source: www.asecap.com).

[8] The member of the Stockholm Group are countries interested in Electronic Fee Collection (Belgium, Germany, Sweden, Switzerland, UK)

role model definition of CESARE III[9], according to which the four main actors in road charging process are: Interoperability Manager (who is not involved in the operation for the interoperable road charging service, and has not been considered), Toll Charger, EETS Provider and Service User. The RCI architecture requires the stipulation of two contracts only: between the toll charger and the EETS provider, and between the service user and the EETS provider (RCI, 2008).

The design of the interfaces is crucial for the efficiency and effectiveness of the system and consequently for its acceptability and success. Appropriate technical interfaces have been defined to allow the different actors of the road charging process (the toll charger, the toll service provider and the service user) to exchange information ensuring the interoperability and security. In practical terms, (European) interoperability means that the service user can access a European Electronic Toll Service on a voluntary basis (by stipulating only one contract) anywhere (in Europe) via an on-board equipment (OBE), receiving only one invoice (RCI, 2008).

The interfaces are (RCI, 2008):

- Service Interface, which provides an in-vehicle access point for the servicing and maintenance of road charging OBE, and its standardisation is not considered critical for interoperability.
- Vehicle Integration Interface, which defines how the OBE can be installed in vehicles and the necessary components (the standardization of this interface can reduce OBE installation time and costs) and its standardisation is not considered critical for interoperability.
- Human Machine Interface, which defines the interaction of the user with OBE and must indicate to the user if the OBE is operational and correctly functioning and to allow the user to declare variable vehicle data. The standardisation of the kind of message the OBE should provide (e.g. normal operation, malfunction, etc.) and the way they should be conveyed (visual texts, coloured LEDs, vocal messages, etc.) is not considered critical for interoperability.
- Charge Data Exchange / Toll Declaration Interface, which permits to send toll charge data from the EETS provider’s front-end to the toll charger’s back-office, and requires standardisation and involves issues concerning privacy.

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9 CESARE (Common Electronic Fee Collection System for an ASECAP Road Tolling European Service) is a project developed so far in three phases (I, II and III) whose objective is to specify, design, develop, promote and implement a common interoperable Electronic Fee Collection System on European toll roads (source: www.asecap.com).

- Toll Context Data Publishing Interface, which enables the exchange of information on specifications relating to the toll chargers' tolled infrastructure (charge objects, charge events, tariff structure) and the expected behaviour of the EETS providers systems when transmitting data (GNSS Charge Data format, frequency). The deployment of the EETS requires the standardisation of the way any Toll Charger defines his Toll Context Data.
- Enforcement Interface, which enables the toll charger to carry out enforcement and compliance checking transactions with the OBE.

Where appropriate, assumptions with respect to the procedural/contractual framework have been made. In fact, these interfaces are crucial for the implementation of the procedural and contractual agreements between actors to ensure interoperability, and for inspiring actors' confidence in the system and its operation (RCI, 2008).

The validation of the RCI architecture from different points of view has led to the conclusion that it can be considered a sound basis for the definition of the EETS, even though only European validated clarifications on procedural and contractual aspects will permit the finalisation of technical specifications (e.g. who defines charge objects' coordinates? Who is responsible for augmentation systems? Who has access to OBE from outside? What are the European privacy requirements?). In fact, the Charge Data Exchange/Toll Declaration Interface, the Toll Context Data Publishing Interface and the Enforcement Interface are not only necessary, but also sufficient to ensure the levels of interoperability required for EETS. Furthermore, the RCI architecture is acceptable to Toll Chargers and potential EETS providers (RCI, 2008).

Finally, the system has been demonstrated with an operational testing which has involved two trucks each equipped with one interoperable OBE able to seamlessly and without user intervention adapt its functional behaviour when crossing borders to comply with the rules of the specific country tolling scheme (Toll Collect in Germany, LSVA in Switzerland, TIS-PL in France, VIA-T in Spain, TELEPASS in Italy, ASFINAG in Austria). The main results has been that interoperable functional prototypes are technically feasible on the basis of an open architecture that can help to realise economies of scale and establish an open and competitive market for the provisioning of interoperability as service, as well as provide the user with a solution that can be used seamlessly anywhere in Europe and that is based on the principle 'one box, one contract and minimum number of invoices' (RCI, 2008).

At national level (Sweden), research has developed a functional concept (called ARENA concept) for a kilometre tax system for HGVs with a view of harmonising the national with the European development. This in response to the intention of the Swedish government to introduce a new HGV tax system based on the marginal cost principle, and to the consideration that several European countries have already started to implement distance-based road tolls and that the EU Commission has begun to develop guidelines for a European Electronic Toll Service (ARENA, 2008).

The functional approach means that the system has been developed independently from specific technical realisations and con be implemented with different technological solutions (for example those used to demonstrate the system). This flexibility allows this concept to catch up with the dynamics of technical development in next year (at least to some extent). Differently from currently operating systems (e.g. in Germany, Austria, Switzerland and the Czech Republic), this concept can manage many toll service providers, a specification already anticipated by EC (ARENA, 2008).

For the development and demonstration of this concept, a number of activities have been carried out to investigate current road traffic tax practices and analyse of distance-based road user charging. Furthermore, both technical and legal issues have been addressed. More specifically, problems concerning OBE and road network taxation, payments, border and control problems, currency and VAT (ARENA, 2008).

The key requirements of the system have been (ARENA, 2008):

- the possibility to levy tax throughout the entire road network;
- the ability to take into account road characteristics;
- the ability to take into account static and dynamic vehicle properties;
- interoperability with the coming EETS service.

The ARENA concept offers a national service, which only works within the borders of Sweden, and the European Electronic Toll Service according to Directive 2004/52/EC (CEC, 2004). Put it simply, the overall function of the system is to manage all information flows and perform all calculations and measurements required to enable users to pay the correct tax. Consequently the main functions are (ARENA, 2008):

- to establish a user contract between a user and a toll service provider (which can also be an organisation operating throughout Europe and offers the European Electronic Toll Service in countries including Sweden), which give the user the OBE;
- to register and transmit track data (route and time) by means of the OBE;
- to charge payment (tax calculation and payment), which requires an interaction between the toll service provider and an organisation appointed as a Toll Charger;

- compliance control, which, among other things, checks in real-time the functioning of the OBE, the correctness of the information reported by the OBE, the correct functioning of the positioning unit, the correctness of the tax calculation.

A business model for the kilometre tax system, which takes into account the introduction of the European Electronic Toll Service, has also been proposed, which allows competition between toll service providers and thus permits the development of new, innovative and more effective solutions (ARENA, 2008).

4.3.4 Policy implications

4.3.4.1 Internal and external transport costs

The correct estimation of internal and external transport costs is crucial for formulating fair and efficient pricing policies which charges according to real costs. The marginal cost approach provides such information in different traffic situations. The use of case study and accounts data together appears to be the most practical means of generating satisfactorily reliable marginal cost estimates for determining pricing policy (GRACE, 2008).

Transport accounts, which provide information on total social costs and revenues for different transport modes, are very valuable for monitoring the impacts of pricing policy (GRACE, 2008).

4.3.4.2 Fair and efficient pricing

Research has formulated the following recommendations for the adoption of pricing policies for the modes with a stronger tradition in pricing (road, rail and air) (IMPRINT-NET, 2008):

- to ensure the existence of dedicated EC Directives, which provide a solid legislative framework defining principles and scope of pricing schemes and implement current approaches for charging noise, air pollution, congestion, scarcity and accident costs;
- to encourage the further development of the currently used approaches for impact assessment of the kilometre based charge in road transport as well as the used technological solutions in order to take into account all type of vehicles and roads including the redistribution of vehicle taxation;

- to improve the coordination of the Infrastructure Managers on international rail transport corridors;
- to ensure, for air transport mode, a more efficient charging of air transport movements and develop a market based strategy for including CO_2 emissions in the European Emission Trading Scheme.

Research has also formulated recommendations for the adoption of pricing policies specific to waterborne transport modes (maritime and inland waterways), which have a weaker tradition in pricing (IMPRINT-NET, 2008):

- to further develop the conditions for the adoption of pricing reforms and to encourage the formulation of appropriate approaches for the internalisation of specific external costs;
- to raise stakeholders' awareness of the importance of pricing reforms and the necessity of extensive impact assessments to estimate benefits and side effects generated by their implementation.

As for New Member States, research recommend to encourage the dissemination of best practices and to carry out impact assessment of pricing reforms in order to help them to follow member countries towards the adoption of pricing reforms (IMPRINT-NET, 2008).

The review of the state of the art and the analysis of case studies on urban RUC have produced the following policy recommendations (CURACAO, 2009):

- city and regional Authorities must clearly specify the objectives of urban road user charging schemes and stick to them;
- a road user charging scheme should be designed taking into account the full range of complementary measures supporting it;
- acceptability must be addressed from the beginning of the design process of an RUC scheme, ensuring a permanent dialogue with public, pressure groups, politicians and media;
- an appropriate use of revenues from RUC positively affects the acceptability and effectiveness of the scheme;
- the European Commission should financially support cities for conducting research and demonstration projects specifically addressing key issues such as acceptability, governance requirements for effective implementation, economic and equity impacts of pricing schemes;
- the European Commission should financially support educational campaigns, training schemes and toolkits explaining the rationale behind urban road user charging;
- the European Commission should financially support research into standardisation and interoperability of road user charging systems and technologies.

The analysis of case studies on pricing differentiation in transport has produced the following conclusions and recommendations (DIFFERENT, 2008):

- do not introduce unnecessary differentiation (too complex pricing schemes are more difficult to deal with, and the risk of unexpected behavioural responses increases);
- build gradually on existing differentiation (users' experiences of any dimension of differentiation reduce the effect of complexity in that dimension);
- inaccuracy and time to respond (latency time) when examining pricing schemes as well as perceived difficulty and perceived uncertainty of price predictions increase when the degree of differentiation increases;
- prefer differentiation elements which are in line with an easy human information processing (conditions of charge differentiation with a higher probability of perceived difficulty are non-linear variation of the charge, unpredictable variation of the charge, not clearly observable differentiation dimensions, charges based on values not immediately understandable, pricing scheme based on spatial divisions not widely known, charges implying complex cross-linking to other elements);
- do not expect precise response to complex pricing signals;
- make pricing schemes familiar to users by assistance and helpful advice;
- provide adequate information and advice about the price structure of the charging schemes;
- provide information to stress the justification for the scheme;
- motivational factors (especially acceptance) affect user's perception of pricing schemes and their response towards differentiated prices;
- users' attitude to deal with pricing schemes and their response to pricing schemes depends on personal price thresholds;
- the effect of the price level on the probability of behavioural response is moderated by the perceived difficulty of the pricing schemes;
- companies and single individuals have different approaches to the understanding of charging schemes and motivation to deal with them;
- according to positive economic theory special interest groups intervene in the political process in order to derive utility for their members; as a consequence the degree of differentiation of a charging scheme reflects the balance of the political power.

As for investigations on users' response to complexity in RUC and the identification of optimal levels of complexity in RUC, research has identified a number of implications which should be borne in mind when implementing pricing regimes: simpler charging regimes in road transport are likely to yield higher net benefits than the most complex scheme; complex pricing regimes with high average charges produces significant revenues, because the complexity of the charge structure reduces the sensitivity to the actual charge; as long as fuel consumption can be considered as a proxy for distance travelled and environmental externalities, overall benefits can be increased more simply and cost- effectively by increasing fuel taxes than by introducing new forms of road user charging. Research has also formulated the following recommendations (GRACE, 2008):

- to implement highly differentiated charges only if they are likely to remain stable for a considerable period of time, because a change in behaviour cannot be expected in the short term;
- to set clear policy objective when identifying the optimal degree of complexity in RUC (the optimal degree of complexity crucially depends on the definition of the policy objective[10]);
- to take into account that individuals do not perceive their vehicle operating costs accurately and then additional charges simply based on the valuation of externalities cannot lead to a social-welfare-maximising behaviour.

4.3.4.3 Road pricing schemes and systems

After demonstration, validation, consultation and awareness raising activities, the high-level architecture for road charging interoperability has been accepted by the principal stakeholders (suppliers, toll operators and toll service providers). This high-level architecture should be taken as the European technical reference for the development of DSRC/GNSS-enabled road charging solutions in order to avoid wasting time and resources for deploying from scratch other road charging systems that will delay or block the introduction of interoperability (RCI, 2008). The results of the RCI project regarding the content and organisation of EETS have been the basis for the Commission's decision on EETS adopted in October 2009.

The work performed at national level for the development of the functional concept for a kilometre tax system for HGVs has been carried out taking into account the requirements of interoperable EETS so far expressed by the EC.

[10] For example, to maximise net benefits (policy objective), a simple charging regime is likely to perform better than complex regime based on link-specific charges (as seen in 4.3.3.2), while to maximise net revenue (policy objective), complex regimes are likely to perform better.

4.4 Implications for further research

4.4.1 Financing tools

High quality modelling and appraisal of major projects is needed to illuminate good decision-making relating to projects of common, i.e. European, interest. Involvement of the EU in infrastructure decisions is warranted where:

- there are trans-boundary environmental costs which are not computed at the national level but which need to be captured at European level, and can not be dealt with via direct environmental regulation or environmental permits and taxes (for example: air pollution of aviation);
- there are significant spillovers between the provision of a piece of infrastructure in one country and costs and benefits in neighbouring countries. It is easy to demonstrate that in the presence of transit traffic, (a) the incentive to an individual state to provide infrastructure is distorted and (b) the incentive to price capacity efficiently is also distorted.

A transport fund at EU level could serve as a device, together with appropriate regulation, for helping to correct for these distortions and to incentivise efficient pricing and investment. A funding contribution from the EU is warranted to pay for non-national benefits; however a funding contribution is not warranted to enable projects with poor rates of return to happen (according to the results of the FUNDING project).

4.4.2 Pricing and taxation

Research and investigations on transport costs have identified a number of topics for further research for the different modes of transport.

For interurban transport it is necessary to further analyse the relationships between marginal costs and traffic volumes adopting both engineering and econometric approaches (IMPRINT-NET, 2008), in particular the variation of the elasticity of wear and tear costs with traffic volume and infrastructure quality (GRACE, 2008). It is also recommended to improve the assessment of risk elasticity and their implications for the marginal external costs of accidents (IMPRINT-NET, 2008; GRACE, 2008), as well as the consistency of the value of human life (IMPRINT-NET, 2008). Another open issue is the high variability in congestion costs estimation because of modelling and site specific conditions. Finally, it is necessary to develop methods which provide consistent damage evaluations for environmental costs (air and noise emissions and climate change) (IMPRINT-NET, 2008).

For rail transport, the estimation of marginal scarcity costs requires further research, because the results of the few studies carried out so far are not satisfactory and there is a need of practical way of assessment (GRACE, 2008; IMPRINT-NET, 2008). It is also recommended further research to dispel all uncertainties concerning the correct assessment of rail asset and determine fair mark-ups (IMPRINT-NET, 2008).

As for waterborne transport, further investigations are also needed to better understand the relationship between port dues and marginal infrastructure costs, as well as the relationship between congestion costs and port infrastructure provision and connection with rail and road inland infrastructure. It is finally recommended to develop more precise impact assessment at port level to better estimate the associated costs (IMPRINT-NET, 2008).

As for air transport, it is recommended to address the problems of slot scarcity by implementing market based instruments. There is also a lack of social costs evaluation of environmental impacts (IMPRINT-NET, 2008).

The review of the state of the art and the analysis of case studies on urban RUC have identified a number of research gaps (CURACAO, 2009):

- interaction between acceptability and effectiveness;
- transferability of RUC schemes from one city to another;
- design and technology applications for enforcement;
- development of technology and business systems and ways of reducing the costs for their application;
- impacts of RUC on the urban economy by economic sector and size of firm;
- effects of RUC on different impact groups;
- interaction between acceptability and equity;
- comparisons between predicted and actual impacts;
- approaches to the design of overall strategies which include RUC;
- methods for the design of RUC schemes;
- improvement of the prediction methods;
- better understanding of behaviour response, especially second order responses;
- impacts of RUC on liveability and health;
- dynamics of acceptability over time;

- specification of appropriate scheduling for the implementation of RUC schemes;
- best practices for evaluating RUC schemes.

The studies on pricing differentiation in transport and user behaviour have identified the following topics for further research (DIFFERENT, 2008):

- Most of the existing studies on urban and interurban tolling systems only focus on physical traffic flows and overlook welfare benefits. It is recommended to investigate the welfare effects of differentiated pricing schemes.
- It is very beneficial to turn to both psychology and economics theories when dealing with pricing differentiation issues. It is recommendable, among other things, to study the effects of incorporating behavioural models like Herbert Simon's "satisfying behaviour" into the study of pricing differentiation (instead of the main-stream "utility maximising" paradigm).
- A further important research topics could verify the Laffont's thought that simpler pricing-schemes might be better (in welfare terms) than more differentiated schemes because are less subject to political manipulation by special interest groups.
- The analysis of case studies has put in evidence how limited, in the case of the rail mode, are data and information to draw reliable conclusions and recommendations on the effect of price changes and pricing differentiation on travel behaviour and modal choice. Since price differentiation might be one (or even "the") key factor to the long-term survival of the rail mode (especially freight rail transport), it is recommended that the European Commission should finance research to find an appropriate way of collecting data which safeguards the strategic interests of the railway industry, but makes better research possible, as well as research to study the relevance of price discrimination for increasing the modal share of railways.

Research on complexity of RUC and the identification of optimal levels of complexity of RUC has identified topics for further research (GRACE, 2008):

- more research is needed to get insights into factors that make one price signal more "complex" than another and into behavioural responses to uncertainty;
- to collect more data on responses to simple charges;
- to develop a network based representation of the performance of time varying tolls;
- to explore by modelling the extent to which the optimal level of complexity varies with the characteristics of the network and the population of travellers;
- to extend the work done on the performance of urban networks dominated by peak hour passenger traffic to other transport sectors where the behaviour of actors, the nature of externalities and the costs of scheme implementation are quite different.

The high-level architecture for road charging interoperability has created the basis for the development of an interoperable EETS. However, there are further steps to take such as (RCI, 2008):

- to continue and finalise the standardization of the interfaces and the work on the contractual aspects;
- to analyse in detail IPR issues (hundreds of patents relates to electronic fee collection);
- to find an effective way of very clearly stating the responsibility of the EETS provider for the EETS front-end (including the OBE) in the EETS architecture;
- to develop appropriate tools for monitoring the system performances that can help inspiring actors' confidence;
- to prepare the development of the EETS (industrial development, pilots, improvements);
- to involve all stakeholders in the definition of a clear European roadmap to the deployment of the EETS.

The ARENA concept for a kilometre tax system for HGVs must be further developed, and further research is needed to (ARENA, 2008):

- better understand the practical, legal, organisational and administrative consequences of the concept;
- carry out further analysis of business models and processes in order to ensure that the system stimulates the "correct" behaviour;
- investigate how system design is affected by technical equipment and services;
- develop and demonstrate the interoperability between different systems and define related responsibility issues (for payment) and possible sanctions.

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GRACE (2008), Deliverable 10 - Policy Conclusions. GRACE (Generalisation of Research on Accounts and Cost Estimation) Project. FP6-SUSTDEV-2 - Sustainable Surface Transport. www.grace-eu.org

HEATCO (2006a) Deliverable 5 – Proposal for harmonised guidelines. HEATCO (Developing harmonised European approaches for transport costing and project) Project, FP6 Research for Policy Support.

HEATCO (2006b) Deliverable 7 – Final technical Report. HEATCO (Developing harmonised European approaches for transport costing and project assessment) project. FP6 Research for Policy Support.

IMPRINT-NET (2008) Final Report. IMPRINT-NET (IMplementing Pricing Reforms IN Transport – NETworking) Project. FP6-SUSTDEV-2 - Sustainable Surface Transport. www.imprint-net.org

RCI (2008) Final Brochure. RCI (Road Charging Interoperability Pilot Project) Project. FP6-SUSTDEV-2 - Sustainable Surface Transport. www.ertico.com/en/projects/completed_projects/rci.htm

Annex: List of projects per sub-theme

Sub-theme 1: Financing Tools				
Project acronym	Project title	Programme	Project website	Coverage
	Alternative urban transport funding: Cost-benefit analysis of alternative public trans-port funding in four Norwegian cities;	Project from Norway		Covered in EXTR@WEB report
	New models for funding of transport infrastructure services - Väyläpalvelujen rahoituksen uudet mallit	Project from Finland		Covered in EXTR@Web report
D9 (NRP 41)	Funding tomorrow's transport systems, Finanzierung des Verkehrs von morgen	Project from Switzerland		Covered in EXTR@WEB report
FUNDING	Funding infrastructure: guidelines for Europe	FP6-SUSTDEV-2 - Sustainable Surface Transport	http://www.econ.kuleuven.be/funding/	Covered in this report

Sub-theme 1: Financing Tools				
Project acronym	Project title	Programme	Project website	Coverage
HEATCO	Developing Harmonised European Approaches for Transport Costing and Project Assessment	FP6 “Research for Policy Support”; Action line: “The development of tools, indicators and operational parameters for assessing sustainable transport and energy systems performance”	www.heatco.ier.unistuttgart.de	Covered in this report

Sub-theme 2: Pricing and Taxation				
Project acronym	Project title	Programme	Project website	Coverage
-	Express buses in the Stockholm congestion charging trial	Project from Sweden		Covered in this report
-	Multi-modal freight model for distance-based HGV charging	Project from The United Kingdom		Covered in EXTR@Web report
ARENA	Kilometre tax for heavy goods vehicles in Sweden - A proposal for a functional concept	Project from Sweden	www.arena-ruc.se	Covered in this report
ASSET	Assessing Sensitiveness to Transport	FP6 - "Integrating and strengthening the European Research Area"	www.asset-eu.org	If reports become available

Sub-theme 2: Pricing and Taxation				
Project acronym	Project title	Programme	Project website	Coverage
CATRIN	Cost Allocation of Transport Infrastructure cost	FP6-SUSTDEV-2 - Sustainable Surface Transport	www.catrin-eu.org	Covered in this report
CUPID	Co-ordinating urban pricing integrated demonstrations	FP5 - GROWTH - KA2 - Sustainable Mobility and Intermodality	www.transport-pricing.net/cupid.html	Covered in EXTR@Web report
CURACAO	Coordination of Urban Road-User Charging Organisational Issues	FP6-SUSTDEV-2 - Sustainable Surface Transport	www.curacaoproject.eu	Covered in this report
D3	Fair and efficient pricing	Project from Switzerland		Covered in EXTR@Web report
DESIRE	DEsigns for Interurban Road pricing schemes in Europe	FP5 - GROWTH - KA2 - Sustainable Mobility and Intermodality	www.tis.pt/proj/desire.htm	Covered in EXTR@Web report
DIFFERENT	User reaction and efficient differentiation of charges and tolls	FP6-SUSTDEV-2 - Sustainable Surface Transport	www.different-project.eu	Covered in this report
ENACT	Design Appropriate Contractual Relationships	FP6-SUSTDEV-2 - Sustainable Surface Transport		If reports become available
GRACE	Generalisation of Research on Accounts and Cost Estimation	FP6-SUSTDEV-2 - Sustainable Surface Transport	www.grace-eu.org	Covered in this report
IMPRINT EUROPE	Implementing Pricing Reform in Transport - Effective Use of Research on Pricing in Europe	FP5 - GROWTH - KA2 - Sustainable Mobility and Intermodality	www.imprint-eu.org	Covered in EXTR@Web report
IMPRINT-NET	Implementing Pricing Reforms in	FP6-SUSTDEV-2 - Sustainable	www.imprint-net.org	Covered in this

Sub-theme 2: Pricing and Taxation				
Project acronym	Project title	Programme	Project website	Coverage
	Transport – Networking	Surface Transport		report
MC-ICAM	Implementation of Marginal Cost Pricing in Transport - Integrated Conceptual and Applied Model Analysis	FP5 - GROWTH - KA2 - Sustainable Mobility and Intermodality	www.its.leeds.ac.uk/projects/mcicam/	Covered in EXTR@Web report
PROGR€SS	Pricing ROad use for Greater Responsibility, Efficiency and Sustainability in citieS	FP5 - GROWTH - KA2 - Sustainable Mobility and Intermodality	www.progress-project.org	Covered in EXTR@Web report
RCI	Road Charging Interoperability Pilot Project	FP6-SUSTDEV-2 - Sustainable Surface Transport	www.ertico.com/en/projects/completed_projects/rci.htm	Covered in this report
RECORDIT	Real Cost Reduction of Door-to-door Intermodal Transport	FP5 - GROWTH - KA2 - Sustainable Mobility and Intermodality	www.recordit.org	Covered in EXTR@Web report
SVI 1999/317	Taxation of cars with a bonus-malus system	Project from Switzerland		Covered in EXTR@Web report
SVI 2000/442	Evaluation of short-term raises in gasoline prices	Project from Switzerland		Covered in EXTR@Web report
TELEPAY	Telepayment System for Multimodal Transport Services using Portable Phones	FP5 - IST - KA1 - Systems and services for the citizens		Covered in EXTR@Web report
UG346	Monitoring effects of road user	Project from The United		Covered in

Sub-theme 2: Pricing and Taxation				
Project acronym	Project title	Programme	Project website	Coverage
	charging in Durham	Kingdom		EXTR@Web report
UNITE	Unification of accounts and marginal costs for Transport Efficiency	FP5 - GROWTH - KA2 - Sustainable Mobility and Intermodality		Covered in EXTR@Web report

Remark: the projects listed in the annex are those that have had the focus on the theme "financing, pricing and taxation". On the TRKC portal www.transport-research.info it is possible to use the "advanced search" functionality, with the options "Financing tools" and "Pricing and taxation", and find all research projects, EU-funded and national, which have treated, to a variable extent, aspects that can be related to the themes.