GRACE

Generalisation of Research on Accounts and Cost Estimation

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Deliverable 10:

Generalisation of Research on Accounts and Cost Estimation

Policy Conclusions

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Executive Summary and Policy Recommendations

Objectives

The GRACE project aims to support policy makers in developing sustainable transport systems by facilitating the implementation of such pricing and taxation schemes that reflect the costs of infrastructure use. It covers the following areas of research:

- Case study research to address gaps in the existing level of knowledge of marginal social costs for road, rail air and waterborne transport,
- Development and refinement of methods to enable the use of transport accounts as a monitoring instrument for the implementation of transport pricing reform in an enlarged Europe,
- Innovative research on the appropriate degree of complexity in transport charges,
- Guidance on the marginal social cost of the different modes of transport in specific circumstances and on simple and transparent methods for determining charges,
- Modelling the broad socio-economic impacts of pricing reform.

Policy Context

- Efficient pricing in transport and the internalisation of the external costs of transport have been key aspects of European transport policy for over a decade now.
- As the GRACE project comes to a close, the Commission is working to prepare a Communication on the internalisation of the external costs of transport that responds directly to the European Parliament's request for further proposals on this issue.

- The estimation of external costs is absolutely central to the pursuit of the Commission's transport pricing policy, and GRACE is the most recent in a series of research projects to undertake such cost estimation.

- Understanding the potential impacts of different policy options is also vital to the process of taking the policy forward, and modelling to understand the impacts of different pricing policies on the economy, on the environment and on society at large has been a core part of GRACE.

- European transport pricing policy is at an exciting juncture and GRACE finds itself drawing its conclusions at a point where policy-makers are actively taking forward the transport pricing policy agenda.

Cost Estimation and Charge Calculation

Road and Rail

- Optimal charges for the use of transport infrastructure will be below average maintenance and renewal costs for road, and a long way below for rail, wherever there is spare capacity and little environmental impact.

- Most of the evidence suggests that charges should be higher for low quality, less heavily used infrastructure, as the low quality nature of the infrastructure makes it more susceptible to damage.

- Where capacity is scarce there is a strong case for a charge to cover marginal congestion costs for roads and scarcity costs for rail. These charges will be very variable in time and space. The effects of such charges on traffic levels on inefficiently priced competing modes need to be taken into account.

- Environmental charges for noise and air pollution should vary with the characteristics of the vehicle; for air pollution, population density and windspeed are the other key cost drivers; for noise, population density and background noise levels.

- The sensitivity of an area in relation to transport has a major effect on the appropriate pricing levels – for example, appropriate charges in Alpine areas may be several times those in flat areas.

Ports, Inland Waterways and Airports

- Efficient charges for ports and inland waterways will comprise a wear and tear charge for the use of locks, plus congestion, scarcity and environmental charges. Methodologies for estimating all of these are put forward. Given current levels of congestion, this approach will result in very low charges relative to average cost.

- Efficient charges for airports will also comprise a base charge well below average cost plus congestion, scarcity and environmental charges.

- Airports produce substantial enviromental costs which are not usually internalised in charges.

- If capacity is expanded in line with demand, and operators reserve blocks of capacity on long run contracts (e.g. in ports) long run marginal cost pricing (incorporating a charge for incremental capacity, perhaps as a fixed element in a two part tariff but excluding congestion and scarcity charges) may be more appropriate.

Generalisation

The generalisation exercise confirms that there are major differences in marginal social cost in time, space and vehicle type that have not internalised in existing charges.

- An appropriate methodology for estimating external accident costs has been set out but there remain major uncertainites concerning risk elasticities and users' perception of risks.

Accounts and Monitoring

- To be useful in connection with pricing policy, transport accounts need to:-
    - Split infrastructure costs into fixed and variable – detailed estimates have been derived for the variability of road and rail costs;
    - Split accident costs into internal and external - a more refined methodology to estimate internal parts of accident costs has been established;
    - Be based on detailed databases showing capacity utilisation ratios for individual sections of the network, and to categorise these by population density
- It is possible for countries to prepare comparable transport accounts using guidelines tested within the project.
- Data shortages exist in some Member States, but perhaps the most important implementation barriers result from policy maker's unfamiliarity with the accounts methodology, a lack of resources and problem perception, organisational opposition against change, fear of undesirable results, and lack of an organisation responsible for making national transport accounts. Overcoming these requires more effort on institutional reform and dissemination of best practice.
- The elaboration of regional accounts can provide useful insights into relevant policy questions, but data support from regional authorities is the major prerequisite.
- It is worthwhile periodically analysing the availability and quality of new data and studies to develop methods further, and to produce in a next step "new" UNITE accounts based on these improvements.

Complexity

- It was not thought that there were any major technological constraints on the introduction of highly differentiated charges in the rail, water or air sectors.

- The costs of implementing the most complex charging regimes for roads appear likely to outweigh the benefits and a simpler scheme is likely to yield higher net benefits.

- A close match between costs and individuals' behaviour cannot be expected in the short term and there is thus little reason to introduce highly differentiated charges unless they are likely to remain stable for a considerable period of time.

- Given that, faced with "difficult" charge structures or unpredictable charges, individuals generally seek to avoid them but are not very sensitive to the precise level of the charges, complex charges (particularly those which vary in more than one dimension) are very unlikely to result in a complete adjustment of behaviour to the pricing signal.

- If individuals can be assisted to estimate distances, distance-based charges appear to offer the prospect of high benefits at relatively low costs.

- Because individuals do not perceive their vehicle operating costs accurately or net of tax, an additional charge based simply on the valuation of externalities can not lead to social-welfare-maximising behaviour; the optimal charge must take this misperception into account.

- Road freight operators are likely to invest time into understanding the cost implications of any charging regime, however complex it might be, and so are likely to be much less affected by problems of misperception and/or lack of understanding.

Socio-Economic Impacts

- Substituting all existing taxes on transport by a fuel tax equal to the external costs would lead to an unrealistically high fuel tax and would not bring welfare improvements. One of the important drawbacks of the fuel tax is that it can not strongly be differentiated within countries.

- The introduction of a flat kilometre charge, differentiated by type of vehicle and perhaps by country would generate substantial revenues and increase welfare significantly.

- Whenever a reform of pricing generates extra revenues, the smart use of the revenues is as important as the design of the pricing reform. From an efficiency point of view, revenue is generally best used to decrease existing distorting taxes. Alternatively, under certain specific circumstances, using the revenues to expand infrastructure may also improve efficiency. There may, however, be instances where concentrating on efficiency improvement is not the over-riding concern.

- The regional differentiation of transport pricing within Switzerland, where marginal social cost differs substantially between the regions, is welfare improving for both regions, showing that differentiation even of inter-urban charges within a country may be important.

- Provided revenue is efficiently recycled, efficient charges will benefit the economies of most or all European countries, but they will tend to benefit countries at the core more than at the periphery. This leads to a possible argument for a mechanism for redistributing revenues between countries, but any such argument should be considered in the context of the EU's existing framework of financial redistribution between regions.

- In looking at such mechanisms, it is also important to take account of the incentives on countries with high levels of transit traffic to overcharge and under invest.

- All member countries with important transit transport flows have an interest to misreport their marginal external costs if their tax and toll cap is a function of their report. The European Commission could use three techniques to control this. The first is to use an incentive mechanism for correct reporting but this will not work for congestion costs. The second is that the Commission uses its estimate as toll cap. This can work for all kinds of external costs. The efficiency of this policy depends on the quality of information. The third policy works only for the external congestion costs and assuming constant returns to scale. It is a toll cap equal to the average road infrastructure cost. In principle this policy can be efficient as it minimizes the amount of monitoring but requires that the transit and local transit flows have the same composition. In practice, there will be incentives to over-charge and under-charge in different parts of Europe.

Further research

- Key issues for further research are:-
    - The treatment of renewals in estimating marginal wear and tear costs
    - Variation of elasticities of wear and tear costs with traffic volume and infrastructure quality
    - Risk elasticities and their implications for the marginal external costs of accidents
    - Practical ways of determining congestion and scarcity costs for rail, water and air transport.
    - Optimal pricing given road users misperception of costs

1. Introduction and Context

1.1 The GRACE Project

This is the final deliverable of the GRACE research project. The focus of this report is on drawing out the policy-relevant conclusions and recommendations from the entire body of GRACE research.

The GRACE project aims to support policy makers to develop sustainable transport systems by facilitating the implementation of pricing and taxation schemes that reflect the costs of infrastructure use. Five areas of research are covered within the GRACE project:

1. Case study research to address gaps in the existing level of knowledge of marginal social costs for road, rail air and waterborne transport,
2. Development and refinement of methods to enable the use of transport accounts as monitoring instrument for the implementation of transport pricing reform in an enlarged Europe,
3. Innovative research on the appropriate degree of complexity in transport charges,
4. Guidance on the marginal social cost of the different modes of transport in specific circumstances and on simple and transparent methods for determining charges,
5. Modelling the broad socio-economic impacts of pricing reform.

1.2 The Policy Context

Efficient pricing in transport and the internalisation of the external costs of transport have been key aspects of European transport policy for over a decade now. Starting with the Commission’s Green Paper 'Towards Fair and Efficient Pricing in Transport' (CEC 1995), and continuing with the White Paper 'Fair Payment for Infrastructure Use' (CEC,1998) and the Common Transport Policy White Paper (CEC,2001), there is a strong emphasis on pricing policy to reflect the full social costs of transport use.

European transport pricing policy has been actively taken forward during the period of the GRACE project. In 2006, ‘smart charging’ formed a key plank of the Commission’s re-statement of its Common Transport Policy which followed their mid-term review of policy goals and progress. Also in 2006 as part of the revision of the Eurovignette directive, the European Parliament asked the Commission to present by June 2008 "a generally applicable, transparent and comprehensible model for the assessment of all external costs to serve as the basis for future calculations of infrastructure charges". They furthermore asked that “this model shall be accompanied by an impact analysis of the internalisation of external costs for all modes of transport and a strategy for a stepwise implementation of the model for all modes of transport".

As the GRACE project comes to a close, the Commission is working to prepare a Communication on the internalisation of the external costs of transport that responds directly to the European Parliament’s request for a model for the assessment of all external costs. This communication is to be adopted in June 2008, with the intention that this will provide a general framework of reference for the internalisation of external costs in the transport sector. More specifically, it may be accompanied by proposals for further legislation, notably in relation to a further revision to the Eurovignette Directive.

The estimation of external costs is absolutely central to the pursuit of the Commission’s transport pricing policy and, over the past decade, there has been a considerable body of research in this area. Indeed, GRACE is the most recent in a series of research projects that also includes EXTERNE, RECORD-IT and UNITE, amongst others. To review the best practices in the estimation of external costs emerging from this research and, hence, identify the best methodology to adopt, DG TREN commissioned the IMPACT study. This study has run in parallel with GRACE and is also now coming to a close. A key output from it is a Handbook on the estimation of external costs in the transport sector.

Understanding the potential impacts of different policy options is also vital to the process of taking the policy forward. Modelling to understand the impacts of different pricing policies on the economy, on the environment and on society at large has been a core part of GRACE and of a number of research projects before it; it also forms a key part of the IMPACT study. Drawing on this body of work, the Commission is working on its own impact assessment of the policy.

European transport pricing policy is at an exciting juncture. GRACE finds itself drawing its conclusions at a point where policy-makers are actively taking forward the transport pricing policy agenda. As the Commission prepares its forthcoming communication on the internalisation of external costs, GRACE is able to provide state of the art research on cost estimation and the impacts of particular policy options. Furthermore, in whatever form the policy is taken forward, GRACE's work on transport accounts provides policy-makers with means of monitoring the progress of reforms.

1.3 This Deliverable

This deliverable seeks to draw together the key findings of the project, and identify the emerging policy conclusions. Section 2 concentrates on the cost estimation and calculation aspect of the research. It summarises the findings from the set of new marginal cost case studies and outlines the work undertaken to develop a cost calculation software tool. Section 3 then focuses on the research to develop transport accounts as a means of monitoring transport pricing reforms. Section 4 concentrates on the research examining optimal degrees of complexity in pricing, whilst section 5 focuses on the research to model the impacts of adopting more efficient transport pricing strategies. Section 6 then draws out key overall conclusions.

2. Cost Estimation and Charge Calculation

2.1 Introduction

The estimation of external costs is a vital element to the calculation of efficient prices and charges. The nature of most external costs is that they are situation-specific. That is, the external cost associated with a particular vehicle, on a particular piece of infrastructure, in a particular place at a particular time is likely to be specific to that set of circumstances. The same vehicle, on the same infrastructure, in the same place but at a different time is likely to give rise to a different level of external cost. Similarly, the same vehicle at the same time, in the same place but on a different piece of infrastructure is again likely to give rise to a different level of external cost. This makes the accurate estimation of external cost a very case-specific task. In theory, a policy to internalize external costs throughout Europe would require cost estimates to be derived for every set of circumstances that exists throughout Europe, but a proposal to undertake such an enormous exercise would almost certainly lead policy-makers to abandon the policy itself. Instead, it is likely to be more fruitful to undertake case-specific cost estimation exercises wherever possible, and then to use those estimates to form an understanding of the ways in which costs vary from one set of circumstances to another. With this understanding, it should become possible to make reasonable approximations of costs in circumstances where detailed cost estimates are not available and where it is not possible, for whatever reason, for them to be undertaken.

GRACE undertook extensive new research on cost estimation across the various modes and cost categories. Furthermore, it sought to understand how costs vary with circumstance and to encapsulate this understanding within a user-friendly software tool that can be used to derive reasonable approximations of external costs. In this way, GRACE has sought to build upon the cost estimation evidence base and to make it generalisable.

The cost estimation work in GRACE was undertaken as a series of case studies, focusing on particular modes and on particular cost categories. For convenience, the case studies were clustered into two broad modal groupings:

- Case studies focusing on road and rail costs – grouped together because, for these modes, there existed some previous research into cost estimation to serve as a starting point and as a reference to compare with; and
- Case studies focusing on port, inland waterways and airports costs – grouped together because, for these modes, there existed very little previous research into cost estimation that might serve as a starting point and as a reference to compare with.

The detail of the numerous case studies undertaken is reported extensively elsewhere (deliverables 3 and 4). This chapter tries to summarise the main results from the case studies and the main conclusions for each cost category considered.

The development of the software tool used the GRACE cost estimation results and combined these with similarly robust results from other research. The software tool enables the user to specify a situation they are interested in and to derive a reasonable approximation of the relevant external costs. This section provides a brief overview of the software tool and its development; it is described fully in Deliverable 7.

Of course, the reason for wishing to estimate or approximate external costs is, usually, in order to consider the introduction of a charge to internalise that cost. The software does not seek to calculate efficient charges itself, as this would also require details of existing charges, taxes and subsidies to be input. However, tests have been undertaken using the software tool to derive external costs, and then, for a limited number of examples, these external costs have been combined with data on existing charges and taxes in order to provide sample charge-calculations. This section closes with an overview of these sample calculations.

2.2 Estimation of Road and Rail Costs

2.2.1 Infrastructure cost

There is a well-known and useful relationship between average cost and marginal cost known as the cost elasticity with respect to traffic output. This relationship was utilized within the GRACE case studies as a means of estimating marginal costs.

Cost Elasticity = Marginal Cost / Average Cost; and hence

Marginal Cost = Cost Elasticity *Average Cost

Within GRACE, econometric methods were used to estimate this elasticity using data for a number of case study countries. In all cases data on maintenance cost was available at the necessary level of disaggregation; appropriate data on renewals and operations was more scarce.

The roads case studies in GRACE found that the elasticity for road infrastructure cost decreases as the measure changes from renewal to maintenance and to operation. The average elasticity for maintenance and renewal cost[1] is between 0.5 and 0.7, while the elasticity for operations cost appears to be more or less zero.

The rail case studies in GRACE found that elasticity for rail infrastructure cost is lower than the elasticity for road and less variable between different measures. The average elasticity is between 0.26 and 0.30 for an aggregate of renewal and maintenance, for maintenance it is between 0.20 and 0.24 and for operation or short term maintenance it is 0.29 to 0.32.

Thus, ignoring externalities efficient prices would be somewhat below average costs for roads and a long way below for rail.

The majority (but not all) of the GRACE case studies suggest that the elasticity decreases with increased traffic. Thus highly used infrastructure has a lower elasticity than low volume of traffic

[1] Renewal costs are the costs associated with replacing worn out infrastructure, where as construction costs generally refer to the costs associated with constructing new infrastructure. A proportion of renewals costs are generally viewed as being directly related to traffic and hence marginal, as the damage imposed by the passage of traffic brings forward the time at which renewal must take place.

infrastructure. This is potentially due to the highly used infrastructure being constructed at the outset to a higher quality (e.g. see below reference to pavement thickness).

All elasticities reported above are from the average traffic in the studies. Further research on the variability of this elasticity with traffic volume and quality of infrastructure would be valuable.

The methodology for estimating maintenance costs is more well-developed than is the methodology for estimating renewals costs. Most of the studies use an econometric approach with paneldata. However, a minority of the studies did use paneldata models but use pooled ordinary least squares to estimate the cost function. In two studies a duration model is used where a function of the lifetime of a road pavement or railtrack is estimated. The result can be used to derive a marginal renewal cost. The rail study gave results in line with the econometric study and supported the conclusion drawn from the econometric studies that there indeed exists a marginal cost related to renewal on railways. The result was similar between the two approaches. However, the road study suggested a very low effect of traffic on the observed lifetime of a pavement. A possible explanation with some support is that the authority predicts the higher traffic volume when deciding on the pavement thickness. The marginal cost is thus not found in observed lifetime but in increased cost of the measures taken.

Given these differences in results, the marginal cost of renewals remains a priority for further research.

2.2.2 Road congestion and rail scarcity

The main focus of the road congestion case study was to identify reasons why previous case studies show such a huge variability in road congestion costs. It was found that these differences can be variously attributed to:

- differences in the definition of “optimal” tolls – the term is often quite loosely applied, e.g. in modelling studies. For example; the term sometimes relates only to congestion tolls (rather than covering other externalities), sometimes allows for the cost of implementation of the tolls (and sometimes not), and sometimes relates only to simple tolls - such as cordons (rather than tolls which vary in space and time).

- differences in the way that optimal tolls (however defined) are calculated. For example, do they fully reflect the behaviour of travellers at the margin or are they derived from a theoretical representation of the marginal impacts?
- differences in the nature of the cities being studied. Factors which are particularly likely to influences the result include the degree of congestion, the availability and attractiveness of alternative modes, the drivers' tolerance of congestion, and the capacity of the network to absorb additional demand.
- differences in the valuation of different externalities – perhaps reflecting different values of time and resource costs.
- differences in the models used to estimate system performance.

Nevertheless, even using the same methodology (the SATURN model) but varying characteristics of the city, congestion costs were found to be important but very variable in time and space.

For rail, a model was used to estimate scarcity costs for the congested East Coast Main Line in Britain.

It showed that a substantial peak scarcity charge per slot is justified, but in contrast, the off-peak charge would only be 10% of this level. The results seem to confirm the view that existing variable charges for the use of infrastructure on key main lines where capacity is scarce are too low as a result of the neglect of scarcity in the charges set.

Furthermore, the private value of a slot is different from the social value of a slot, indicating problems with a simple market based solution. This result is mainly an effect of high congestion cost on the road network that is not internalized in a road pricing regime, meaning that there are major external benefits to attracting traffic from road to rail.

2.2.3 Accidents

Based on an overview and state-of-the-art survey, it seems that there is a growing consensus on the method to estimate the value of statistical life (VSL). The HEATCO project suggests specific values for each Member State. Nevertheless, research on VSL continues with the aim to explore the numerous biases that have been found to potentially affect the estimates.

On the question of the proportion of internal and external cost, an appropriate methodology has been set out but there is still uncertainty on the empirical evidence. The perception of road users' risk is still an area of large uncertainty. However, by making assumptions about the perceived cost, actual databases can be used to estimate the proportion of internal versus external cost.

There is still no consensus on the risk elasticity. Surprisingly, many studies find decreasing risk with increasing traffic volume. This could be a problem associated either with the studies or behaviour effects. If we do not control for infrastructure quality, we may find that roads with higher expected traffic volume are designed with a higher traffic safety standard. In addition, road users may react to a perceived increased risk by driving more carefully and slower. This is an unobserved cost component that would increase the cost.

2.2.4 Air pollution and Greenhouse gases

Four case studies for road transport within densely built areas have been conducted. They fill gaps in the picture on air pollution from existing studies and analyse the variations of environmental costs and the driving parameters. Assessing data availability and due to the fact that a broad range of European countries and local meteorological conditions should be considered, the cities selected for this purpose were Berlin, Prague, Copenhagen and Athens.

The results show that for all vehicle types the higher marginal costs due to airborne emissions correspond to the city of Athens, followed by Berlin, Copenhagen and Prague in that order. The factors that seem to be more relevant for these results are the wind speed and the population density. The high share of low wind speeds for the Athenian area together with a population density close to 20 000 hab/km^2 in some zones, leads to a pollutant exposure of the population which is about a factor of two higher compared to the other cities. In addition, petrol cars cause lower cost per vehicle kilometre compared to diesel cars as they emit much less fine particles, leading to lower health impacts.

A European abatement cost of €20 per tonne of CO_2 represents a central estimate of the range of values for meeting the Kyoto targets in 2010 in the EU based on estimates by Capros and Mantzos (2000). They report a value of €5 per tonne of CO_2 avoided for reaching the Kyoto targets for the EU, assuming a full trade flexibility scheme involving all regions of the world. For the case that no trading of CO_2 emissions with countries outside the EU is permitted, they calculate a value of €38 per tonne of CO_2 avoided. It is assumed that measures for a reduction in CO_2 emissions are taken in a cost effective way. This implies that reduction targets are not set per sector, but that the cheapest measures are implemented, no matter in which sector. Recent work has confirmed the assumption that emissions in future years will have greater total impacts than emissions today.

Hence, for application in GRACE we used a range of €14 to €51 (with a central value of €22 per tonne of CO_2- equivalent emission in the period 2000 to 2009). These shadow prices were derived from Watkiss et al. (2005b), converting from £2000/t C to €2002 (factor prices).

2.2.5 Noise

Based on a state-of-the-art review, it is observed that existing estimates show considerable non-linearities of marginal noise cost with background noise levels. Population density along the route and average distance of traffic from buildings are also found to be key determinents of cost.

2.2.6 Sensitive areas

The impact pathway approach has been used to estimate a factor that relates the cost in Alpine regions to the cost in 'flat' regions. The biggest effect is found to be related to the topographical and meteorological conditions.

The results indicate that local air pollution costs, noise costs, accident costs and infrastructure costs are all substantially greater in Alpine regions as compared with flat regions. Local air pollution costs from road transport in an alpine region would be five times higher than in a flat area, with a slightly higher factor for cars than for HGVs. The corresponding factor for rail is around 3.5. The noise cost is also estimated to be about 5 times higher in road transport and 4 times for rail transport. The number of accidents is higher per kilometre in Alpine regions suggesting a factor of 1.2 for road transport. The infrastructure maintenance cost is for the road sector about 4.5 times higher and for rail transport 1.4 times. In addition, a factor for visual intrusion is suggested to be around 10 due to the specific alpine conditions. This has however, no corresponding marginal cost.

2.3 Cost Estimation for Ports

A simulation tool was built in order to calculate the marginal cost in case of a vessel calling at and leaving a port. Marginal costs taken into account are:

- infrastructure costs as a consequence of using locks in the port;
- crew cost on the vessel;
- operating and maintenance cost of the vessel, tugboats and pilotage boat (or helicopter);
- accident costs (cargo as well as injuries of persons);
- noise costs and air pollution costs.

It is illustrated that the simulation tool can be used for all types of ports and for several effects. Five ports for the case-studies have been selected: Port of Antwerp (Belgium), Port of Bordeaux (France), Port of Genova (Italy), Port of Felixstowe (UK) and the Port of Gdynia (Poland). It is clear that the simulation tool can be used for the selected ports.

First provisional estimations have been included. They show that marginal costs per vessel call usually increase in vessel size. A 200 TEU container vessel in Antwerp for instance incurs a marginal cost of €12,150, whereas a 3000 TEU vessel incurs a marginal cost of €28,842. The effect is mainly, but not always, due to higher vessel crew and operating costs.

Marginal infrastructure costs are only a small fraction of overall marginal costs (€706 per vessel in Antwerp for instance), and fully depend on lock use: if no locks are used, no marginal infrastructure costs occur. Marginal costs are usually comparable in level over vessel and corresponding commodity types. A comparison between the ports of Antwerp and Bordeaux, where the port-approach as well as the in-port timing is known, shows that marginal costs of calls in Bordeaux are not always lower than corresponding costs in Antwerp, although Bordeaux' approach is a lot shorter in distance. For Genova as well as for Felixstowe, no approach timing is known. A comparison of the at-terminal costs shows that for container vessels, Felixstowe usually incurs higher marginal costs than Genova, the main reason for which may be port efficiency.

For the port case study, the simulation tool can be used to deal with congestion and scarcity costs. However, in the case of the ports that were investigated, congestion and/or scarcity seems not to be relevant nowadays, e.g. due to existing overcapacity. However, port economists start to take into account potential future capacity problems. Therefore, it is necessary to provide a simulation tool able to calculate the consequences of possible congestion.

If capacity is expanded in line with demand, and operators reserve blocks of capacity on long run contracts (e.g. in ports) long run marginal cost pricing (incorporating a charge for incremental capacity, perhaps as a fixed element in a two part tariff but excluding congestion and scarcity charges) may be more appropriate, than short run marginal social cost pricing.

The environmental costs of maritime transport are assessed for air pollution, global warming and oil spills. Environmental costs of air pollution are estimated for 15 types of marine vessels using fuel consumption, emission factors and damage factors.

Using the resulting figures for air pollution and oil spills, the environmental costs of six maritime trajectories in Europe are computed. Using these examples the outcomes quantify the monetary impacts maritime shipping has on the environment in Europe.

2.4 Cost Estimation for Airports

An econometric model was developed to evaluate economies of scale, economic inefficiency and marginal costs. It consists of estimating a translog model, formed by a cost function and two input cost share equations that allows to estimate the airport parameters under study.

Three case-studies are distinguished: a Spanish airports case-study, an international airports case-study and Chicago O'Hare airport case-study. The first two cover airport provision costs and the latter congestion costs.

The results confirm that the resource use is statistically not economically efficient. Whilst marginal costs vary greatly between airports, most of the airports operate in the area of increasing returns to scale. Thus, ignoring externalities, efficient charges will be below average cost.

The analysis of congestion at O'Hare airport showed the difficulty of estimationof this external cost. Evidence was found that airlines add time to their schedules to reduce the degree to which congestion results in late departures and arrivals. Further research on this issue is required.

Costs caused by emission of airborne pollutants, greenhouse gases and noise (for aircraft) were assessed, based on the Impact Pathway Approach. Quantifiable costs due to taking-off and landing at Frankfurt airport – the biggest airport in Germany – were calculated for a number of aircraft. Costs due to air pollution amount to – depending on aircraft type –between 10 and 235 € per Landing and Take-Off (LTO) cycle, greenhouse gas emissions add another 20 to 220 € per LTO cycle. Noise costs were quantified for different times of day: day time, evening and night time with the latter showing the highest cost. Quantified night time noise – depending on flight route – ranges from 4 – 16 € per take-off to 200 – 900 € per take-off. Costs for landing tend to be lower, but are in the same order of magnitude. This suggests substantial external costs which are not usually internalised in taxes or charges.

2.5 Cost Estimation for Inland navigation

Computing infrastructure costs of inland waterways is complicated by the fact that the waterways serve multiple purposes. In order to compute the infrastructure costs it has to be clear what part of the total costs is related to the transportation function. In a second step, the infrastructure costs are divided into fixed costs and marginal costs. In a next step, the mathematical relation is determined between total infrastructure costs and the marginal costs.

It is reported that the average marginal infrastructure cost for inland navigation in the Netherlands in 2002 is on average € 0.53 per vessel-kilometre.

The significance of congestion costs is very much dependent on the specifics of the situation. In general there is not much congestion on the inland waterways. However, for particular locks and bridges there are significant waiting times and these times can increase rapidly when traffic intensity increases.

The methodology for estimating congestion and scarcity on inland waterways was divided into three parts:

- congestion at locks;
- congestion at bridges;
- scarcity on waterways.

The methodology for estimating congestion at locks was tested on several case studies and is proven to be easily implemented and generating promising results. The methodology has been applied to 5 locks in the Netherlands. The increase in costs per ship when the intensity increases by 1 million ton per year varies between € 0.08 (Volkerak locks) and € 379.55 (Lock Eefde). The increase in costs per ship when the intensity increases by 1% is in the range € 0.15 (Locks at IJmuiden) to € 49.52. When a lock is already heavily congested, marginal costs are very high.

The methodology for estimating congestion at bridges is considered an interesting suggestion, however, for now it can not yet be implemented, because of a lack of data.

Air pollution costs for inland water transport are calculated for two selected trajectories on the Rhine and the Danube. The approach uses a regionally differentiated method including the newest findings of European research on emission factors and damage costs. Emissions costs were computed and relative figures in terms of costs per tonne kilometre were calculated, as shown in **Error! Reference source not found.**1. Environmental costs range between 0.17 and 0.41 cent per tkm. These costs are well within the range given by UNITE (2001)[2]. The graph shows clearly, that the Vienna- Bratislava voyage is cheaper due to the lower population densities along the trajectory. The figure illustrates as well the decreasing environmental costs for larger vessels[3].

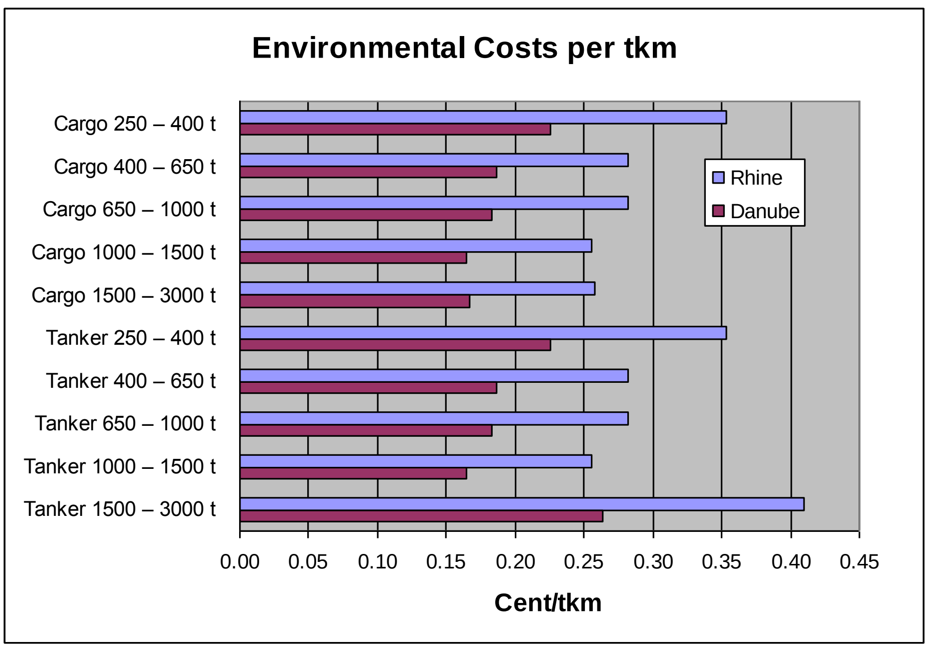

Figure 1 Air Pollution costs per tonne-kilometre

[2] UNITE (2001) WP5/8/9, Version 2, p.33
[3] However, some implausibilities occur, e.g. for large tankers, which are due to problematic input data on the emission side.

2.6 Generalisation of Research on Cost Estimation

GRACE has developed a software tool in order to assist the user in the estimation of marginal costs for any section/node of the TEN-T for which all the detailed information required for a fully fledged, bottom-up calculation does not exist. Drawing heavily on previous RTD projects that have addressed the calculation of marginal costs (e.g. UNITE, RECORDIT), in addition to the new insights coming from the GRACE case studies, the GRACE tool incorporates methods ensuring the transferability of marginal costs estimates and their generalization, i.e. identifying the variables (cost drivers) and parameters whereby existing marginal costs can be adapted to different contexts and/or new estimations can be carried out.

Marginal costs estimates for the use of transport infrastructure have been produced for a wide range of situations, and using a variety of different approaches. One thing that these case studies have in general shown is that there is no standard methodology for marginal costs estimation, and that the methodological approaches available are strongly influenced by data availability issues and by the type of transport mode under examination.

However, it is important to stress that transferability methods cannot be implemented with the same degree of confidence across all cost categories. Although much of the effective implementation depends on sheer data availability, the level of difficulty varies with the cost categories.

The following table provides an overview of the two basic approaches adopted in the GRACE tool, i.e. the cost functions (CF) and the reference costs (RC), across transport modes and external cost categories. Empty cells in the table correspond to modes and cost categories for which the absolute value of external costs is known to be very small, and to all intents and purposes is therefore considered negligible.

Cost functions have been devised when causal functional relationships have been identified between variations in the drivers (the independent variables in the function) and the values of marginal costs (the dependent variable). This is clearly the preferred option, allowing the user to carry out sensitivity analysis through the modification of values and parameters of the function.

On the other hand, reference costs have been proposed, as a second best solution, when the current state of research does not allow for the identification of a usable (i.e. simple and reliable) cost function, and only reference marginal external costs are available for typical situations, e.g. urban and non urban context, without allowing sensitivity analysis. In fact, this fallback option is only adopted in the case of wear and tear marginal external costs, for which the current methods of assessment state of the art do not allow for the determination of a cost function, so that reference costs available from literature have been proposed for road and rail transport modes.

Cost Category	ROAD		RAIL	IWW	AIR	SSS
	Urban	Interurban				
Air Pollution	CF	CF	CF	CF	CF Airport	CF (Port)
Noise	CF	CF	CF	-	CF Airport	-
Accidents	CF	CF	-	-	-	-
Congestion /scarcity	CF	CF	-	CF	CF Airport	-
Global Warming	CF	CF	CF	CF	CF Airport	CF (Port)
Wear and tear	RC	RC	RC	CF	CF Airport	CF (Port)

The case studies with the tool confirm that there are large differences in marginal social cost by time, space and vehicle types that are not internalised in existing charges.

3. Transport Accounts and the Monitoring of Pricing Reforms

Transport accounts, developed in the UNITE projects for all EU 15 countries and for Switzerland and Hungary, provide information about the total social costs (infrastructure costs, supplier operating costs, delay costs due to congestion, accident costs, environmental costs) and revenues of transport for road, rail, other public transport, air, inland waterway and maritime transport, disaggregated by network types, differentiation, transport means and user groups. Since transport accounts show the total or average social costs rather than marginal costs they should not be viewed as an instrument for determining charge levels or charge structures. The major purpose of transport accounts is rather to serve as a monitoring tool.

However, the conclusion from the UNITE project and from the early GRACE work was, that both methodological and data improvements are required in order to enable the use of transport accounts for monitoring pricing policy. Hence, this work package considered potential methodological advancements and derives conclusions on the necessary data collection procedures. It has suggested a range of methodological improvements of transport accounts with the aim to enable their use as monitoring tool for transport pricing reform.

In particular, recommendations were put forward on how to split infrastructure costs between fixed and variable cosdts and on how to split accident costs between internal and external. In ordeer to be useful for monitoring transport pricing, transport accounts need to handle these issues and to be basedon databases which disaggregate the network by capacity utilisation levels and by population density.

Furthermore, we have analysed the situation in the new member states and have developed recommendations and guidelines to produce transport accounts for these countries. Conceptual issues for elaborating regionalised accounts were explored and tested for the urban areas of Rome and Amsterdam and for the Swiss Alpine region. Finally, for making the accounts capable to fulfil their envisaged monitoring function, simplified updating procedures were developed. This work is described in detail in Deliverable 5.

For some new member states, it was found that there are serious problems with data availability. However, the major conclusion from this part of research is that the most important implementation barriers result from policy maker's unfamiliarity with the accounts methodology or originate from a lack of resources and problem perception, organisational opposition against change, fear of undesirable results coming from the accounts, and lack of an organisation responsible for making national transport accounts. The most important recommendations for overcoming the implementation barriers are:

- dissemination and marketing targeted at policy makers,
- explaining more clearly the use and policy implications of transport accounts,
- appointing organisations responsible for creating these transport accounts,
- providing funds, and coupling with applications for (regional) funding.

For the Swiss Alpine region different types of regional accounts were successfully developed, each of them depending on the perspective taken and on the way how transboundary effects are considered. For the urban area of Amsterdam a conceptual approach for an urban account was developed including an analysis of data requirements and availability. The same is true for the Rome case study where conceptual issues and the methodology have been developed, but future work is needed to fill in the framework with data and cost estimates. Our major conclusion is that the elaboration of regional accounts can provide useful insights into relevant policy questions, but data support from regional authorities is the major prerequisite.

Our major and overall conclusion from the research reported in this deliverable is that it is well possible to improve the methodology of accounts if new and improved data is available. The emergence of such new data, but also of new country case studies stimulated the development and testing of methods as demonstrated in this deliverable. It is worthwhile to analyse periodically the availability and quality of new data and studies to develop methods further, and to produce in a next step "new" UNITE accounts based on these improvements.

4. Price-Complexity

This area of GRACE sought to investigate the optimal degree of complexity in pricing. It was, first, necessary to explore some definitions of optimal complexity and to introduce the trade-off between the theoretical advantages of highly differentiated charges and the practical problems that such differentiation might bring. It then addresses four modal sectors and, for each one, explores four issues:

- the existing degree of charge differentiation,
- the differentiation implied to achieve marginal social cost pricing,
- the level of differentiation that is likely to may become possible in the medium term, and
- the information required to define or identify optimal complexity of charges.

It was not considered that there were significant barriers to implementing complex pricing systems in the rail, air or water modes. Hence, subsequent work concentrated on the passenger market in the road sector. This section goes on to discuss the results of surveys which used a specially designed questionnaire to explore user response to complexity in road user charges and modelling work to identify optimal levels of complexity in road user charges. This work is described in Deliverable 6.

Analysis of optimal complexity in the road sector is seen to require information on costs (of delays, of environmental emissions including noise, of accident costs, of pavement damage and of alternative payment channels), on user responses to charges and on user responses to complexity per se.

The major new research undertaken on this issue was development of models based on a questionnaire to establish user reaction to pricing systems of varying complexity. The most important findings from this were that:

- respondents were not able to produce accurate estimates of their current motoring costs or trip distances and were themselves aware that this was the case;

- substantial proportions of the sample claimed that they didn't always seek the "best" deal when dealing with everyday household bills and that they did not normally think about the costs of alternative travel routes;
- although most respondents claimed that they found the charge scenarios easy to understand, many were unable to estimate the charge that they would incur on their regular journeys and most of them recognised that this was the case;
- charges that were a function of distance travelled seemed to be particularly difficult for people to predict;
- respondents who said that they had found the charges difficult to predict were likely to be less certain about their likely behavioural response;
- many respondents said that, even if charges were introduced, they would not bother to think seriously about alternatives to their current transport arrangements because they felt they had no choice;
- many respondents said that they would not think seriously about alternative travel arrangements unless the charge represented a significant daily sum and that, at lower levels, the effort required to think about it was not worth it;
- most of the respondents who said they were very likely to continue with their existing travel arrangements had said the charge was too low to warrant serious consideration of alternatives; and.
- most of our respondents showed an aversion to uncertain charges – though a minority seemed actively to be risk-seeking.

The questionnaire data was used to specify and calibrate models of response to charges for use in the next stage of the work. Although there was some support for a model which explicitly recognised the process of disengagement (whereby people elect not to make a serious effort to consider the implications of a new charge) as a precursor either to a heuristic response or a more considered evaluation, that model did not perform well enough to justify such a radical departure from conventional practice in the next stage of the work. A fairly conventional logit model was therefore used to capture the likelihood of each of a series of behavioural responses to complex charges. These models suggested that the responses were influenced by the size of the charge (although to a lesser extent than is implied in a conventional elasticity model), by the age, gender and income of the trip maker, and by the purpose of the trip – with mandatory trips being less affected than discretionary trips.

The next stage of the work involved the construction of a network modelling package to test the performance of charge regimes with different degrees of complexity. The package was built around the SATURN assignment model, a charge estimation module, and a demand response module which, between them predicted an equilibrium level of network conditions, charges and demand. The demand response module differed depending on the complexity of the charges being studied; responses to complex charges were predicted using the logit models calibrated on the questionnaire results while responses to simple charges were predicted using a conventional elasticity model. The most complex charge regime had link-specific charges based on the environmental externalities associated with traffic using that link plus a charge based on the increment to congestion caused by an additional vehicle using that link at the current demand level. A range of simpler charging regimes were derived from this fully complex specification.

A number of different charging regimes were tested using this network modelling package and several very interesting results emerged, of which the following are particularly relevant to the question of optimal levels of complexity:

- The complex charging regime produced larger revenues and greater reductions in externalities than any of the simpler regimes but produced lower benefits even before allowing for the less precise response to the pricing signal and the higher costs of scheme operation.
- The underperformance of the complex regime was even greater when allowance was made for the less precise response to the pricing signal and the higher costs of scheme operation.
- The basic underperformance of the complex regime seems to be related to the fact that it was based on link-specific charges which, while reducing congestion, encouraged the use of longer routes and so led to an increase in vehicle operating costs.
- We note in this context that, because users do not perceive their current operating costs correctly, their response to supposedly optimal charges will not be efficient.

Key policy conclusions from this part of the work are:

- It was not thought that there were any major technological constraints on the introduction of highly differentiated charges in the rail, water or air sectors.
- The costs of implementing the most complex charging regimes for roads appear likely to outweigh the benefits and a simpler scheme is likely to yield higher net benefits.
- A close match between costs and individuals' behaviour cannot be expected in the short term and there is thus little reason to introduce highly differentiated charges unless they are likely to remain stable for a considerable period of time.
- Given that, faced with "difficult" charge structures or unpredictable charges, individuals generally seek to avoid them but are not very sensitive to the precise level of the charges, complex charges (particularly those which vary in more than one dimension) are very unlikely to result in a complete adjustment of behaviour to the pricing signal.
- If individuals can be assisted to estimate distances, distance-based charges appear to offer the prospect of high benefits at relatively low costs.
- Because individuals do not perceive their vehicle operating costs accurately or net of tax, an additional charge based simply on the valuation of externalities can not lead to social-welfare-maximising behaviour; the optimal charge must take this misperception into account.
- Road freight operators are likely to invest time into understanding the cost implications of any charging regime, however complex it might be, and so are likely to be much less affected by problems of misperception and/or lack of understanding.

We did not specifically examine the road haulage sector, but it seems likely that the issue of misperception is much less serious on this sector given the obvious incentive on a professional commercial organisation to correctly estimate the costs of alternative courses of action.

- An important conclusion from our network modelling work was that tolls designed to optimise levels of congestion can not perform well unless they recognise the fact that users do not base their decisions on an accurate assessment of vehicle operating costs (net of tax). There is clearly a need for some further theoretical work to define a toll which recognises this kind and to operationalise the calculation of such a toll within the context of a network model such as SATURN.

5. Socio-Economic Impacts

Introduction

In order to understand the socio-economic impact of pricing traffic according to the marginal external cost we need to put the transport market in a broader economic context. In GRACE we took five different approaches that each highlight a different research or policy question relating to socio-economic impact. These were as follows:

Research or Policy question	Approach
What is the effect of implementing marginal social cost pricing on the composition of transport flows and on welfare?	Use of GRACE estimates in TREMOVE model for 27+4 EU countries
What is the socio-economic effect of transport pricing in sensitive areas?	Test GRACE estimates with a general equilibrium model for Switzerland that contains a sensitive region (Alps) and a non sensitive region
What are the regional employment effects of marginal social cost pricing?	Use the GRACE estimates in a multi-regional general equilibrium model for the EU to estimate the effects of alternative pricing policies
How to implement marginal social cost pricing when the EU level does not know the marginal external cost at the member country level?	Theoretical analysis using the basic regulation model with asymmetric information
Is a more general equilibrium approach to accident externalities necessary?	Theoretical model with a numerical illustration

Results are outlined below. Detailed discussion is to be found in Deliverable 9.

General impacts of pricing reform

TREMOVE was used to analyse three possible pricing reform scenarios. The three pricing reform scenarios vary in the complexity of the pricing reform that is simulated. The pricing reforms are principally based on marginal external cost information generated in the GRACE project. A model is required to analyse the impacts for three reasons: first some external costs (congestion) are a function of the volume of transport, second the ultimate effect of the pricing policy depends on the demand reactions and modal shifts, third the ultimate welfare effects will depend on the way the transport revenues are used.

All scenarios tested have in common that all existing taxes, charges and subsidies on transport are abolished and that the non road modes cover their variable costs and marginal external environmental and noise cost. Scenario 1 relies on fuel taxes plus a flat rate kilometre charge for heavy goods vehicles. Scenario 2 introduces country and vehicle specific kilometre charges for all vehicles. Scenario 3 differentiates the kilometre chage more finely in time and space.

For each of the 3 scenarios two variants are defined that help to understand the role of the use of the net change in transport revenues that result from the policy change. In most partial equilibrium models, the net change in tax revenues is added as a benefit to the changes in consumer surplus and producer surplus with a weight of 1. In TREMOVE, the value of extra tax revenue collected will depend on two factors: where it is taken away and how it is used. For the use of the tax revenues two variants are defined. In the first variant “general tax decrease”, all net changes in transport tax revenues are used to decrease general taxes outside the transport sector. 1 € of extra tax revenues collected from non commuting transport and used to decrease general taxes is given a value slightly higher than 1 for most countries. This means that this general tax decrease generates a small extra beneficial welfare effect. In the second variant “labour tax decrease”, the change in transport tax revenues is used to decrease existing labour taxes. There is now a much stronger beneficial effect on the labour market, the value of the extra € ranges between 1.26 and 2.52 depending on the national labour taxes[4]. The reason is that taxes are shifted away from labour, alleviating directly the labour market distortion.

[4] See “The marginal cost of public funds in OECDE countries: hours of work versus labour force participation” H.J. Kleven and C.T. Kremer, CESito Working Paper Series, April 2003

The aggregate results (EU-27+4) are summarized in the table below.

In % of GDP	total revenues	Welfare change when general taxes are decreased	Welfare change when labour taxes are decreased	change in tonkm in % of reference	change in passkm in % of reference
Reference	2.298	0	0	0	0
scenario 1	6.224	0.034	1.706	-10.7	-17.4
scenario 2	5.402	1.191	2.725	-11.0	-11.5
scenario 3	5.391	1.181	2.702	-10.8	-11.2

We draw seven lessons from these scenario results:

a) it is clearly very difficult to use the fuel tax as the only instrument to address all the externalities of cars and motorcycles. Scenario 1 shows that this requires enormous increases in fuel taxes, large increases in tax revenues (factor 3) but only a tiny efficiency gain if we rule out the pure recycling effect of tax revenues to alleviate labour market distortions;

b) when a km charge for cars and trucks takes over as main pricing instrument (scenario 2), revenues are double those in the reference scenario and welfare improves strongly – overall transport volumes decrease by some 11% ;

c) the benefits of finer spatial and temporal differentiation (scenario 3 compared to scenario 2[5]) give indeed higher congestion relief benefits but generate less revenues – because of the large weight given to the increase in tax revenues, the result is that scenario 3 generates a smaller welfare gain than scenario 2 if taxes are equal to marginal external costs – if taxes could be optimised in both scenarios scenario 3 would produce clearly better results than scenario 2;

d) it is well known that the introduction of a more refined (area and time based) charging and taxing regime increases the transaction costs (billing, enforcement etc.); this is not yet taken into account in the welfare computation and this needs to be checked region by region as a more refined pricing regime may only make sense in heavily congested areas;

[5] The total tkm and vkm are not lower in scenario 3 but the reduction is more targeted in the congestion areas.

e) the way the extra tax revenues are used is as important as the selection of the pricing reform scenario;

f) the welfare gains come mainly from a reduction of external accident costs, a reduction of external congestion costs and from a good use of the extra tax revenues;

g) the pricing reform policies suggested here are not yet a complete mix to address the different externalities, some externalities like accident externalities need more refined instruments like fines for speeding or alcohol in order to signal the social costs of drivers' behaviour.

5.1 What is the socio-economic effect of transport pricing in sensitive areas in Switzerland?

In this analysis, we evaluate the relative economic impacts on the Swiss economy of regionally differentiated transport pricing strategies reflecting the especially high costs of transport in a sensitive area like the Alps. We also look at cost recovery considerations within each transport mode, which is still a major concern for policy makers. In addition, the importance of the recycling of transport tax revenues to reduce existing distortionary taxes is examined.

Transport policy scenarios are simulated applying SwissTRANS, a multi-sectoral general equilibrium model of Switzerland introducing both, the Alpine region and the rest of Switzerland, and calibrated to an initial economic equilibrium in 2001. The model combines inter-sectoral linkages within regions together with linkages among regions. Transport per mode is represented in an aggregate way using aggregate congestion functions for road transport.

Simulation of different transport pricing scenarios in an economy-wide perspective suggests that a change from the current pricing regime towards a marginal social cost pricing scheme that is regionally differentiated is beneficial for both the Alpine region and the rest of Switzerland.

5.2 What are the regional employment effects of marginal social cost pricing?

The regional economic impacts of 3 policy scenarios of European-wide transport pricing on the regional welfare and (un)employment in Europe are computed using the spatial computable general equilibrium model CGEurope. The scenarios are identical to the scenarios defined for the TREMOVE model: fuel taxes as the only instrument, a CO2 tax under the form of a (much smaller) fuel tax supplemented by a km charge differentiated by country and finally a CO2 tax under the form of a small fuel tax supplemented by a time and place differentiated km charge.

Compared to the TREMOVE and the Swiss general equilibrium model, this model introduces two new market distortions: imperfect competition on the tradable goods markets (prices above marginal costs) and unemployment.

The proposed EU-wide pricing reform scenarios have overall small negative effects on real income and on employment. The overall impact on real income equals -0.11% of GDP but this is before counting the benefits of lower environmental, accident and congestion relief that are of the order of 2 % or more of GDP according to TREMOVE results for the same scenario. The reason for the negative effects is as follows. In the CGEurope model, the presence of imperfect competition makes that prices of tradable goods are already larger than the marginal production costs, so adding the external costs tends to make the tradable goods even more expensive. The spatial pattern of the GDP and unemployment effects of the pricing reform is characterized by a concentration of losing regions in the EU-27 periphery. The regions suffering the strongest losses of welfare and unemployment are located in the new member states. The precise mechanisms at work are complex as trade effects and returns to scale tend to balance each other. On the other hand it is logical that reforms that raise the price of transport affects most those regions that rely more intensively on international trade for their trade.

5.3 How to implement marginal social cost pricing when the EU level does not know the marginal external cost at the member country level?

This research focuses on one particular problem: the asymmetric information problem in the implementation of marginal social cost pricing. While the upper level (EU, or country) is in principle concerned with the welfare of all the EU citizens and wants social marginal cost based pricing, a lower level government (a member state or region) may prefer much higher transport charges to extract revenue from through traffic (called transit here) . This issue is present in the European policy debate: there are the high transit taxes of Switzerland and there is the fear of peripheral countries that road charges for trucks contain a monopoly margin. One of the solutions proposed by the European Commission is to cap the road toll to the average infrastructure costs.

A simple theoretical model is used to explore the asymmetric information problem. One transport link crossing a single country is used by transit and local traffic. The local government knows the external costs but the federal government does not. We consider two stylized cases of external costs. First constant marginal external costs that are independent of the volume of traffic but affect the local population only (some forms of air pollution or accident externalities on locals). Second, we consider external congestion costs that are a function of the volume of traffic and affect the local users and the transit users.

For external costs that do not affect the volume of traffic (air pollution etc), the federal government (here EU) can use two policy instruments to control the potential misuse of marginal external cost pricing by the member states. The first is an incentive mechanism (financial reward) that makes the member countries reveal the information correctly. This scheme is theoretically appealing but may be difficult to implement politically. The second is to impose a toll cap based on the federal government estimate of the marginal external cost. This can not result in perfect pricing but improves welfare compared to the case where the regions set the tolls they want.

For external costs that affect traffic volumes (congestion costs) there are three instruments available for internalization. The first instrument, rewarding truthful revelation, does not always work for external costs that affect the volume of traffic. The second policy, a cap based on the external cost estimate of the federal government can also work for congestion; it improves welfare but is not perfect. The third policy is a cap based on the average infrastructure expenditures for road. This requires a minimum of information to monitor for the federal level. If transit and local traffic are homogeneous and average infrastructure costs are constant (constant returns to scale in road capacity), this generates in principle optimal pricing and even optimal investment policies because it is in the region's interest to do so. This could be the theoretical justification of Eurovignet type of directives. When the composition of transit and local traffic differs (say more trucks in transit or in off peak), the scheme may not work as well. Then there exists the risk that trucks are overcharged as this is a way to make transit pay a disproportionate share of the infrastructure costs.

Overall we find that there is a need for federal control of regional tolling. This requires investment in knowledge of the possible range of external costs. For air pollution, accident and noise, the federal government could implement toll caps based on the estimated marginal external cost. For the external congestion cost, a cap equal to the average infrastructure cost could be an interesting instrument.

5.4 Is a general equilibrium approach to accident externalities necessary?

Accident costs are considered as an important negative externality. In the traditional partial equilibrium approach one tend to overlook the effects on other markets that are distorted : labour markets (heavily taxes), markets of medical services (subsidized). It is not clear à priori if this calls for a strong correction in the estimation of the marginal external accident cost.

The marginal external accident cost that needs to be charged in a richer general equilibrium model has the following structure:

General equilibrium marginal external accident cost =
(1) Partial equilibrium external accident cost + (2) Correction for labour tax revenues + (3) Correction for change in mitigation activity + (4) Correction for the induced labour supply effects

Where

(1) the Partial equilibrium external accident cost represents the effect of one more carkm on general accident risk times [productivity value of sick days lost due to a change in the general accident risk + congestion time loss of an increase in accident risk + discomfort of subjective accident risk that remains after mitigation].

(2) the Correction for labour tax revenues equals the labour tax losses of the driver associated to the extra sick days of the driver in case of accidents (positive term)

(3) the Correction for a change in mitigation activity: the increased taxation of trips may reduce accident risks and thus the mitigation efforts by the households, as these efforts are often heavily subsidized, reducing these mitigation activities is in itself a gain (positive or negative term)

(4) the Correction for the induced labour supply effects represents the fact that increased taxation of commuter trips may decrease the supply of labour, as labour is already heavily taxed; this is itself a loss and calls for a downward correction of the externality tax (negative term).

If we distinguish between safe and dangerous driving we find that the marginal external accident cost of a kilometre driven is higher for dangerous driving because the general accident risk effect of dangerous driving is higher than for safe driving and also the correction for labour tax revenues is higher as dangerous driving also generates more sick days for the dangerous driver himself.

A numerical illustration of the partial equilibrium approach used in GRACE and the general equilibrium approach proposed shows that the differences are very small (<1%).

6. Conclusion

The GRACE project has undertaken novel work in a number of key areas for pricing policy – namely, measurement of marginal social costs for all modes of transport, further development of the use of transport accounts for monitoring purposes, optimality complexity of transport prices, generalisation of marginal social cost estimates, and measurement of the impacts of marginal social cost pricing. Based on these studies, a number of policy recommendations have been reached which should assist policy makers in implementing more efficient pricing policies. These have been brought together in the executive summary and policy recommendations at the start of this deliverable.