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UNITE

UNIfication of accounts and marginal costs for Transport Efficiency

Final Report for Publication

Version 1.0

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UNITE Partner Organisations

ITS/UNIVLEEDS (UK), DIW (De), NEI (Nl), CES/KUL (Be), TIS.PT (Pt), IWW/UNIKARL (De), VTI (Se), IER/USTUTT (De), CERAS/ENPC (Fr), HERRY (Au), EIET/ULPGC (Es), ISIS (It), STRATEC (Be), SYSTEMA (Gr), VATT (Fi), ECOPLAN (Ch), INFRAS (Ch), EKONO (Fi), EKI (Se)

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1. Table of Contents

2. Executive Publishable Summary

This report presents the overall results of the UNITE project. The objective of the project was to support policy makers in setting charges for the use of transport infrastructure by the provision of appropriate methodologies and empirical evidence. The work of the project fell into three broad areas:

- development of methodologies and case studies for the measurement of marginal social cost
- development of pilot transport accounts for all the countries of Western Europe and certain accession countries
- consideration of how to integrate the information from transport accounts and marginal cost case studies in taking decisions on transport pricing

We will first consider the marginal cost methodology and case studies. The transport modes covered in UNITE and consequently by the case studies are: road transport, public transport, railway transport, aviation, inland waterway transport and maritime shipping. The case studies cover the cost categories defined in UNITE: infrastructure costs, supplier operating costs, transport user costs and benefits, accident costs, and environmental costs.

Marginal *infrastructure* cost is the cost to infrastructure managers of additional traffic using it, principally maintenance and renewal but potentially other aspects of operating cost such as administration.

Marginal supplier *operating* costs are understood as the increased costs of operating transport services as a result of an additional transport unit entering the flow.

The marginal external *transport user* costs relate to the increased operating costs/ benefits and the impact of increases/decreases in journey time caused by increased traffic flow. The main negative case, e.g. when the additional journey of one user causes extra costs for others, is that of congestion costs. In the positive case, when users' activities improve the welfare situation of other users we refer to the 'Mohring effect', which is the benefit resulting from increased frequency of service when traffic volume increases. The Mohring effect obviously applies only to scheduled public transport.

The marginal *accident* cost is the economic value of the change in accident risk when a user enters the traffic flow (this risk relates to the user himself as well for other users). Marginal external accident costs are understood as the difference between the marginal social accident cost and the private marginal cost (a part of the marginal accident cost which is internalised by the user). Marginal social costs include repair costs, medical costs, suffering and delays imposed on others as a result of an accident. UNITE seeks to identify external accident costs.

Environmental external effects of transport cover a wide range of different impacts, including the various impacts of emissions of noise and a large number of pollutants on human health, materials, ecosystems, flora and fauna. Most early studies on transport externalities followed a top-down approach, giving average costs rather than marginal costs. The basis for the calculation is a whole geographical unit, a country for example. For such a unit the total cost due to a particular externality is calculated. This cost is then allocated based on the shares of total pollutant emissions, by vehicle mileage, etc. But marginal environmental costs of transportation vary considerably with the technology of the vehicle, train, ship or plane and site (or route) characteristics. Only a detailed bottom-up calculation allows a close appreciation of such site and technology dependence. The above-mentioned facts are the reason why several of the case studies are for the estimation of the marginal environmental costs.

Not surprisingly the largest number of case studies cover road transport. This is explained in particular by the relative importance of the costs for this mode of transport. Some of the costs are considered of no or minor significance for certain modes and therefore no case studies were undertaken. For example accidents in aviation are rare, and most costs are internal while the role of congestion in waterborne transport is normally insignificant.

Regarding methodology, the conclusion was that a combination of cost allocation, econometric and engineering models are needed in practice. Whilst there may be a strong preference for econometric methods in that they provide firm statistical evidence on the relationship sought, lack of sufficiently disaggregated data, or problems such as multicollinearity between explanatory variables, mean that often it is necessary to use econometric and engineering studies as ways of informing work based on cost allocation methods. This is particularly true for infrastructure and operating costs. Congestion cost estimates have been produced for road, rail and air transport, although the latter two modes are little researched and more evidence is needed. Scarcity costs – the value of creating or taking up a path or slot in a capacity-constrained network - are even less well understood and remain a priority for future research. For accident costs, a methodology is put forward that (unlike many previous studies) correctly distinguishes between external and internal costs, and finds evidence that this leads typically to lower estimates than previous studies, but it does rely on the measurement of risk elasticities, and these are still subject to uncertainty. The impact pathway approach for the measurement of environmental costs appears to be the only reliable approach, but transferability (except for the costs of global warming) appears limited. Detailed results are presented in the body of the report.

The above discussion implies that accounts information will be important in the estimation of marginal costs, although often it will need to be the business accounts of specific enterprises rather than national accounts that are used, as the latter will inevitably be too aggregate. Other important uses of accounts are for monitoring developments in the transport sector, including the efficiency of pricing schemes. For this purpose ideally accounts would be disaggregated to a much greater degree and show measures of social benefits as well as costs. Given the difficulty of even producing information at the level provided in UNITE, these are very much longer term aspirations. Nevertheless our view is that national social cost accounts of the form provided here are of value, and should be updated periodically although it is not necessarily worth the effort of collecting this data every year.

A major effort in UNITE was devoted to the development of so-called pilot accounts for all transport modes in all EU countries, Switzerland, Estonia and Hungary. The UNITE pilot accounts show the social costs (the cost of infrastructure, accidents, environmental damages, delays and the costs of supplying transport services) and the revenues from taxes, charges and subsidies of transport for a core year (1998) and two other years of analysis and forecast (1996 and 2005). For the first time, a comprehensive set of transport accounts, using a standard methodology, has been attempted for all EU countries. The accounts compare the social costs and revenues of transport on a national level. They were not designed to be a tool for directly setting transport charges or taxes but were intended to provide the data necessary for in-depth policy analysis. Furthermore the use of three years allow to monitor the development of transport related costs and revenues over time.

The main purposes of the UNITE accounts are to monitor
- the level and structure of social costs and revenues
- the progress towards sustainable transport
- financial viability
- equity
- budgetary needs for second-best pricing schemes.

Furthermore, they can support the estimation of average variable costs which can be used in some cases as a proxy for marginal costs.

In general the methodology of the UNITE pilot accounts has proved to be robust to serve these purposes. However, it has also to be mentioned that the compilation of the accounts required a considerable amount of time and labour. This raises the question of suitable update procedures and the required level of disaggregation.

Summary results from the accounts are provided in the body of the report, but one or two key conclusions may be provided here. For road, total revenues cover total infrastructure costs in all countries except for Hungary. In more then half of the countries studied, the total revenues exceed the total costs of infrastructure, accidents and the costs of air pollution, global warming and noise. However there are substantial shortfalls in Austria, France, Germany, Greece, Hungary, Spain and Switzerland. By contrast, the degree to which rail system costs are covered by revenue from passengers and freight differs substantially between the countries studied, from a maximum of 63% in the case of Finland to a minimum of 8% in the case of Hungary. The simple unweighted average for all the countries in the study is 36%.

This should not necessarily be taken to imply that rail transport is underpriced relative to road. In terms of efficiency it is necessary to look at the marginal costs of road and rail use. The marginal cost case studies imply that the marginal cost of rail transport is very much below the average cost, whilst for congested roads the reverse may be the case.

The total social cost of road provision and use (excluding vehicle operating cost) amounts on average to some 4% of GDP in Western Europe. Infrastructure costs some 1.5%, Congestion amounts to around 1%, external costs of accidents 0.5%, air pollution 0.6%, noise 0.3% and global warming 0.2%. (It should be remembered that congestion is both imposed and suffered by road users so it is not appropriate to add the *total* costs of road congestion to the costs to be covered by road users. It is the *marginal* external cost that is relevant for pricing. However, the average cost of congestion may, on certain assumptions, be used as a first approximation –

probably a lower bound - to the marginal external cost). These proportions are somewhat lower than those quoted in previous estimates (as for instance in the 1995 Green Paper on Fair and Efficient Pricing in Transport) but are still very substantial.

The third area of work in UNITE is integration. Two concepts of integration are presented. The first is a 'hard-wired' concept in which the accounts and marginal cost information are formally combined to produce advice on transport pricing. A second more pragmatic approach is to accept that both provide valuable information for decision makers faced with a variety of objectives, including efficiency, equity and financial objectives.

An important part of the integration work in UNITE was to model the implications of alternative pricing rules. It is sometimes argued that accounts information should be used to set prices to cover total cost on each mode, perhaps on the grounds of budget constraints or that this is the most equitable way to cover the costs of the transport system. The UNITE integration work modelled the consequences of this and compared them with two other policies; pure marginal social cost pricing, and social welfare maximisation subject to a budget constraint (Ramsey pricing). Two types of model – partial equilibrium and general equilibrium models were used.

The results of the TRENEN partial equilibrium model, as applied to a number of cities or regions, indicated – as would be expected – that maximum benefit would be obtained by marginal social cost pricing; the second best pricing policy was Ramsey pricing and average cost pricing was worst. Compared to the current situation, average cost pricing typically reduced taxes on road traffic and raised public transport fares, with damaging consequences for congestion and the environment.

The general equilibrium model for Belgium permitted the use of revenue to be modelled, and thus allowed equity issues to be addressed. The conclusion was that the most efficient use of revenue was to reduce labour taxes, benefiting the better off. If it was desired to benefit poorer groups via income supplementation there was an efficiency cost. By contrast average cost pricing made all groups worse off. Thus there is no case for average cost pricing in terms of equity or efficiency.

The general equilibrium model for Switzerland also enabled indirect economic effects for the economy as a whole to be examined. For marginal social cost pricing a small but negative indirect effect was found; for average cost pricing the indirect effect was negative and larger.

The lesson from these studies is that crude use of accounts information, for instance to ensure full cost recovery, should be avoided as it may easily lead to worse outcomes than the current situation. Where budget constraints are needed they should be applied flexibly and allow for cross subsidisation between modes in order to do least damage to economic efficiency. Equity between income groups is best served by appropriate use of the revenue from efficient pricing rather than by average cost pricing rules.

The final task in the UNITE work programme was to consider what policy implications arise as a result of the project. These may be summarised as below.

- Firstly, the *marginal cost* approach provides information for efficient pricing in different traffic situations. Even though pricing policy in transport involves consideration of multiple objectives and constraints, an important starting point for policy is the pattern of efficient prices by mode, area type and route type. The marginal cost case studies provide relevant information to help populate that approach. However, it is unrealistic to expect a comprehensive set of marginal costs to be derived from such an approach on its own. In practice, we need to rely on social accounts data as a generic source of information, and to derive approximate or "average" marginal costs information from such data using such evidence on cost/output relationships as can be found in the literature. It is the use of case study and accounts data together which is likely to be the most practical means of generating practical marginal cost estimates which feed into pricing policy.
- Secondly, the creation and maintenance of a set of consistent social accounts for the transport sector is particularly valuable for monitoring the impacts of policy, including pricing policy. To achieve consistency across modes and countries is a formidable task to which we believe UNITE has made a contribution.
- Thirdly, in practice, pricing policy may involve balancing a mixture of considerations. Efficiency is clearly one but notions of equity, fairness, cost recovery and revenue raising are others. Thus, second-best questions such as how to set efficient prices in relation to marginal cost in the transport sector while achieving a given budgetary result, or how to set transport sector prices in relation to marginal cost given distortions in related sectors elsewhere in the economy are clearly relevant policy issues which may draw on both marginal cost and accounts information and which the integration strand of UNITE has addressed.
- Fourthly, the information both from marginal costs and accounts may provide relevant inputs to other decisions such as decisions on investment and to non-price regulation. The interrelationship between pricing and efficient investment is an issue of considerable policy interest, both in an economic sense and in relation to the case for Trust Funds and other ways of ring-fencing revenues for transport investments. Such issues are likely to be particularly relevant for the accession countries.

3. Objectives of the Project

The UNITE project is designed to meet the research needs of decision-makers involved in the development of **pricing and taxation policies for all significant passenger and freight modes** – road, rail, air, inland waterway and short-sea shipping - in Europe. Decision-makers at the national and European levels have a strong desire for a robust policy development framework, in which the key economic, financial, environmental and social factors relating to transport are integrated within a consistent methodology that may be applied across all modes of transport. Furthermore, to put any methodology into practice, there is also an urgent requirement for empirical evidence about the costs, benefits and revenues associated with individual modes.

From these needs, the three core aspects of the UNITE project can be defined. These are known as "*marginal costs*", "*transport accounts*" and the "*integration of approaches*", and are defined as:

- ***marginal costs*** – the way in which different categories of costs and benefits vary with an additional vehicle kilometre. This information is a fundamental building-block in the development of pricing policy, since understanding the way in which costs and benefits vary often forms the starting-point for developing appropriate charging levels and structures;
- ***transport accounts*** – a comprehensive statement of all the costs, benefits and revenues associated with a given mode of transport, in a geographic area and for a set period of time. Entries within the accounts are in monetary terms and generally based on economic, as opposed to financial, flows. This information, as an example, enables the level of cost coverage to be examined for any mode, provoking debate over whether the current level and structure of charging systems is adequate;
- ***integration of approaches*** – uniting the *transport account* and *marginal cost* perspectives in the development of an overall policy for transport infrastructure use charging. This integration is needed if the comprehensive information provided by the accounts and the detailed information about marginal costs are to be fully exploited in the creation of an overall charging framework.

The UNITE project **objectives** in relation to these three core aspects are to:

- advance the methodologies for the estimation of marginal costs;
- implement these advanced methodologies by means of case studies;
- provide guidance on how the case study evidence can be transferred for use in different contexts.
- develop and implement the structure for pilot transport accounts;
- provide guidance on the future development of transport accounts;
- design alternative frameworks for the integration of approaches;
- test these frameworks;

The **outputs** that UNITE has produced in the achievement of the objectives are:

- a clearly presented methodology which advances the state-of-the-art in marginal cost estimation;
- empirical estimates of marginal costs for:
    - the key cost, benefit and revenue categories
    - various contexts around Europe
    - a wide range of passenger and freight modes;
- guidance on how to transfer marginal cost estimates to new contexts, to maximise the value-added offered by the new empirical results.
- pilot transport accounts for:
    - 18 countries (EU15, Estonia, Hungary and Switzerland),
    - the years 1994, 1996 and 2005;
    - all significant passenger and freight modes;
- guidance on future approaches to the development of transport accounts;
- theoretical development of alternative frameworks for the integration of approaches;
- empirical results on the transport and economy-wide outcomes from alternative integration approaches;

- *marginal costs* – the production of marginal cost estimates, along with associated methodological tools, will give national governments important evidence to build upon in matching costs generated by mode with appropriate charging instruments.

The **outcomes** that result from the project outputs relate to the 3 core aspects:

- *transport accounts* – by complementing the integration of approaches with pilot accounts for each of 18 countries and for all significant modes, the transport accounts will highlight the current situation of each mode, and thus the imbalance between the level and structure of costs incurred and associated revenues. This is likely to encourage national governments to examine their infrastructure charging policies, and also to build upon the UNITE pilot accounts to examine the issues raised in greater detail.

- *integration of approaches* – in providing possible solutions that reconcile the conflicting approaches to charging policy for transport infrastructure use that are apparent around Europe, the project will contribute to the formation of consensus on the way forward. Decision-makers tend to look at their overall, national situation in determining future policy direction, so that the way in which the marginal cost and transport account approaches can be united, is of fundamental importance.

4. Scientific and Technical Description of the Results

The results of the project will be summarised in the three main areas of work, marginal costs, accounts and integration.

4.1 Marginal Cost Research

4.1.1 Introduction

The following table presents the wide variety of case studies undertaken by the modes and cost categories they cover.

Table 1. Quantitative overview of the case studies by mode and cost category

Category	Road	Rail	Air	Inland Waterways	Maritime	Total – by cost category
Infrastructure costs	2	2	1	1	2	8
Supplier operating costs	0	2	1	0	0	3
Congestion costs	6	1	1	0	0	8
Mohring effect	0	1	1	1	0	3
Accident costs	3	2	0	1	1	7
Environmental costs	6	3	0	1	1	11
Total – by mode	17	11	4	4	4	40
Source: D3, Unite – update						

As can be seen, not surprisingly the largest number of the case studies cover road transport. This is explained in particular by the relative importance of the costs for this mode of transport. Some of the costs are considered of no or minor significance for certain modes and therefore no case studies were implemented. For example accidents in aviation are rare, and most costs are internal while the role of congestion in waterborne transport is normally insignificant.

In the following, we will bring together the main conclusions of the UNITE case studies firstly on methodology and secondly on empirical results.

4.1.2 Methodology

In this section we summarise our conclusions about the appropriate methodologies for use in estimating marginal social cost and the extent to which marginal cost estimates may be adapted or transferred from one context to another. We consider transferability in terms of methodology, input values, functional relationships and output values, and look at each cost category in turn.

4.1.2.1 Infrastructure costs

For road and rail, previous studies tend to use a (top-down) cost accounting approach, based on a simple division into fixed and variable costs. Very few included regression analysis to derive marginal costs. The cost accounting approach basically divides costs into categories and allocates them to the output measure deemed most appropriate. This is a simple practical approach for which the data is usually readily available. For an example of this approach from a specific UK study see Table 2. In this case, marginal cost is estimated as around 50% of average cost, with marginal cost varying between vehicle types mainly on the basis of standard axle kilometres. However, this result depends on a specific set of assumptions about which cost elements are fixed and which are variable, and there is no agreement between different studies on this issue, or on the question of with which output measure they vary; different countries tend to use different conventions.

Table 2. Values of Cost Drivers and inclusion in MC Analysis in the UK (Sansom et al, 2001)

Description	PCU -km	av.gwt -km	max gwt -km	sa - km	Include in MC?
Long-life pavements				100%	✓
Resurfacing				100%	✓
Overlay				100%	✓
Surface dressing	20%	80%			✓
Patching and minor repairs		20%		80%	✓
Drainage	100%				✓
Bridges and remedial earthworks		100%			-
Footways, cycle tracks & kerbs		100%			-
Fences and barriers	33%	67%			-
Verges, traffic signs and crossings	100%				-
Sweeping and cleaning	100%				-
Road markings	10%	90%			✓
winter maintenance & misc.	100%				-
Street lighting	100%				-
Policing and traffic wardens	100%				-

Note: av.gwt– average gross vehicle weight; max gwt – maximum gross vehicle weight; sa – standard axles (a measure of the relative damage due to axle weights). The costs attributed to pedestrians for roads other than motorways (50% of the categories from Fences and barriers through to Street lighting) are removed prior to allocation to motorised vehicles.

Source Sansom et al (2001)

Both econometric and engineering approaches can help with this problem. But data requirements are heavy, and it cannot be expected that such studies will be undertaken every time marginal cost estimates are required. Moreover, the econometric approach is best for getting general information about cost elasticities; it cannot identify the impact of different types of vehicles in great detail because of multicollinearity between the explanatory variables. The engineering approach is therefore needed for this.

In practice many studies will continue to use data from accounts, with cost elasticities and vehicle relativities borrowed from other studies. However even these parameters vary with context. For instance cost elasticities vary with traffic density, and relative marginal costs of heavy vehicles are higher when infrastructure quality is low. This seems to be less of a problem for rail where cost elasticities are generally lower. Also, many authorities do not decide expenditure on the grounds of necessity, but in relation to budgetary reasons. More research on cost elasticities is needed, particularly for road infrastructure, where considerable variation in the results was found. Our case studies found evidence of a cost elasticity of around 0.8 for road maintenance and renewal, but with much lower figures for less heavily used roads, and 0.2 for rail maintenance and renewal.

Much less work has been done for air and water transport; it appears that marginal infrastructure costs are very low, but that result needs further work to confirm it. For nodes (airports and ports) estimates of marginal operating costs are also needed; a regression approach has been used but again data requirements are heavy. It has to be considered that cost data in a liberalised transport sector are owned by private companies and thus difficult to compile. Again the marginal operator cost appears to be very low.

4.1.2.2 Supplier operating cost

As with infrastructure costs, our preferred approach is the econometric approach, but there are big problems with it. The first is getting appropriate data. Usually data is only available as time series data for an entire company, or for a cross section of different entire companies (or both). One company includes a wide variety of types of service, but it is difficult to estimate the costs of each type of service accurately from such data, and variables representing different types of output are highly correlated. The result is that the econometric approach is most useful to provide evidence on economies of scale and scope at an aggregate level. Cost elasticities appear to be transferable; usually as in the air case here they are found to be around one with respect to vehicle kilometres, implying constant costs for this category of costs, meaning that an approach based on fully allocated cost should be adequate as an estimate of marginal cost.

The main approach for more detailed estimates of marginal cost is the cost accounting approach. Accounts are the obvious source of the relevant data, but usually business accounts of the companies concerned rather than national accounts, which are too aggregated. The standard formula for supplier operating cost is along the lines of:

Cost = *a* + *b** train hours +*c** vehicle kilometres + *d** peak vehicle requirement

As with infrastructure costs, this estimates the costs resulting from the pattern of service provided. To estimate costs per passenger kilometre it is necessary to understand how the service pattern will respond to changes in traffic. This point is returned to in the next section in the discussion of Mohring effects.

Logic, rather than econometrics, is used to determine which output variable determines the level of each cost category. This approach does not necessarily deal adequately with effects of peaks on staffing levels, or with variability by type of vehicles. In situations of peak demand, many costs are attributed entirely to the times and locations providing the peak vehicle requirements. This may result in huge differences between peak and off-peak MCs. To estimate this accurately, a better approach is to do a complete vehicle and crew scheduling exercise to identify numbers required and cost.

4.1.2.3 User cost

Under user costs we consider three elements; congestion costs, scarcity costs and Mohring effects. Congestion arises where one vehicle delays another; scarcity costs where one vehicle prevents another from gaining access to the network and Mohring effects where additional traffic leads to increased frequency of a public transport service leading to external benefits for existing users.

For road, studies using speed flow relationships, either for individual links or on a network basis are commonplace. Many existing models are available which may be used. Yet there is still considerable variability of results. The UNITE urban case studies produced results that are an order of magnitude less than some other case studies, such as the TRENEN case studies. This may simply be because the UNITE case studies concentrated on locations which were not particularly congested, but this is not always the case. For instance Greater Brussels was one case study where the UNITE figure is very much lower than those in TRENEN. Another explanation is that UNITE has computed congestion costs as they would be were a perfectly differentiated congestion charge introduced, allowing for the substantial reduction of congestion via rerouting that would then take place. This will be much lower either than current congestion costs or congestion costs were a simple cordon or area charge introduced. A third reason may be that UNITE has looked at relatively large areas rather than just core cities as many previous studies have done. When these areas were broken down, of course congestion was found to vary substantially by section of the network.

Speed flow relationships as well as demand patterns and traffic data cannot be readily transferred due to differences in the standard of infrastructure, traffic laws and in behaviour between countries. Resulting output values are only transferable with regard to situations where these factors are similar, as well as having similar traffic levels and values of time. If the only difference is in income, values of time may be transferred using an appropriate income elasticity.

Data from the accounts may be of some help here. In the accounts we estimated the average cost of congestion relative to speed flow conditions. If the average and marginal cost curves were linear, then it is easy to show that this is equal to the difference between marginal and average cost, which is the marginal external congestion cost. Given known non linearities, it is likely that in fact this value forms a lower bound to the marginal external cost of congestion. However, the accounts give this at an aggregate level for the country as a whole. Thus whilst this value may be of some use for monitoring the average level of prices relative to marginal cost on the average, it is no help in formulating the details of pricing policy for congestion.

For rail and air, there is very limited evidence on congestion. Within UNITE the methodology we used was regression analysis relating delays to volume of traffic. Much more detailed studies of the relationship between delays and capacity utilisation have been undertaken by Railtrack, the rail infrastructure provider in the UK. The basic regression methodology used in these studies should be readily transferable provided that data may be obtained. It is more doubtful whether relationships and outputs can be transferred given differences in the infrastructure and the level and mix of traffic. The Railtrack work required the use of different parameters even for different parts of the British rail network. The assessment of opportunity costs of scarce railway and airport slots remains a difficult and under researched area which is a priority for future research. The analysis of slot trading mechanisms and marginal willingness to pay for additional slots (for air and rail transport) might be a possibility to improve the situation.

The Mohring effect is the effect by which increasing volumes of traffic lead to improved services, thus benefiting existing users. For the Mohring effect, which only applies to scheduled transport, an approach based on first principles assuming that operators increase service frequencies in direct proportion to increases in patronage (see Sansom et al, 2001, section 5.5) may be used to give a simple formula. This may also be adapted to cases where other behavioural rules apply.

For high frequency regular interval services, the benefit of an additional passenger is:

B = 0.5*h*v*ef

Where B = Mohring benefit from an additional passenger (euros)
h = headway between services (mins)
v = value of waiting time (euros/min)
ef = elasticity of service frequency with respect to traffic volume

If the service is a long way from being regular interval than an accurate calculation requires knowledge of the distribution of desired departure times and the precise timetable before and after the increase in traffic. Where passengers are adapting to a known timetable, and are indifferent between travelling earlier or later, then the mean schedule delay becomes 0.25h instead of 0.5h as in the above formula, and v must be replaced by the value of a departure time shift, rather than waiting time. It is usually lower than the value of waiting time.

The rail case study put forward theoretical arguments to suppose that frequency will increase with the square root of traffic levels (ef = 0.5), and showed that this was in fact the case for inter urban rail services in Sweden. In such a case, it is necessary to allow for the economies of scale in supplier operating cost that result from higher load factors.

The air and scheduled inter-modal freight case studies found a much more varied pattern of response, but in both cases there were significant benefits to existing users from increasing traffic levels. In other words, the UNITE case studies show that this basic result, that increases in traffic lead to external benefits to existing users, applies not just to urban public transport but also to inter urban rail, air and scheduled freight services. In each case users value the improved frequencies and increase in through services resulting. However, the value of these benefits relative to other cost elements is obviously smaller for longer distance trips. Moreover, price differentiation may recover a larger proportion of consumer surplus as revenue for longer distance trips since more complex price structures may be used. Thus, whilst in principle the Mohring effect provides an argument for subsidising all scheduled public transport services, its practical importance is greatest for local public transport.

This methodology is general, subject to knowledge of the way in which operators respond to changes in traffic levels, and the value users place on these changes. Values of time and of departure time shift are transferable given knowledge of relevant income elasticities. If frequencies are optimal then the Swedish rail case study shows that marginal social cost should be the same, irrespective of the way frequency adapts to traffic levels.

4.1.2.4 Accident cost

Many studies in the past have failed correctly to distinguish between internal and external accident costs and used simple average figures. The risk elasticity method and theory presented in UNITE is summarised in the equation for marginal external accident cost below

$$\mathrm{MC}_{\mathrm{j}}^{\mathrm{e}} = r(a+b+c)\left[(1-\theta)+E\right]+\theta rc$$

where r represents accident risk, a the value of statistical life (VOSL), b ditto for relatives and friends, c the costs for the rest of society, θ the proportion of accident cost that falls on the traveller of type j and E the risk elasticity (ie the relationship between accidents and traffic volume).

It is clear from this that marginal external costs of accidents will differ when any of these parameters differs, and that direct transfers of values from one context to another may only be done if it is believed that all these parameters are unchanged.

We expect the external marginal cost to be high if:

- the accident risk **r** is high
- the cost per accident is high **(a+b+c)**;
- most of the costs fall on other groups (**θ≈0**);
- the risk increases when the traffic increases (**E>0**);
- or a large part of the accident cost is paid by the society at large (**c**).

We believe that this method is suitable for all modes in all member states. We cannot foresee any more general form of the external marginal accident cost, except that risk avoiding behaviour should be introduced. This involves formidable practical issues in terms of estimation, however.

Our formula requires knowledge of:

- The accident risk for the mode and context. Such data is usually available and is derivable from the UNITE accounts.
- The relevant risk elasticity. UNITE research has extended the knowledge of risk elasticities and how they vary but this is still an area of uncertainty. However, estimation of elasticities is difficult on a case by case basis.
- The value of a statistical life, which may generally be transferred using data on real incomes. Within UNITE, a general VOSL of 1.5 Mio Euro (European average) has been used. This most sensitive unit value can be adjusted to different countries according to GDP per capita. The value is based on the state of the art of willingness to pay studies to avoid fatality risks.
- The proportion of costs borne by the injurer, which will need to be estimated locally, as it varies with legal and insurance company provisions.

4.1.2.5 Environment

Bottom up impact pathway studies are the best way of calculating environmental costs, and are generic enough to be applied to all modes of transport. However, there are several areas of controversy surrounding the use of this methodology such as amibiguities over the effects of particles and nitrate aerosols on human health, the valuation of mortality, ozone impacts and the potential omission of other impacts which cannot be quantified.

Physical impacts (except global warming) are difficult to transfer to other countries/regions/contexts. A direct transfer of costs due to *air pollution* cannot be recommended; a generalisation methodology should account for local scale conditions such as population density and meteorology and regional scale costs per tonne of pollutant emitted in a certain area. Most important are dose-response functions to value the impact of PM10 concentration to human health.

Noise cost estimates are also difficult to generalise due to their local nature and dependence on background noise level.

Whilst exposure response functions can be generalised, inputs to dispersion models, due to their site-dependence, cannot be generalised. Specific exhaust and noise emission factors for vehicle types can be generalised, accounting for driving characteristics and average speed. Generalisation of emissions related to vehicle fleets is not recommended. Economic values may be transferred using real income and the Purchasing Power Parity structure.

Regarding *global warming*, damage cost estimates are transferable as location of emissions is irrelevant. It has to be considered, there is a wide range of unit cost estimations and that unit values are rather sensitive for the comparison of different transport modes.

To the extent that for environmental costs other than noise marginal costs are assumed equal to average costs, accounts do at least produce countrywide averages of marginal cost to monitor overall price levels. For noise, average cost is likely to exceed average marginal cost. This of course means that an optimal level of noise nuisance cannot necessarily be achieved by pricing alone; nevertheless, in determining optimal traffic levels the marginal cost of noise is still the appropriate concept to use.

4.1.2.6 Empirical results

In this section we present an overview of some of the empirical results from the UNITE case studies, and seek conclusions on the relative importance of the different cost elements by mode and context as well as the degree to which the magnitude of estimates for that cost category varies. It should be noted that in general each cost category for each mode was studied in a different case study, so that the various cost categories cannot simply be added together. Moreover the output variables that were used in the different studies varied, so to make them comparable various assumptions had to be made. The bar charts should therefore be seen as illustrative of general tendencies rather than as precise numerical estimates. Where a range of results is produced by different case studies the bar charts show the upper and lower values.

Figures 1a-b summarise the results for car travel. It is clear that for car the dominant element is congestion (especially for urban trips), however, this varies greatly between case studies. Accident costs are also comparatively large, particularly in urban areas. Also, in urban areas noise is very important, particularly at night, and air pollution is also significant. Many of the environmental costs also vary due to differences in traffic densities and speeds. Areas of high traffic speed and density report lower marginal noise and air costs, as an additional car has less impact than in quieter areas. Marginal infrastructure costs, air pollution and global warming costs for car are all relatively small.

The most striking feature of these diagram is the enormous variation from case to case for the costs of congestion, noise and air pollution.

Figures 2a-b produces the same diagram for heavy goods vehicles. Here congestion costs are similar as for car, but a smaller component of the overall marginal cost, whilst infrastructure costs are somewhat greater. Noise costs are important for urban HGV travel, and air pollution costs remain important for interurban routes, and in most cases these are over a factor of ten higher than for cars. One urban study in a low density traffic area finds night-time noise the dominant factor.

Figures 3a-b show the results for rail passengers. Naturally, supplier operating costs are the dominant element, and are many times higher in the peak than in the off peak. Urban congestion and inter-urban air pollution costs are the next most significant items. Air pollution and global warming costs varying with type of traction and (where relevant) prime energy source for electric traction. Marginal infrastructure costs for passenger services are low. It should be noted that in the inter urban rail case study, supplier operating costs are strictly for lengthening trains; for purposes of comparability they have been expressed per train kilometre given typical train loadings but this is somewhat misleading given the nature of the case study. Also when capacity is expanded solely by lengthening trains there is no Mohring effect, so these two cost categories certainly cannot be added together.

Figure 4 shows comparable figures for rail freight, except that we do not have a supplier operating cost case study for freight. Air pollution, global warming and noise are all of similar orders of magnitude to marginal infrastructure costs. Infrastructure costs are higher than for passenger rail due to the higher gross tonne km per train of freight.

Finally figure 5 shows the results for air transport. Of course supplier operating cost is dominant, but these results suggest that both congestion costs and the Mohring effects are more important than environmental effects. In circumstances where line density is low, the Mohring effect is quite important, leading at least to an a priori case for subsidy for scheduled air services. (For consistency across cost categories, we have assumed an average journey length of 930km as was used in the environmental cost case study.

4.1.3 Conclusions on Marginal Cost

The UNITE case studies have produced estimates for a wide range of circumstances and using a wide variety of approaches. In some cases (such as supplier operating costs for rail and air) these have been the subject of much previous analysis; in others, such as infrastructure costs for water transport, the existing literature is very sparse.

These case studies illustrate that there is no unique 'state of the art' approach for the estimation of marginal costs. For instance, for infrastructure and supplier operating costs, there may be a preference for econometric estimation, but it is seldom possible to do that at a level of detail that lends itself directly to pricing decisions; a mixture of econometric research with engineering and cost accounting approaches therefore is necessary. For user costs, road congestion has been extensively investigated using either single link or network models based on speed flow relationships and junction delay formula. For rail and air congestion a regression based approach has also been developed but work in this area is new; there are few existing studies. No estimates of scarcity costs for these modes have been found and this is a priority for future work.

For accidents, a correct methodology has been developed which requires inputs from a variety of sources; the most difficult being risk elasticities. The impact pathway approach is recommended for environmental costs, but further research on transferability of results would be worthwhile.

The quantitative results suggest that marginal infrastructure costs are generally low; it is supplier operating costs, congestion costs, the Mohring effect and in some circumstances elements of environmental costs, particularly noise, that are the most important categories.

In terms of external costs, for the car, as expected, generally congestion costs dominates, followed in the case of urban areas only, by noise and air pollution (especially for diesel cars) with global warming generally much smaller. Accident costs are also significant in urban areas. In general, the differences between areas are quite large. Outside urban areas, noise and air pollution costs are generally much smaller.

When load factors are taken into account, external costs of air and rail are generally much smaller than car. The exception to this is congestion costs, where our case studies, as was noted earlier, yield lower results for cars than in other comparable car studies. The congestion costs in our air case study, Madrid airport, appear to be of the same order of magnitude as for car when allowing for load factors, although the results for rail appear to be somewhat lower. We have no quantification of pure scarcity costs, which can be important for rail and air.

Figure 1a

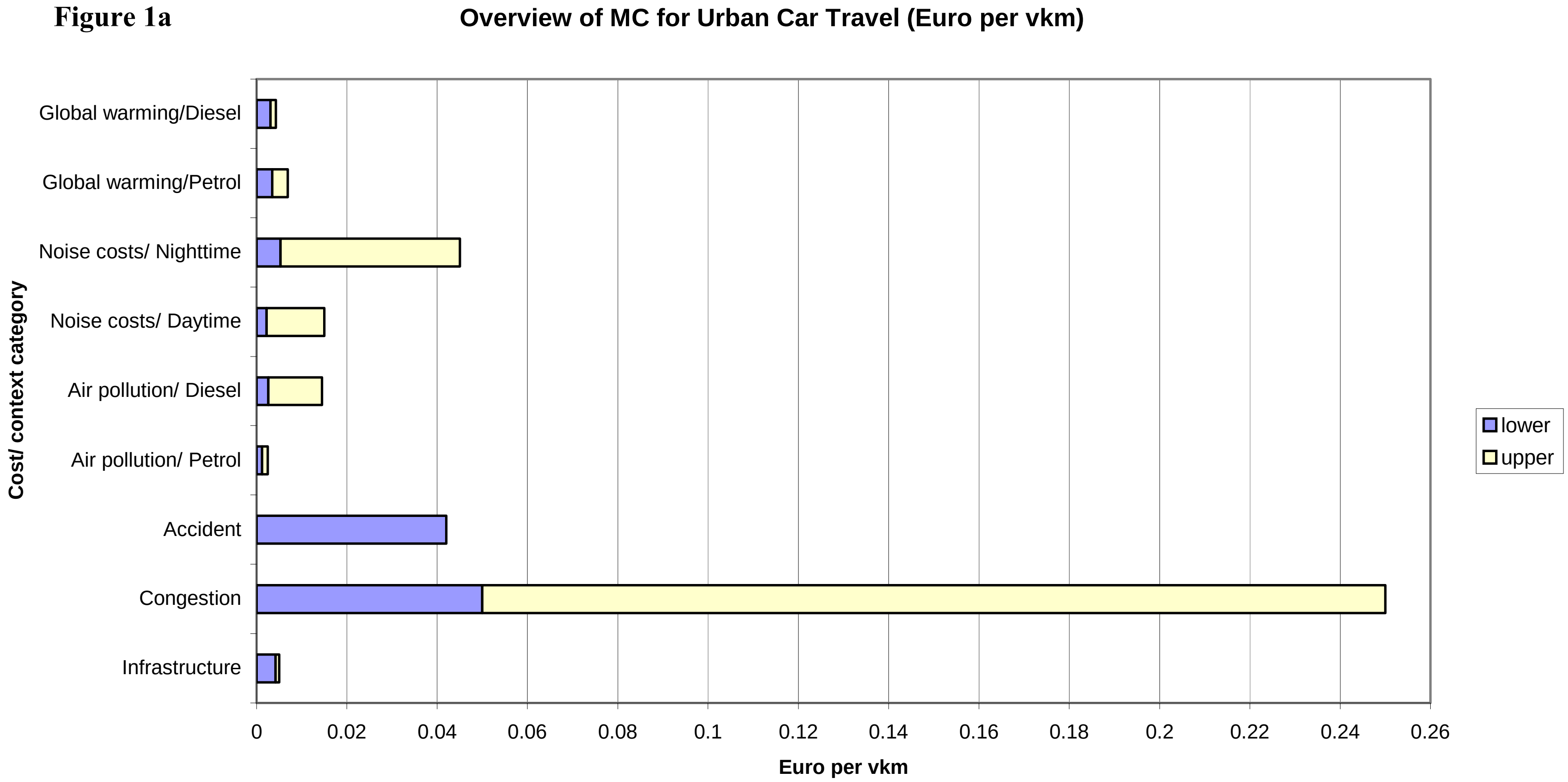

Overview of MC for Urban Car Travel (Euro per vkm)
Cost/ context category
Global warming/Diesel
Global warming/Petrol
Noise costs/ Nighttime
Noise costs/ Daytime
Air pollution/ Diesel
Air pollution/ Petrol
Accident
Congestion
Infrastructure
0
0.02
0.04
0.06
0.08
0.1
0.12
0.14
0.16
0.18
0.2
0.22
0.24
0.26
Euro per vkm
lower
upper

Figure 1b

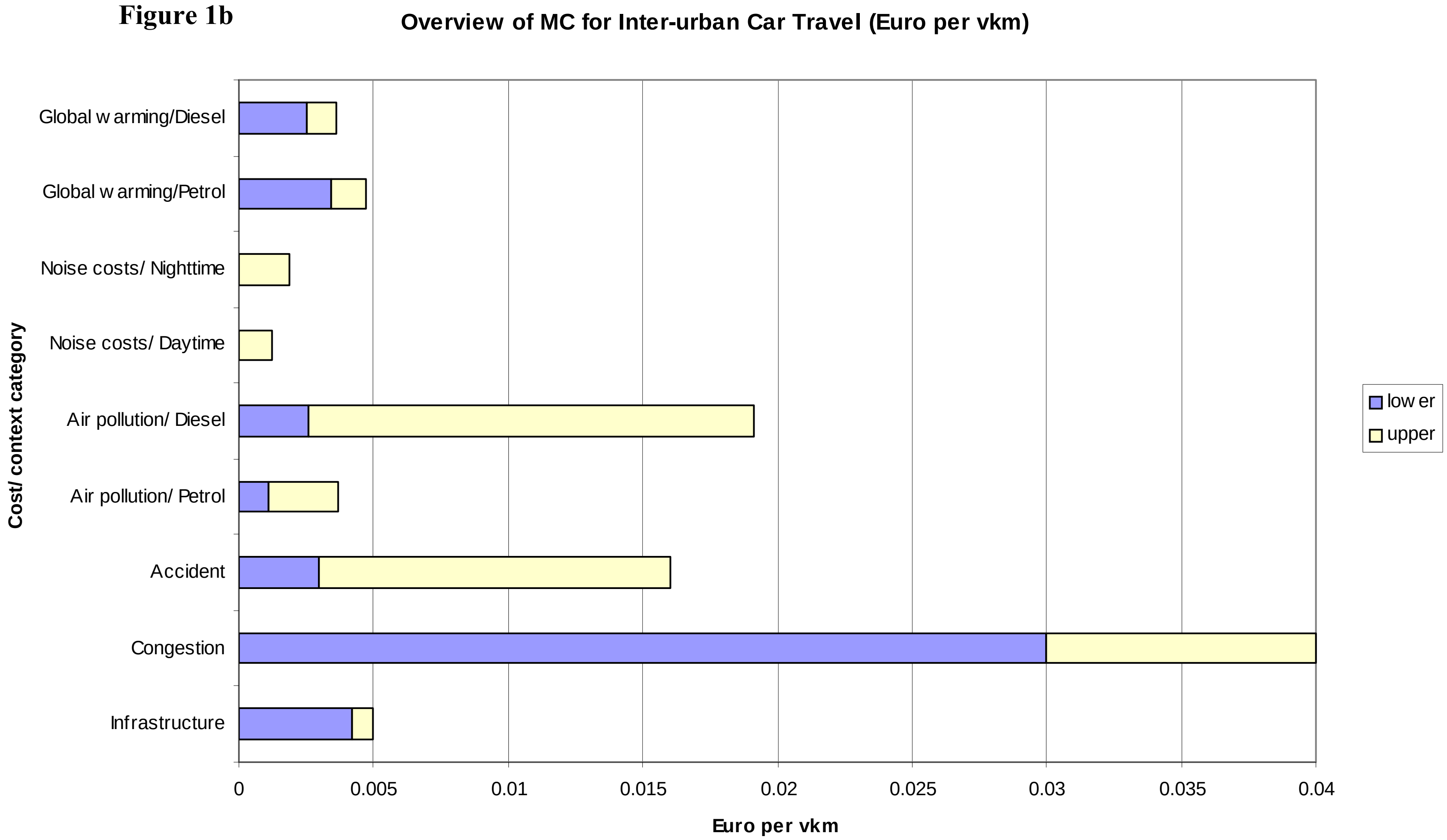

Overview of MC for Inter-urban Car Travel (Euro per vkm)
Global w arming/Diesel
Global w arming/Petrol
Noise costs/ Nighttime
Noise costs/ Daytime
Air pollution/ Diesel
Air pollution/ Petrol
Accident
Congestion
Infrastructure
Cost/ context category
0
0.005
0.01
0.015
0.02
0.025
0.03
0.035
0.04
Euro per vkm
low er
upper

Figure 2a

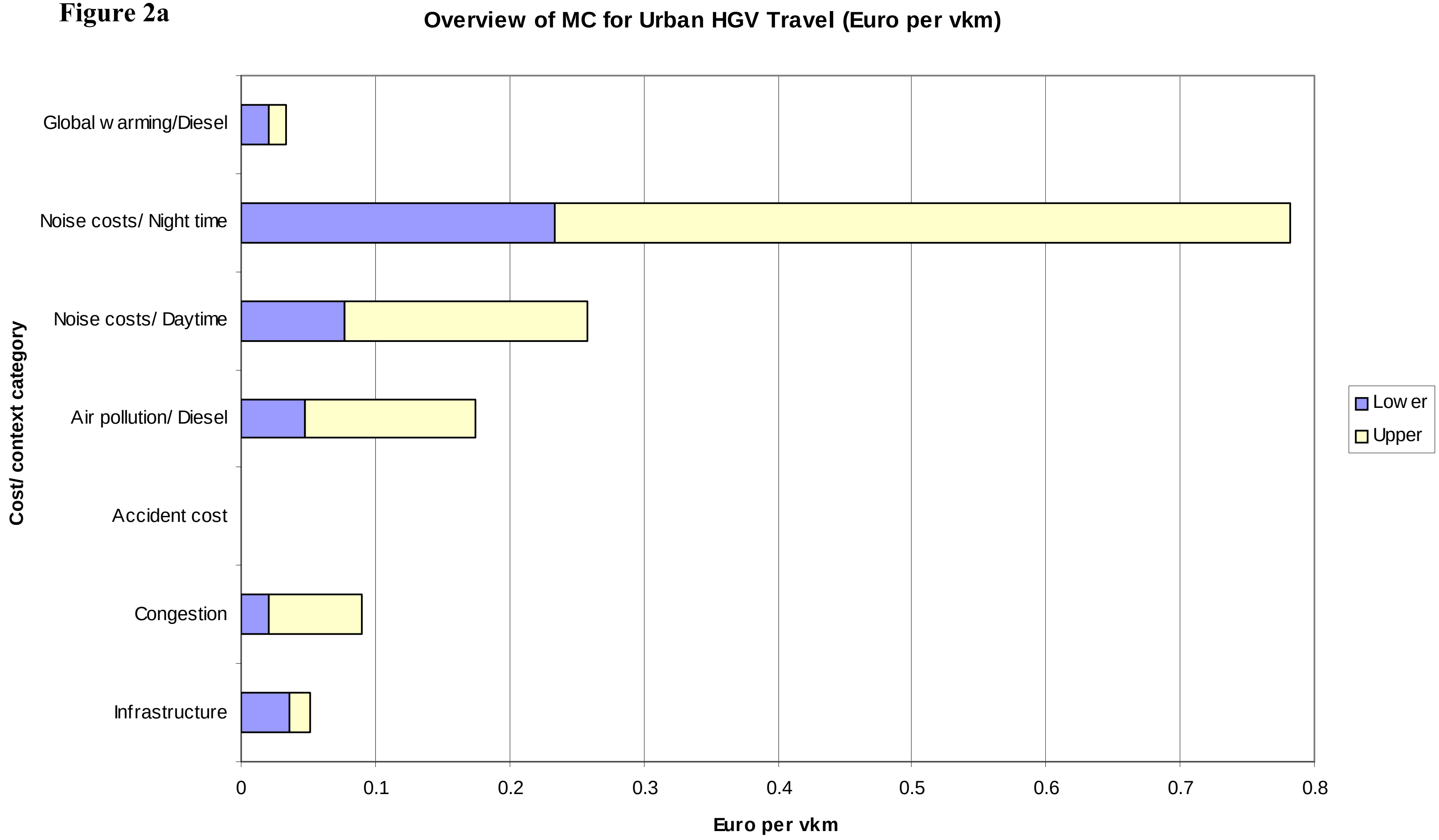

Overview of MC for Urban HGV Travel (Euro per vkm)
Cost/ context category
Global w arming/Diesel
Noise costs/ Night time
Noise costs/ Daytime
Air pollution/ Diesel
Accident cost
Congestion
Infrastructure
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
Euro per vkm
Low er
Upper

Figure 2b

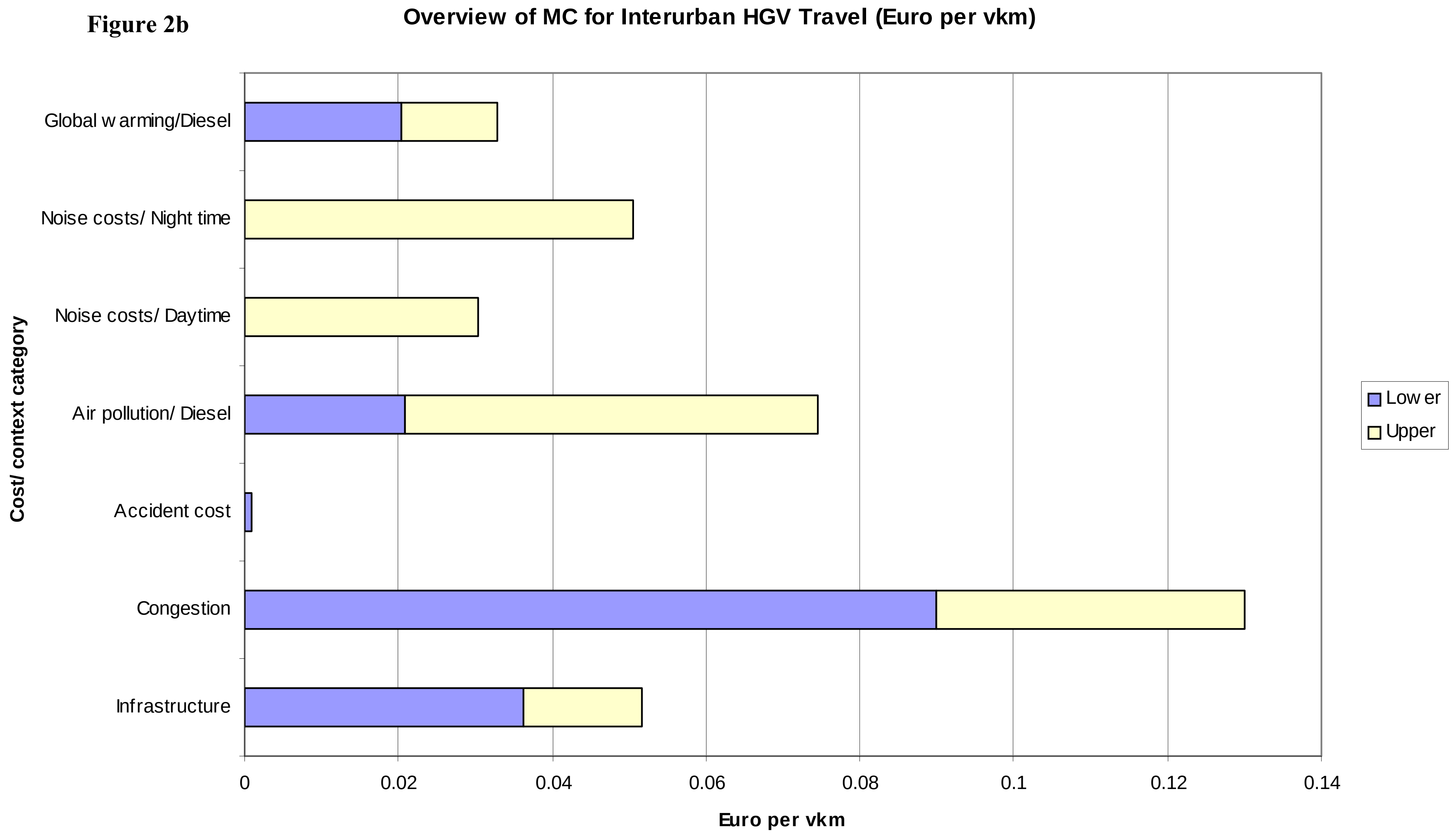

Overview of MC for Interurban HGV Travel (Euro per vkm)
Cost/ context category
Global w arming/Diesel
Noise costs/ Night time
Noise costs/ Daytime
Air pollution/ Diesel
Accident cost
Congestion
Infrastructure
0
0.02
0.04
0.06
0.08
0.1
0.12
0.14
Euro per vkm
Low er
Upper

Figure 3a

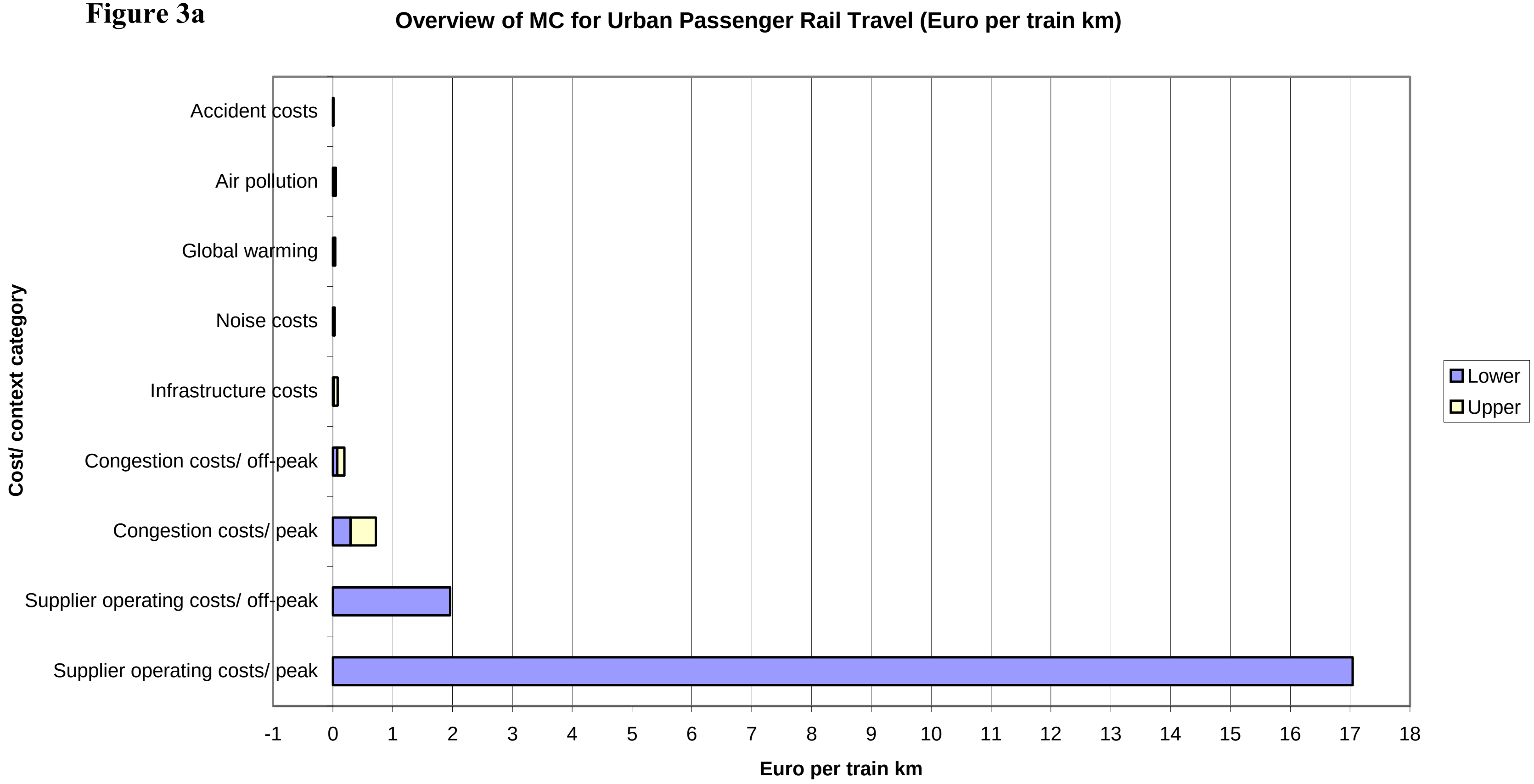

Overview of MC for Urban Passenger Rail Travel (Euro per train km)
Accident costs
Air pollution
Global warming
Noise costs
Infrastructure costs
Congestion costs/ off-peak
Congestion costs/ peak
Supplier operating costs/ off-peak
Supplier operating costs/ peak
Cost/ context category
-1
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
Euro per train km
Lower
Upper

Figure 3b

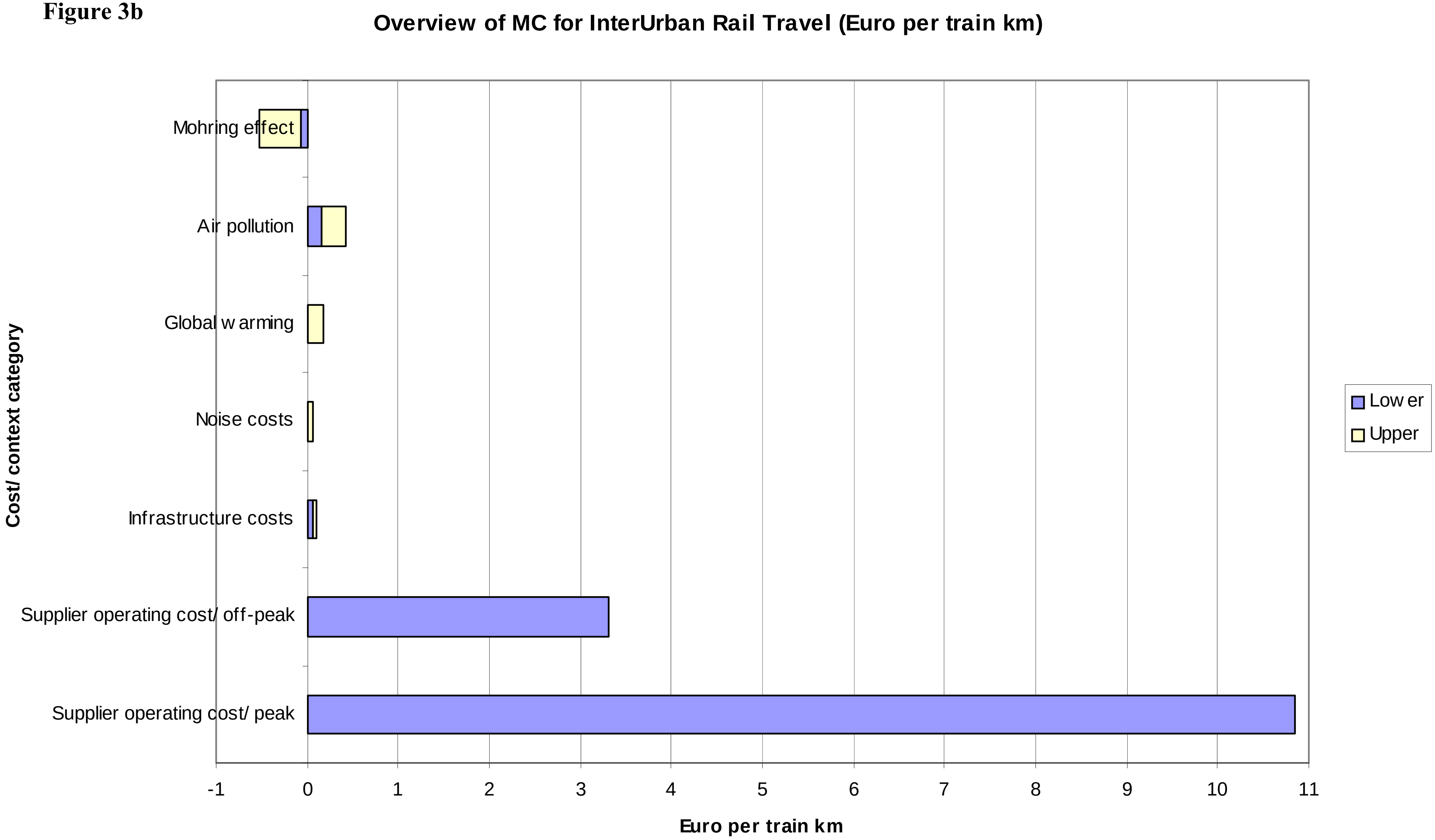

Overview of MC for InterUrban Rail Travel (Euro per train km)
Cost/ context category
Mohring effect
Air pollution
Global warming
Noise costs
Infrastructure costs
Supplier operating cost/ off-peak
Supplier operating cost/ peak
-1
0
1
2
3
4
5
6
7
8
9
10
11
Euro per train km
Lower
Upper

Figure 4 Overview of MC for Rail Freight Travel (Euro per train km)

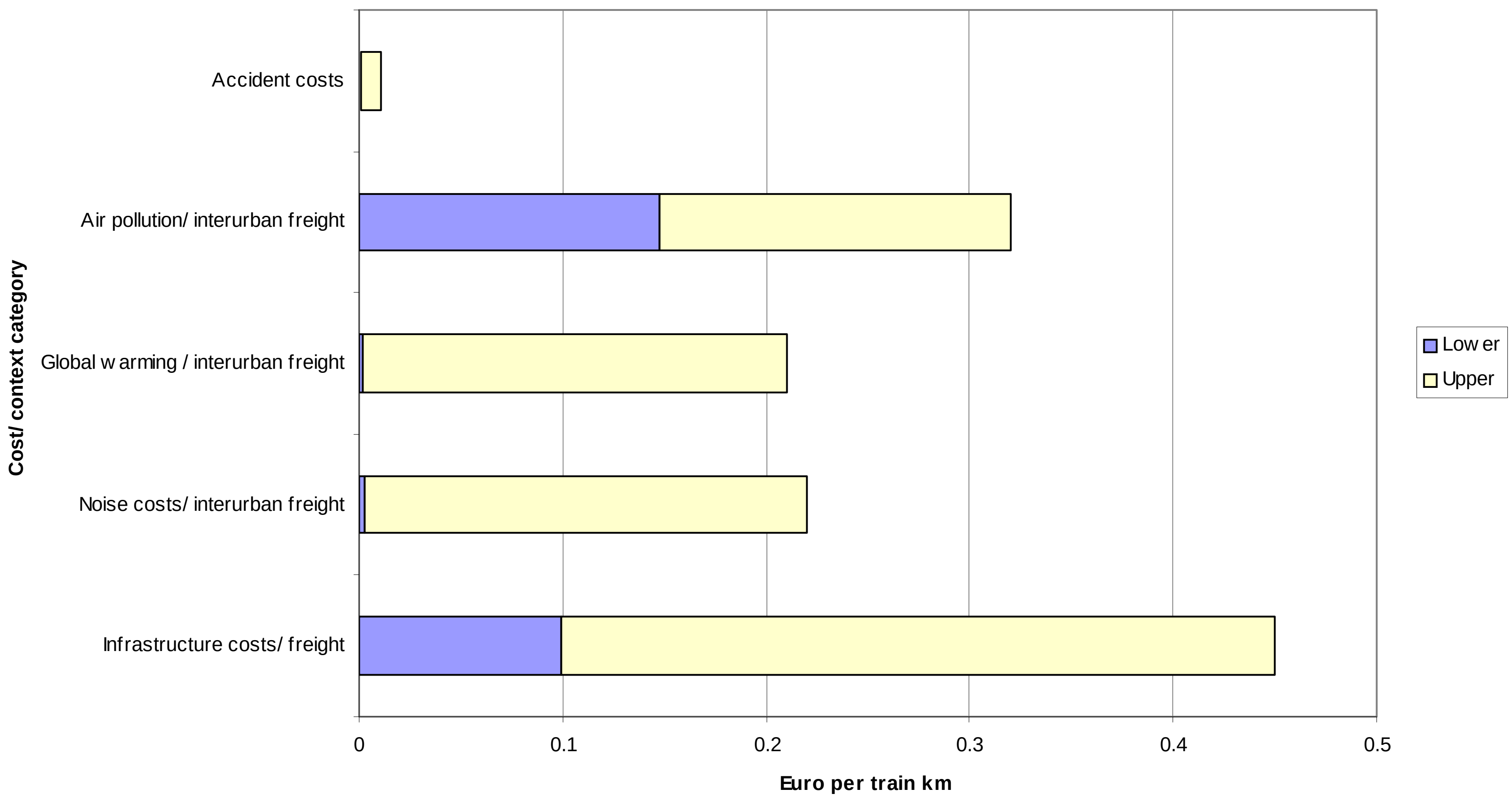
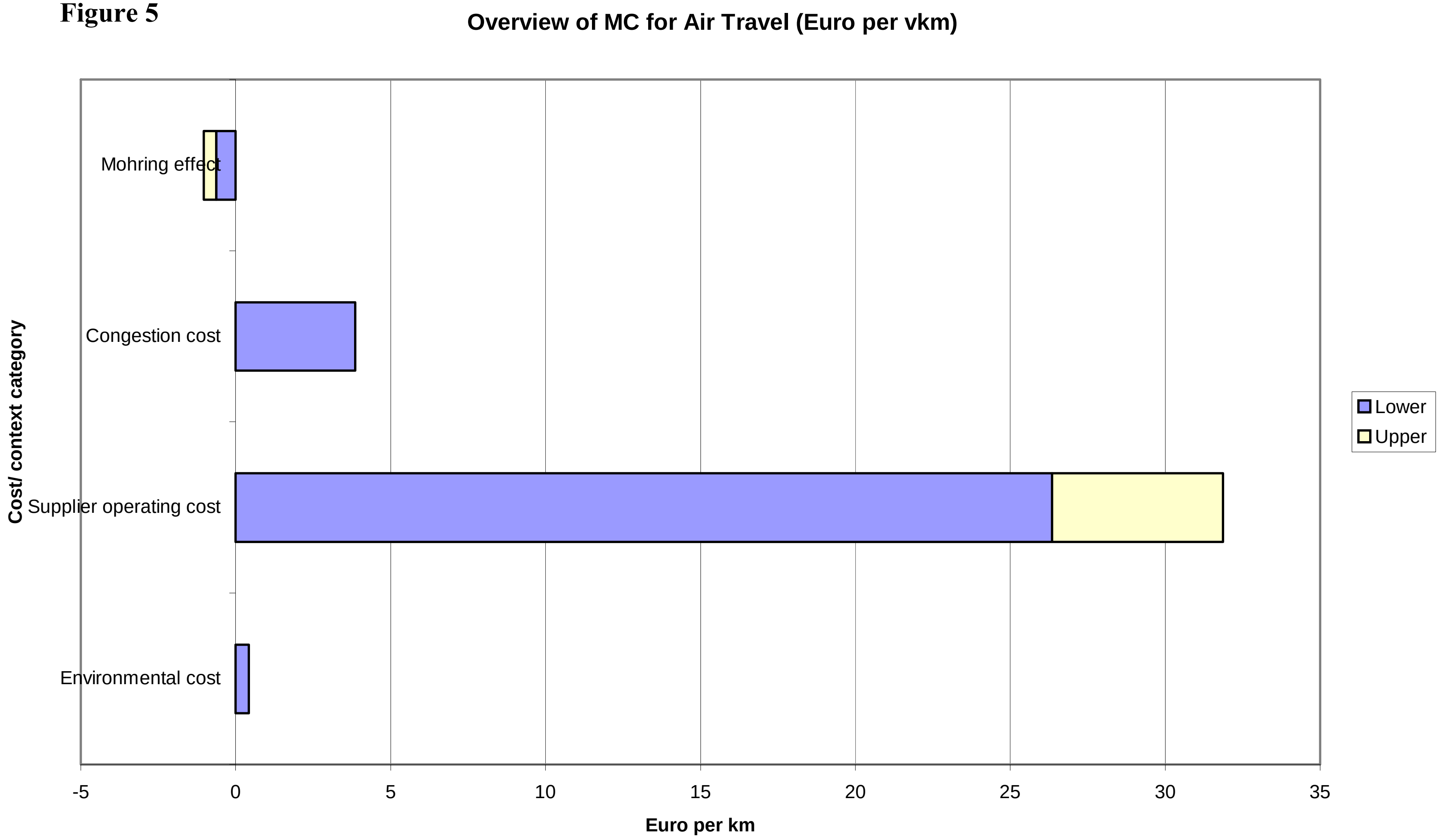


Figure 5



Overview of MC for Air Travel (Euro per vkm)
Mohring effect
Congestion cost
Supplier operating cost
Environmental cost
Cost/ context category
Lower
Upper
-5
0
5
10
15
20
25
30
35
Euro per km

4.2 Accounts approach

4.2.1 The use of Accounts

Transport accounts are an important tool to show **performance** of the transport sector for a specific spatial entity and a specific period of time. The following table contrasts the information provided by accounts and marginal cost estimates.

Table 3 Comparisons between marginal cost and accounts information

	Marginal Cost Information	**Transport Accounts**
Use	Input figures for efficient pricing	Output/Impact monitoring of the transport sector
Cost information	Unit costs/specific information: Additional costs of an additional transport unit, related to additional vehicle km	Total costs and revenues/ aggregate information: Total and average costs/revenues for a specific entity
Differentiation, systems delimitation	Different type of vehicles, different traffic situations, different exposure levels	Regional boundaries (e.g. national level), different time periods, different transport modes
Elaboration	Bottom up, based on analysis of a cost function	Top down, based on national transport statistics
Use of information	Pricing decisions	Transport monitoring

D14 (Link et.al. 2002) has identified seven purposes for transport accounts:

Strategic Monitoring
The basic information of accounts helps to understand the structure, the level and the development of costs and revenues on a national level. On a policy level, this can be used for

- Relevance analysis: To identify important cost elements within different transport modes,
- Comparison: To compare different countries, transport modes and different spatial aggregation levels,
- Forecasting: To develop early diagnosis of trends in the transport sector and use for policy scenarios.

Monitoring financial viability
Accounts contain information which is directly relevant for financial purposes. Most important are infrastructure costs, supplier operating costs and related revenues or subsidies. Hence one part of social accounts is an aggregate of transport operators accounts (e.g. public transport suppliers, privatised motorway companies, airport operators etc.), which sets the financial costs in relation to total social costs. Accounts make visible the financial performance of private and state owned transport entities, showing as well explicit and hidden subsidies. These subsidies can be provided for specific transport services, such as public service obligation (e.g. of public transport), to cover deficits of transport operators, or to cross-subsidise specific transport

services. The financial balance within the accounts can be used to answer two types of questions:

- what is the total cost of the sector in question?
- to what extent is this cost borne by users as opposed to taxpayers or the community at large?

The results also provide a starting point for considering issues of finance and equity.

Since cost recovery is an important aim for business units, the monitoring of financial viability is still one of the most important aims of transport accounts. In actual fact, it was one of the early aims of national initiatives to develop transport accounts in countries such as Germany, Switzerland, Austria. One has to consider however, that cost recovery indicators need assumptions for the allocation of costs and revenues. These allocation rules cannot be provided solely on a scientific level and are very difficult to generalise. Moreover, there are good economic arguments for believing that 100% cost recovery is not necessarily the best policy. This issue is returned to in Section 4.3.

Monitoring progress towards sustainable transport
Social costs and revenues show the performance of the transport sector in monetary terms. This common monetary denominator is also used to make visible important sustainability issues like the quality of the transport sector (e.g. expressed as delays or congestion), safety problems (social costs of accidents), and environmental problems (social costs of environmental nuisances). The respective indicators can be integrated in regular monitoring tools on a national basis. EEA for example (see TERM 2001) is using total environmental cost information as one out of 20 periodic indicators on a European level.

Monitoring Equity
Equity issues are very important in the public discussion of transport policy and refer to different dimensions such as

- Regional equity: Costs and revenues of urban and rural areas, different state levels and different nations.
- Equal treatment of different transport services: Most important are those being in direct competition, such as road and rail (passenger and freight), high speed rail and air transport services.
- Equity between social groups: Well elaborated and sophisticated accounts can be used as well for the presentation of equity considerations between different income groups or between consumers and producers. This is clearly an interesting task of future research.

Equity concers may also include the polluter pays principle as being one of the central concepts for sustainable transport policy. It has to be considered that there are different interpretations possible for the implementation of this principle. Accounts are useful for presenting the basic information for this task, although they may typically not provide the level of disaggregation necessary for their full resolution.

Monitoring Efficiency of pricing schemes
Accounts provide different elements of information on efficiency: Firstly accounts provide information on the social costs of transport, which are clearly relevant in considering the

efficiency performance of the transport system. The lower average costs, the better the efficiency. But it is important to note that the UNITE pilot accounts do not cover all efficiency aspects. The work on integration (D4, Mayeres et al 2001) has shown that accounts should be enlarged by the measurement of the development of the consumer surplus of the transport sector as a whole in order to have a comprehensive magnitude of overall efficiency. This is not an easy task.

Secondly accounts provide information on average prices (e.g. revenues per unit of transport) in the transport sector. The more these prices converge with marginal cost figures, the higher the efficiency.

Thirdly accounts information can be used for benchmarking and comparing different country performances. This is a link to the aim of strategic monitoring.

Development of marginal cost estimates
Accounts provide aggregate information, which can be allocated to specific transport services (top down allocation). Parts of such information can be used for aggregate proxies of marginal social costs. Average variable infrastructure costs or average variable environmental or operating costs for example can be used as general information for marginal cost figures (e.g. on a national basis). Such figures are helpful as a starting point for development of more detailed marginal cost estimates for specific circumstances.

Provision of basic data for transport statistics
Accounts are in general a product of national statistics providing a set of aggregate transport data. This information can be used like any other statistic information for very different purposes, as well for future research and for further elaboration of indicators (see below).

4.2.2 Elaboration of accounts

UNITE has studied optimal structures of transport accounts on a practical and on a theoretical level. The experience of the elaboration of the national pilot accounts can be used as well for policy recommendations for the future elaboration and development of accounts.

4.2.2.1 Templates for costs and revenues

It is useful to make a distinction between basic transport accounts and further sophistication (ideal accounts). Within UNITE, the basic transport accounts were elaborated as so called pilot accounts. The experience with this task showed, that the templates developed are appropriate; in general it is possible to collect the relevant basic data and to estimate related costs and revenues on a national level. The following major difficulties have to be challenged:

- The allocation of costs and revenues to certain type of vehicles, especially the differentiation between freight and passenger transport and respective type of vehicles (especially for road transport).
- The differentiation of costs between fixed and variable parts.
- The aggregation of costs and revenues of individual transport service units (e.g. public transport, airports, ports) to national figures.

The following recommendations for a further use and development of national accounts refer to the pilot accounts experience within UNITE.

a) Basic transport information

In order to produce the accounts and to elaborate the relevant indicators, the following basic data per country (or other spatial entities) and per year should be provided:

Table 4 Basic transport information for the accounts

Basic data	Specification
Socio economic indicators	Population, Land area, GDP (real and nominal, growth rates, employment rate, consumer price index)
Transport infrastructure	Network length, capital stock
Transport performance	Passenger transport: Passenger carried, Passenger km Freight transport: Goods transported, Tonne km Number of vehicles Vehicle km
Safety performance	Number of accidents (injuries, fatalities)
Environmental performance	Direct transport emissions (NOx, PM10, NMVOC, SO2, CO2) People exposed to noise

b) Differentiation of accounts per mode

The more differentiated, the more relevant are the results of the accounts for transport policy. There is however a trade-off between data quality or accurate allocation methods and a sophisticated differentiation. The following table shows a useful level of differentiation.

Table 5 Differentiation of accounts according to modes and further criteria

Transport modes	Network and institutional differentiation[1)]	Means and user breakdown[1)]
Road	-Motorways -Inter-Urban roads -Urban and Local Roads	–Motorcycles –Passenger cars –Buses (private and public) –Light goods vehicles –Heavy goods vehicles (HGV)
Rail	-All rail	–Passenger transport –Freight transport
Other public transport	–	–Trams –Metro –Trolley buses – Public buses
Aviation	-Airports -Air transport	–Passenger –Freight
Inland waterway	-Inland waterways -Inland waterway harbours	–
Maritime shipping	-Seaports	–

c) Basic templates for costs and benefits

Due to different institutional frameworks, different relevance of costs and differentiation, the structure of the costs and revenue information of different transport modes is not exactly the same. The following table shows the basic structure of the relevant information for different modes as it was defined for the UNITE pilot accounts. Future improvement could refer to supplier operating costs for air and waterborne transport.

Table 6a Basic templates for transport accounts per mode – cost side

Cost and revenue information	Road	Rail	Urban Public Transport	Aviation	Shipping (Canals/ Ports)
Costs					
Core information					
Infrastructure Costs	X	X	X	X	X
Capital costs	X	X	X	X	X
Running costs (Variable/Fixed)	X	X	X	X	X
Traffic control costs	-	-	-	X	-
Supplier Operating Costs	-	X	X	-	-
Accident costs (user external)1)	X	X	X	X	X
Environmental costs	X	X	X	X	X
Air pollution	X	X	X	X	X
Global warming	X	X	X	X	X
Noise2)	X	X	X	X	X
Additional information	X	X	X	X	X
Congestion/Delay costs3)	X	X	X	X	-
Time costs	X	X	X	X	-
Fuel costs	X	X	X	X	-
Accident costs (user internal)4)	X	X	X	X	X
From this: risk value	X	X	X	X	X
Environmental costs	X	X	X	X	X
Nature and landscape, soil and water pollution	X	X	X	X	X
Nuclear risk	-	X	X	-	-

Table 6b Basic template for transport accounts per mode – revenue side

Cost and revenue information	Road	Rail	Urban Public Transport	Aviation	Shipping 1)
Revenues					
Directly related to a specific cost category	X	X	X	X	X
Charges for infrastructure usage	X	X	X	X	X
Fixed[5)]	X	X	X	X	X
Variable	X	X	X	X	X
User tariffs	-	X	X	X	X
Compensation for concessionary fares	-	X	X	-	-
Charges for traffic control	-	-	-	X	-
Other transport specific revenues					
Fuel tax	X	X	X	X	X
Annual vehicle tax	X	-	-	-	-
Sales tax	X	-	-	-	-
VAT on fuel tax/other charges	X	X	X	X	X
Security charges	-	-	-	X	-
Non transport related revenues	-	X	X	X	X
Subsidies		X	X	X	X

[1)] Refers to those parts of road accident costs which are not borne by road users and insurance companies but by the public sector and third parties. – [2)] metro, tram and trolley bus, diesel bus. – [3)] Expressed as delay costs. – [4)] Refers to those parts of accident costs which are caused and borne by road users and insurance companies. – [5)] Charges not depending on the mileage.

4.2.2.2 Estimation and valuation of costs and revenues

a) Collection of input data

The estimation of costs and revenues is based on the following inputs:

- Transport statistics: Basic transport indicators, such as transport volumes, number of accidents etc,
- Financial information of transport service companies and infrastructure operators: Investment time series, expenses, costs and revenues, business balances,
- Modelling of specific information such as environmental nuisances, additional information to estimate fixed and variable costs,
- Additional information on economic costs (hidden subsidies etc.).

The following table indicates the sources needed to produce the relevant figures.

Table 7 Basic sources for the estimation of costs and revenues per transport mode

Cost and revenue information	Road	Rail	Urban Public Transport	Aviation	Shipping (Canals/ Ports)
Costs					
Core information					
Infrastructure Costs	T/M (B)	T/M/B	T/M/B	M/B	M/B
Supplier Operating Costs		B	B	B	B
Accident costs (user external)[1)]	T/M	T/M	T/M	T/M	T/M
Environmental costs	T/M	T/M	T/M	T/M	T/M
Air pollution	T/M	T/M	T/M	T/M	T/M
Global warming	T/M	T/M	T/M	T/M	T/M
Noise[2)]	T/M	T/M	T/M	T/M	T/M
Additional information					
Congestion/Delay costs[3)]	M	B/M	B/M	B/M	
Accident costs (user internal)[4)]	T/M	T/M	T/M	T/M	T/M
Environmental costs	M	M	M	M	M
Revenues					
Directly related to a specific cost category	T/B	B	B	B	B
Charges for infrastructure usage	T/B	B	B	B	B
User tariffs		B	B	B	B
Compensation for concessionary fares		B	B		
Charges for traffic control				B	
Other transport specific revenues					
Fuel tax	T	T	T	T	T
Annual vehicle tax	T				
Sales tax	T				
VAT on fuel tax/other charges	T	T	T	T	T
Security charges				B	
Non transport related revenues		B	B	B	B
Subsidies	A	A	A	A	A

T Transport Statistics
B Business Reports
M Modelling
A Additional information

b) Valuation methods

In order to guarantee certain comparability between countries and different transport modes, it is necessary to use a standardised approach for valuation and value transfer. Based on the findings in D14 (Link et.al, 2002), we can recommend the following main approaches:

- Value transfer between countries: Unit values should be transferred from one county to another by using a GDP per capita correction.
- Infrastructure costs can be produced out of annual expenditure data using the perpetual inventory method. The values should be expressed at constant prices (with the price base being the account's year), using real interest rates.
- Other financial costs and revenues should be valued in nominal terms of the account's year.
- Delay costs can be modelled by estimating the difference between existing and uncongested traffic conditions. The latter refer to a situation in off peak situations (private transport) or according to transport schedules (public transport).
- Accidents costs should be produced by using a risk value for the valuation of fatalities. We recommend an average risk value for Western Europe of 1.5 million €. The external part can be produced by subtracting the level of insurance premia paid by different transport modes.
- Environmental costs should be modelled with specific emission and valuation models (e.g. ExernE, impact-pathway approach). The unit values for different environmental nuisances should be based – if possible - on national estimates.

If possible the unit values should be based on national estimates. UNITE however has carefully considered how and when value transfers from one country to another are possible.

4.2.2.3 Relevant Indicators

Accounts can be seen – this is shown by the different purposes – as a tool for monitoring. In order to facilitate the interpretation, it is useful to define some basic indicators. The following table provides an overview according to the different purposes identified above.

Table 8 Basic indicators for the interpretation of transport costs and revenues

Purpose	Indicators
Strategic Monitoring	• Total costs per GDP/per capita • Infrastructure costs per network km • Annual growth rate of costs and revenues
Monitoring progress towards sustainable transport	• External accident and environmental costs per capita/per GDP
Monitoring financial viability	• Infrastructure cost recovery rate, net balance of financial costs
Monitoring Equity	• Average accident and environmental costs per pkm and tkm • Subsidies for public transport
Monitoring Efficiency of pricing schemes	• Average variable cost • average price, compared with marginal cost • (subsidies per transport mode)

Data on these indicators may be found in UNITE D16. (Maibach et al, 2003)

4.2.3 UNITE results

In this section we present some key data from the UNITE accounts. The costs reported in the tables 9 and 13 comprise i) the costs of infrastructure (capital costs and running costs), ii) the part of accident costs that are paid for from public funds (national health insurance costs, police costs, rescue costs, damage to property not covered by insurance, production loss etc.), iii) the cost of supplying the transport service by the provider (for rail transport)[1] and iv) the costs caused by air pollution, noise and global warming. For the revenue tables a distinction between direct user contributions (in the form of tolls, Vignettes, access charges etc.) and transport related taxes (vehicle and fuel taxes) was made. Explicit subsidies as far as they increase revenues (referring mainly to subsidies for concessionary fares) are reported in the revenue tables, too. Note, that the type and structure of revenues differ considerably between transport modes. For road transport, taxes and charges play the major role in raising revenues. The tables for rail transport provide information about user tariffs and in countries where infrastructure access charges are raised, these revenues. For rail transport these two revenues sources are not additive: part of the price of a ticket or freight charge pays track access charges.

Tables 9 and 12 show the total costs and the revenues of road transport for the 17 countries completing the UNITE accounts for the year 1998. The structure of the tables reflects the total cost categories described above. Table 10 shows costs as a percentage of GDP. It is seen that on average, road infrastructure costs amount to 1.5% of GDP. The environmental costs of road

[1] For aviation, supplier operating costs are not quantified. It is assumed that usually these are covered by the user through fares, although certainly subsidies do exist in this sector, as discussed below.

traffic amount to a little over 1% of GDP. The total cost of road congestion amounts to a further 1% and external accidents costs 0.5%. Although it is only the marginal external cost of road congestion that is relevant for pricing, on certain assumptions the average cost of road congestion may be used as an approximation of this. In practice it probably forms a lower bounds.

Table 9
Costs of road transport for European countries in 1998, in Million Euros

Country	Infrastructure Costs	Congestion Costs	Air Pollution Costs	Noise Costs	Costs of Global Warming	External Costs of Accidents
Austria	4382	1555	833	329	36	1367
Belgium	1570	-[1]	1671	655	625	877
Denmark	400	407	496	-[1]	265	679
Finland	1119	-[1]	435	112	253	232
France	25520	17293	14087	3989	2611	1528
Germany	26176	17381	8411	6245	3849	14592
Greece	2802	5192	978	266	320	3355
Hungary	6075	792	1163	180	191	-[1]
Ireland	263	401	312	352	165	240
Italy	13645	-[1]	7229	2784	2324	4145
Luxembourg	105	-[1]	61	33	36	56
Netherlands	4411	3103	1482	311	686	1421
Portugal	1791	121[2]	472	212	483	501
Spain	6224	3312	2067	2965	1474	2307
Sweden	2172	-[1]	456	143	383	953
Switzerland	4030	587	532	521	202	925
UK	12728	19371	5192	5768	2392	1994
Total	113413	69515	45877	24865	16295	35172

[1] No data
[2] Lisbon and Oportom metropolitan areas only

Table 10
Costs of road transport for European countries in 1998, as a percentage of GDP

Country	Infrastructure Costs	Congestion Costs	Air Pollution Costs	Noise Costs	Costs of Global Warming	External Costs of Accidents
Austria	2.3095	0.8195	0.4390	0.1734	0.0190	0.7205
Belgium	0.6978	-[1]	0.7427	0.2911	0.2778	0.3898
Denmark	0.2743	0.2791	0.3401	-[1]	0.1817	0.4656
Finland	0.9626	-[1]	0.3742	0.0963	0.2176	0.1996
France	1.9546	1.3245	1.0789	0.3055	0.2000	0.1170
Germany	1.3620	0.9044	0.4376	0.3249	0.2003	0.7593
Greece	2.6101	4.8364	0.9110	0.2478	0.2981	3.1252
Hungary	14.2941	1.8635	2.7365	0.4235	0.4494	-[1]
Ireland	0.3416	0.5208	0.4052	0.4571	0.2143	0.3117
Italy	1.4080	-[1]	0.7459	0.2873	0.2398	0.4277
Luxembourg	0.6362	-[1]	0.3696	0.2000	0.2181	0.3393
Netherlands	1.2524	0.8810	0.4208	0.0883	0.1948	0.4035
Portugal	1.8090	0.1222	0.4767	0.2141	0.4879	0.5060
Spain	1.2787	0.6804	0.4247	0.6092	0.3028	0.4740
Sweden	1.0168	-[1]	0.2135	0.0669	0.1793	0.4462
Switzerland	1.7180	0.2502	0.2268	0.2221	0.0861	0.3943
UK	1.0191	1.5509	0.4157	0.4618	0.1915	0.1596
Totals	1.4630	1.1191	0.5918	0.3269	0.2102	0.4562

[1] No data

Table 11
Costs of road transport for European countries in 1998, per vehicle kilometre (euros)

Country	Infrastructure Costs	Congestion costs	Air pollution costs	Noise costs	Costs of global warming	External costs of Accidents
Austria	0.0740	0.0263	0.0141	0.0056	0.0064	0.0231
Belgium	-[1]	-[1]	0.0190	0.0080	0.0070	0.0100
Denmark	0.0287	0.0095	0.0116	-[1]	0.0062	0.0159
Finland	0.0250	-[1]	0.0095	0.0036	0.0048	0.0050
France	0.0490	0.0330	0.0220	0.0080	0.0050	0.0030
Germany	0.0417	0.0277	0.0134	0.0100	0.0061	0.0232
Greece	0.0170	0.0310	0.0060	0.0020	0.0020	0.0200
Hungary	0.3170	0.0410	0.0610	0.0090	0.0100	-[1]
Ireland	0.0062	0.0105	0.0082	0.0092	0.0043	0.0063
Italy	0.0280	-[1]	0.0150	0.0060	0.0050	0.0080
Luxembourg	0.0340	-[1]	0.0200	0.0110	0.0120	0.0180
Netherlands	0.0374	0.0263	0.0126	0.0026	0.0058	0.0121
Portugal	0.0260	0.0020	0.0070	0.0030	0.0070	0.0070
Spain	0.0327	0.0174	0.0109	0.0156	0.0078	0.0121
Sweden	0.0320	- [1]	0.0070	0.0020	0.0060	0.0140
Switzerland	0.0731	0.0106	0.0096	0.0094	0.0037	0.0168
UK	0.0277	0.0422	0.0113	0.0126	0.0052	0.0043

[1] No data

Table 11 expresses the costs of road transport per vehicle kilometre. Some wide variations are observed, though usually in the expected direction.

Table 12
Road revenues and taxes

- € million 1998-

	Charges for infrastructure use		Vehicle taxes			Fuel taxes		Total
	Fixed	Variable	Registration tax	Circulation tax	Other	Fuel tax and duty	VAT on fuel tax	
Austria	266	237	[13)]	834	391[3)]	2591	604[4)]	4923
Belgium	95	18	284	1153	901[9)]	3297	491	6239
Denmark	[13)]	38	2439	725	179[5)]	1178	[13)]	4558
Finland	0	0	[13)]	1262	[13)]	1938	426	3626
France	0	4167	[13)]	[13)]	4983[7)]	18720	16146	44016
Germany	411	0	[13)]	7757	[13)]	28983	4565	41416
Greece	[13)]	1327	[13)]	280	741[10)]	2765	407	5520
Hungary	122	[13)]	[13)]	31	76	1240	413	1882[12)]
Ireland	0	27	770	373	[13)]	1223	[13)]	2393
Italy	[13)]	2222	865	3325	934[5)]	21994	6845[4)]	36185
Luxembourg	3	[13)]	1	24	8[5)]	327	43	406
Netherlands	91	0	[13)]	1873	2425[3)]	5040	857	10286
Portugal	52	332	[13)]	1030	63[11)]	2342	[13)]	3819
Spain	0	919	908	1266	[13)]	8428	1349	12870[6)]
Sweden	59	0	[13)]	684	30[1)]	3547	887	5266
Switzerland	266	0	[13)]	1041	125[1)]	2858	192[2)]	4482
UK	259	0	[13)]	7500	[13)]	30770[8)]	5454	43983

[1)] Vehicle import tax. - [2)] Also includes VAT on import tax and circulation tax. - [3)] Sales tax. - [4)] Also includes VAT on infrastructure charges. - [5)] Insurance tax. - [6)] Not included in this total are subsidies payments received by private motorway concessionaires for exchange rate risk totalling €197 million in 1998. - [7)] All vehicle taxes: registration tax, insurance tax, taxes on company cars, tax on the vignette and tax on vehicle parts. - [8)] Bus fuel duty rebate of €398 million has been deducted from this total. - [9)] Insurance and radio tax. - [10)] All other vehicle taxes. - [11)] Municipal vehicle tax. - [12)] Not included are subsidies granted for the provision of infrastructure totalling €171 million in 1998. - [13)] None reported within the country account.
Source: Link et al. (2002a,b,c)

Tables 13 and 14 show the costs of rail transport and the various types of revenues including explicit subsidies. It has to be borne in mind that for the calculation of these costs and revenues the transport provider has to be taken into account. Because the addition of all costs or all revenues would cause double counting (with respect to access charges paid by the train operators) the totals shown in tables 4 and 5 exclude the track access charges paid by operators. In comparison to the road account, the costs of rail transport are dominated by infrastructure costs and the costs of supplying transport services. Balanced with these costs are the comparatively low accident and environmental costs. Due to the fact that infrastructure costs (depreciation and interests, running costs) were calculated by using all investment expenditure on infrastructure for capital valuation, independent of the source of finance, explicit subsidies (granted for infrastructure construction, enlargement, upgrading etc.) are included in the cost figure but cannot be separated. Construction subsidies for tracks and stations, however, can take a considerable amount. In many countries most or all capital investment in the rail infrastructure is provided in the form of a government grant. An example is Germany where in 1998 about €4.5 billion were granted by the federal government amounting to almost two thirds of the total investments of DB. Even in Great Britain, where the policy following privatisation was to direct all subsidies to the train operating companies rather than the infrastructure manager, investment grants for rail infrastructure are now totalling several hundred million pounds per annum.

Table 13
Total rail transport costs

- € million 1998-

Country	Infrastructure Costs	Air pollution costs	Noise costs	Costs of global warming	External costs of accidents	Transport operator costs	Total
Austria	1933	15	6	7	23	2183	4 167
Belgium	1142	19	38	11	2	2579	3 791
Denmark	255	12	2)	9	21	795	1 092
Finland	360	7	22	6	5	451	851
France	4790	62	51	16	3	10944	15 916
Germany	12621	220	1031	152	83	7336	21 443
Greece	390	6	8	2	4	326	736
Hungary	505	41	27	6	2)	432	1 011
Ireland	22 1)	8	29	2	2)	255	316
Italy	5605	145	243	61	10	6673	12 737
Luxembourg 3)	90	3	1	1	2)	294	389
Netherlands	1095	10	22	2	58	2339	3 526
Portugal	292	22	5	3	11	558	891
Spain	3500	50	219	27	19	2013	5 828
Sweden	856	5	43	3	32	1270	2 209
Switzerland	2762	5	60	0.1	8	2095	4 930
UK	3288	343	107	54	26	6664	10 482

1) Operating, signalling and depreciation costs only. - 2) No data available for the estimation of these costs. 3) Rail owned buses included.
Source: Link et al. (2002a,b,c)

As can be seen from table 14, information about the revenues, taxes and subsidies for rail transport is not complete. This is in particular true for implicit subsidies such as tax losses due to reduced tax levels or exemptions. For example, the VAT raised on the price of a train ticket is normally reduced compared to the countries VAT level. The rate of VAT raised also varies for national and international travel making general assumptions or basic calculations to estimate VAT loss impossible. Where VAT lost could be calculated, these results are included in table 14. In contrast to that, fuel and energy taxes are charged for rail transport in several countries. The level of these taxes is given in table 14.

Even without comprehensive estimates on revenue losses due to tax reductions and exemptions it is clear from table 14 that the rail sector is characterised by a high level of subsidy. In addition to the high level of subsidies for the provision of services and for concessionary fares are substantial implicit subsidies by the failure of total revenue (including explicit subsidies) to cover total social cost.

Table 14
Rail revenues and subsidies
- € million 1998 –

	Revenues		Taxes	Explicit subsidies		Implicit subsidies	Total [7]
	Ticket and freight revenues	Track, station and other infrastructure charges	Fuel and energy tax	For the provision of services	For concessionary fares	Lost revenues due to reduced VAT on ticket	
Austria	1277	349	5[1]	1045	619	[6]	2 946
Belgium	908	[5]	0.85	1615	[5]	69	2 524
Denmark	566	20	0	219	30	[6]	815
Finland	533	54	4.8[1]	53	9	37	600
France	6380	946	41	5678	296	[6]	12 395
Germany	8614	4566	251[1]	7175	4244	[6]	20 284
Greece	126	[5]	9[1]	[5]	126	[6]	261
Hungary	84	124	27	295	[5]	[6]	406
Ireland	127	[5]	[5]	42	[5]	[6]	169
Italy	3441[3]	[5]	[5]	1740	1700	[6]	6 881
Luxembourg[4]	100	[5]	0.4	104	[5]	4	204
Netherlands	1210	155	[5]	81	81	[6]	1 372
Portugal	188	[5]	[5]	10	[5]	[6]	198
Spain	1495	[5]	0	1925	[2]	[6]	3 420
Sweden	1325	98	[5]	500	[5]	[6]	1 825
Switzerland	2191	774	[5]	1621	[5]	[6]	3 812
UK	5677	3448	[5]	43	2254	[6]	7 974

[1] Including VAT on fuel tax. - [2] Unknown level of subsidies for concessionary fares included in subsidies for provision of services. - [3] Including revenues of €1517 million from public service contract, which may also be seen as a subsidy. - [4] Revenues, taxes and subsidies from rail owned buses included. - [5] None recorded within the country account. - [6] Can not be calculated with the available data. – [7] Excluding infrastructure charges and implicit subsidies.

Source*: Link et al. (2002a,b,c)*

The degree to which rail system costs are covered by revenue from passengers and freight differs substantially between the countries studied, from a maximum of 63% in the case of Finland to a minimum of 8% in the case of Hungary. The simple unweighted average for all the countries in the study is 36%.

In contrast to road and rail we do not report total costs and revenues for urban public transport here. The reason for this is the lack of reliable and consistent estimates for this mode caused by several difficulties. First, the infrastructure, accident and environmental costs of UPT are divided between road (for buses) and rail (for urban rail) costs and can not be considered separately from these. Second, in most countries numerous companies provide services. Data from these companies is not collected in a systematic way in any country.

The costs of supplying air transport are given in table 15. It should be mentioned that actually similar to rail the operators, e. g. the airlines, would need to be considered. Such data, however, were not collected or estimated and there is to our knowledge no other European study available on this issue. Furthermore, it needs to be mentioned that current data regarding noise pollution was difficult to obtain for many countries. This results in either low costs or no costs being calculated at all. As in rail transport, accident costs relate to specific incidents and unlike road accident costs vary greatly between years.

Table 15
Total air transport costs

- € million 1998 -

Country	Infrastructure Costs	Air pollution costs	Noise costs	Costs of global warming	External costs of accidents	Total
Austria	509	29	3	41	6	588
Belgium	184	11	:	116	0,85	312
Denmark	293	7	:	9	2	329
Finland	:	4	:	17	0,2	21
France	8110	60	:	31	0	8201
Germany	3488	162	278	434	35	4397
Greece	239	6	24	0,03	:	269
Hungary	127	2	9	3	0	141
Ireland	401	20	:	57	:	478
Italy	571	77	193	197	2	1041
Luxembourg	37	1	:	2	:	40
Netherlands	98	25	186	15	0,4	325
Portugal	203	106	4	50	1	363
Spain	411	62	188	208	4	873
Sweden	447	2	0,4	65	1	515
Switzerland	804[1)]	17	27	34	10	738
UK	2236	656	155	49	5	3101

[1)] Including the costs of air traffic management services totalling €154 million in 1998. *Source*: Link et al. (2002a,b,c)

Although for several countries complete data was not available the importance of subsidies going to air transport is apparent. However, due to the fact that we do not have information on the airlines cost a subsidy rate comparable to that for rail cannot be derived. It is clear however, comparing tables 15 and 16, that in most countries landing charges fail to cover airport infrastructure costs and make no contribution towards external costs.

Table 16
Revenues, charges, taxes and subsidies within the aviation sector (1998)

-€ million-

	Revenues		Taxes	Other charges	Explicit subsidies	Implicit subsidies	
Country	Airport revenues	ATM charges				Revenues lost : VAT on ticket price	
Austria	278	151		25[3]			
Belgium	255	120					
Denmark	:	:		:	:	103	
Finland	181				0.3	231	
France	1687	1117			279[7]		
Germany	3121	767[1]		48[1]		252[2]	
Greece	767[5]		34				
Hungary	103		2				
Ireland	134	:					
Italy	795	200	12				
Luxembourg	11	1.1			0		
Netherlands	224	:	1.3				
Portugal	114	86					
Spain	501	341			77[6]		
Sweden	184	119		17			
Switzerland	651	159					
UK	:	137[8]		1210[4]	28		

[1] Meteorological services charge. - [2] For Lufthansa only. - [3] Security charge. - [4] Air passenger duty. - [5] All airport and ATM charges. – [6] Subsidies to airlines. – [7] €194 million to airports, € 85 million other general subsidies. – [8] Profit from these services going to general budget.
Source: Link et al. (2002a,b,c)

4.3 Integration

4.3.1 Introduction

The third area of work in UNITE is integration. Two concepts of integration are presented. The first is a 'hard-wired' concept in which the accounts and marginal cost information are formally combined to produce advice on transport pricing. A second more pragmatic approach is to accept that both provide valuable information for decision makers faced with a variety of objectives, including efficiency, equity and financial objectives.

An important part of the integration work in UNITE was to model the implications of alternative pricing rules. It is sometimes argued that accounts information used be used to set prices to cover total cost on each mode, perhaps on the grounds of budget constraints or that this is the most equitable way to cover the costs of the transport system. The UNITE integration work modelled the consequences of this and compared them with two other policies; pure marginal social cost pricing, and social welfare maximisation subject to a budget constraint (Ramsey pricing). Two types of mode – partial equilibrium and general equilibrium models were used.

To explain the work undertaken in the integration work area more thoroughly:

- We test three arche-types of pricing rules. As shown by Table17 they differ by two characteristics: (i) whether they need to balance the financial transport account (by mode or for the sector) or not and (ii) whether they use marginal social cost information.

Table 17
Arche-types of transport pricing rules

Modal transport account balanced or financial cost recovery	Pricing principle	
	Average costs	Marginal costs
Imposed	Average cost pricing	Ramsey social cost pricing
Not imposed	-	Marginal social cost pricing

Average cost pricing is defined in this deliverable as follows: prices are set equal to the sum of financial costs of that mode divided by the total volume of that mode. This implies that there is no attention for the structure of resource costs (fixed or not, sunk or not etc.), no consideration of the external costs and identical treatment of all transport services (freight, passengers etc.) within that mode. The main goal of average cost pricing is cost recovery. When people are confronted with transport accounts, a common reaction is that costs and revenues should be balanced, which implies a form of average cost pricing. In UNITE Deliverable 4 (Mayeres et al., 2001), a conceptual analysis of the use of transport accounts for pricing showed that transport accounts are a useful source of information for pricing policies but should not serve as guideline or criterion for transport pricing. Here we analyse this issue further by quantifying the welfare effects of average cost pricing.

Marginal social cost pricing means that prices are set equal to the marginal resource cost (fuel, driver etc.) plus the marginal external cost (including congestion, air pollution, noise, accidents and maintenance cost of the infrastructure), all this for a given infrastructure. Marginal means here additional. In this pricing principle there is no consideration whatsoever for the financial impact per mode. In this modelling work we assume that there are no implementation costs.

Ramsey social cost pricing means that prices are set as optimal deviations of the marginal social costs. The deviations are necessary in order to meet certain cost recovery targets by mode or for the transport sector as a whole. If marginal social costs generate insufficient financial cost recovery, Ramsey social cost pricing requires that prices are increased and that the increase is inversely proportional to the price elasticity of demand. This means that mark ups on top of marginal social costs are differentiated between the different transport services (peak, off-peak, passengers, freight). We again assume that there are no implementation costs.

- We test the effects of these pricing rules using two types of models: a partial equilibrium model for the transport sector and two general equilibrium models that represent the whole economy. Table 18 compares the features of both approaches. The partial equilibrium model can analyse in a more detailed way the transport markets and different pricing policies. The degree of detail in modelling the transport markets is important for assessing the potential of alternative pricing instruments. The more disaggregate the structure, the higher the benefits one can expect from marginal cost pricing relative to single aggregate average cost pricing.

The partial equilibrium model contains a breakdown of transport markets by transport mode, time of day (peak and off-peak) and environmental characteristics of vehicles. However, area and route type (urban/interurban/rural) are not included. It generates detailed effects on transport volumes and on the efficiency of the transport sector. The partial equilibrium model is in principle also better suited to evaluate more sophisticated pricing rules, such as Ramsey pricing, than the general equilibrium models.

Table 18
The features of the models used

	Partial Equilibrium model	General Equilibrium models
Focus	Transport sector of a region or a country (different modes)	Whole economy of a country
Markets modelled	All transport markets of a region or country	Transport markets, labour market and other input markets, markets of all consumption goods
Cost or benefit of extra tax revenues raised in the transport sector	Exogenous – here set equal to 1[a]	Endogenous, will depend on the way the extra revenue is used
Equity issues	Are not dealt with because the use of the surplus or deficit is not specified	Studied by income group or on the basis of another classification (urban, non – urban household
Welfare measure used	Sum of consumer and producer surplus, tax revenues and external costs on the transport markets	Differences in utility for different households
Model case studies	4 regions in Germany 2 regions in UK	Belgium Switzerland
Infrastructure	Exogenous	Exogenous

[a] The partial equilibrium model assumes a first best economy: perfect lump sum redistribution of revenues is possible and there are no distortions in the rest of the economy.

The general equilibrium models cannot offer the same degree of modelling detail of the transport sector as the partial equilibrium model. However, they offer two important advantages. Firstly, they allow to model the economic costs of financing a larger deficit in the transport sector. Any increase in the deficit in the transport sector will require an increase of labour or other taxes and this may be more or less costly. The second advantage of the general equilibrium models is that they allow to track better the full incidence of a tax reform on the utility of different individuals. The general equilibrium models are therefore better suited for an analysis of the equity effects.

A common assumption of the partial and general equilibrium models is that the pricing reforms are evaluated for a given infrastructure.

We test the effects of alternative pricing rules. We also analyse whether the changes in the transport accounts that are recorded after a pricing reform are also good welfare indicators. We know from Mayeres et al. (2001) that the answer to this question is in general negative because the transport accounts do not report all components of the welfare function.

4.3.2 Partial equilibrium analysis: the direct effects of alternative pricing approaches

- In the partial equilibrium analysis we analyse alternative pricing policies for six different regions: four regions in Germany (Düsseldorf, Münster, München, and the Westphalen region) and two regions in the United Kingdom (Greater London and the Southeast region). For each of these regions we analyse the effect of using the three basic pricing rules and compare them with present pricing. In the six regions studied the present pricing rules generate for the total transport sector as a whole over-recovery of financial costs with under-recovery for the public modes and over-recovery for the road, in addition the pricing structure is not really geared to marginal cost pricing although there is some differentiation in prices towards marginal cost pricing or towards higher mark-ups for inelastic demand categories.

- It is found that, compared to the reference situation, average cost pricing reduces welfare while Ramsey social cost pricing (mostly) and marginal social cost pricing (always) improve welfare (cf. Table 19). These results suggest, first, that defining strict cost recovery by mode on the basis of financial costs (excluding external costs) is not a good starting point for a welfare maximising policy. Second, if the price mechanism itself allows for sufficient (second-best) differentiation of transport prices across modes and times of day (Ramsey social cost pricing), the effect of a budget constraint at the level of the transport sector as a whole is mitigated to a considerable degree.

Table 19
Welfare impacts* of pricing scenarios – partial equilibrium model (2005, % change with respect to REF)

	Average cost pricing	Ramsey social cost pricing (cost recovery for transport sector as a whole)	Pure marginal social cost pricing
Germany			
Düsseldorf	-0.79	+0.09	+0.14
München	-0.61	+0.14	+0.41
Münster	-2.45	-2.15	+2.45
Westphalen region	-0.17	-0.06	+0.09

UK			
London	-0.76	+1.28	+2.70
South east region	-1.89	+0.18	+0.55

* The welfare impact is measured with basis the full income (National Income + value of leisure).

In line with the theoretical analysis, marginal social cost pricing outperforms Ramsey social cost pricing, which in turn is better than average cost pricing. First, the introduction of a budget constraint reduces the efficiency effects of transport pricing systems. Second, the way in which this constraint is met, has further consequences for the welfare effects. Ramsey social cost pricing cannot be worse than average cost pricing.
Interestingly, average cost pricing leads to a reduction of welfare with respect to the reference situation in all cases. While the size of the reduction varies substantially between cases, the basic reasons for the welfare reductions are the same.

4.3.3 General equilibrium analysis: the indirect effects of alternative pricing approaches

General equilibrium results are presented for two countries: Belgium and Switzerland. The transport situation is not identical in these two countries, which has implications for the policy choice. In Belgium congestion is the dominant marginal external cost of transport. Transport instruments which tackle this problem efficiently have an advantage over the others. In Switzerland congestion is less important. Therefore, instruments which do not make a distinction between congested and uncongested situations get a smaller penalty. Secondly, the ratio of transport revenue to financial costs is different in the two countries. In the reference equilibrium in Belgium revenue from the road transport modes is much higher than financial costs. In Switzerland revenue is approximately equal to financial costs. For public transport the rate of financial cost coverage is lower in Belgium. This entails that the alternative pricing instruments have different implications for the transport accounts and government budget in the two countries.

While starting from the same philosophy, the two general equilibrium models are not completely comparable and the simulations focus on different issues. Both models compare the effects of average and marginal social cost pricing. While the model for Belgium focuses on the equity effects of transport pricing, the Swiss model considers more pricing rules. In particular it looks at the effects of marginal social cost pricing in combination with various types of budget constraint.

General equilibrium analysis for Belgium

In the general equilibrium analysis for Belgium four different scenarios have been tested.

- In the two average cost scenarios all existing taxes (except the VAT) and subsidies are set equal to zero. The VAT rate is set at the standard rate. A uniform levy per mode is introduced that guarantees that the financial cost of that mode are covered.
- In the two marginal social cost scenarios, the existing taxes and price structures are replaced by an ideal tax such that every transport user pays his marginal social cost. There is no cost recovery target in the marginal social cost pricing scenarios.

For each of these two basic pricing scenarios, two alternative ways of using surpluses or financing deficits of the transport sector have been used. The first is to change the marginal labour tax rate, the second way is to vary the level of social transfers. There are two main differences between the two financing rules. First, a decline of labour taxes has an additional positive efficiency effect because an existing distortion is reduced. Second, labour tax reductions (here a proportional reduction of all marginal tax rates) benefit the rich more than the poor.

Table 20 summarises the welfare effects of the policy reforms in Belgium. We report the effect on the population divided into five income quintiles. The welfare impact on the quintiles is measured by means of the equivalent gain: the increase in the initial equivalent income of an individual that is equivalent to implementing the policy reform. In the table it is presented as the percentage increase in the initial equivalent income of the individual. The effect on social welfare is described by the social equivalent gain. This is defined as the change in each individual's original equivalent income that would produce a level of social welfare equal to that obtained in the post-reform equilibrium. The social desirability of a policy depends not only on its efficiency, but also on its equity impact. Hence we present the social equivalent gain for two degrees of inequality aversion, denoted by ε. With ε equal to zero, only efficiency matters. We also present the social welfare change for ε equal to 0.5. This corresponds with a medium degree of inequality aversion. In this case the marginal social welfare weight of people belonging to the richest quintile is approximately 70% of those belonging to the poorest quintile.

Table 20
The welfare effects of the policy reforms – general equilibrium analysis for Belgium

	Benchmark	Scenario 1	Scenario 2	Scenario 3	Scenario 4
		Average cost + higher labour income tax	Average cost + lower social security transfers	Marginal social cost + lower labour income tax	Marginal social cost + higher social security transfers
Equivalent income (EURO/person/year)		percentage change w.r.t. benchmark			
Quintile 1	18586	-0.78%	-0.97%	0.47%	3.88%
Quintile 2	22260	-0.04%	-0.16%	0.03%	2.21%
Quintile 3	25027	-0.24%	-0.29%	-0.16%	0.75%
Quintile 4	28330	-0.20%	-0.19%	0.22%	0.00%
Quintile 5	35579	-0.49%	-0.38%	1.45%	-0.51%
Social equivalent gain (EURO/person/year)					
$\varepsilon = 0$		-92.71	-92.08	160.66	148.89
$\varepsilon = 0.5$		-89.56	-91.74	142.50	179.17

In the initial equilibrium the financial cost coverage rate, defined as the ratio of revenue over financial costs, equals 2.5 for road transport, 0.28 for rail and 0.37 for other public transport. The two average cost pricing scenarios therefore imply a reduction in the taxes on road transport and a substantial increase in the taxes on public transport. This leads to a reduction in government revenues from the transport sector by 18%. In Scenario 1 this is financed by an increase in the labour income tax by 0.5% for all quintiles. In Scenario 2, the social security transfers are reduced by 1% for all quintiles.

Both average cost scenarios reduce welfare for all quintiles. Consequently they both lead to a social welfare loss. This shows clearly that balancing the financial part of the transport accounts is not an objective that one should aim at. This is in line with the conclusions of the partial equilibrium analysis. Table D also shows that average cost pricing cannot be defended because of equity reasons, since all income groups become worse off.

Within each average cost scenario the differential impact on the quintiles can be explained by their share in the consumption of the transport goods, their share in the social security transfers or labour income, the level of initial taxation and the quintiles' valuation of the reduction in the externalities. The difference in welfare impact between Scenario 1 and 2 is due to the choice of the budget neutralising instrument. When the social security transfers are reduced, the welfare losses for quintiles 1 to 3 are higher than when the labour income tax is increased. This is because the social security transfer accounts for a larger share of their income. The share of labour income is relatively smaller for these quintiles, as is the labour income tax rate.

Social welfare is reduced in both average cost scenarios, as is reflected in the negative social equivalent gain. The social equivalent loss does not differ a lot between the two revenue-recycling strategies. This is because the required changes in the labour income tax and the social security transfers are relatively small. With average cost pricing the impact on welfare is dominated by the change in the transport taxes.

Since the marginal social cost scenarios increase the tax revenue collected by the government in the transport sector, the full welfare assessment needs to take into account how this revenue is used. In Scenario 3 the labour income tax is reduced by 10% for all quintiles. In Scenario 4 the extra revenue is used to increase the social security transfers by 11%.

In both marginal social cost scenarios the impact on social welfare is positive. The reason for this is similar as in the partial equilibrium analysis. However, not all quintiles benefit to the same extent from the policy reforms, and some are even worse off. Moreover, the welfare impacts on the quintiles are quite different in the two marginal social cost scenarios. The poorer quintiles benefit most from the higher transfers, since they make up a higher share of their income. In this scenario the two richest quintiles do not benefit from the policy reform: they pay higher transport taxes, but benefit only to a small extent from the redistribution of the extra government revenues.

While the transport account is similar in Scenario 3 and 4, the impact on social welfare is not. It depends on the revenue-recycling instrument that is used, and on the inequality aversion of society. When only efficiency considerations are important ($\varepsilon = 0$), the labour income tax is preferred as revenue recycling instrument. When a higher weight is given to the poorer quintiles (as is the case with $\varepsilon = 0.5$) it is better to recycle the revenue through higher transfers. This illustrates that transport accounts are not an appropriate instrument for assessing the equity impacts of transport pricing.

General equilibrium analysis for Switzerland

In the general equilibrium exercise for Switzerland nine different scenarios have been tested. Here the discussion focuses on the results of three scenarios: AC-FIN, MC-PUREa and MC-TCRc. In the average cost pricing scenario (AC-FIN) all modes have to cover their financial costs. In the marginal social cost scenario (MC-PUREa) each transport user has to pay his marginal social costs. The third scenario (MC-TCRc) starts from marginal social cost pricing but imposes total cost recovery for the transport sector as a whole. This implies flexibility in meeting the budget constraint, with possibilities for cross-subsidisation between the modes. In all three scenarios the VAT rate is changed in order to ensure budget neutrality.

Table 21 summarises the welfare effects of the three scenarios. They are measured in terms of the Hicksian equivalent variation in income of the households (HEV). A HEV decrease of 1%, for example, corresponds to a loss of income for the households by 1% compared to the base case. The model distinguishes two households, namely an urban and a non-urban household. The total welfare effect is the sum of the welfare implications for the two household types.

The way in which non-Swiss users of the Swiss road network are integrated in the pricing and financing schemes of the scenarios influences the welfare implications. Therefore a distinction is made between two cases. The "standard" case assumes that foreign and domestic road users are subject to the same pricing scheme. In the "domestic only" case, only domestic road users contribute to the budget constraint, while foreign users are priced at marginal social costs.

Table 21
Welfare implications of three pricing scenarios – general equilibrium analysis for Switzerland (% change in HEV in income w.r.t. the base case)

	MC – PUREa	MC – TCRc	AC – FIN
Standard case			
Urban HH	-0.17%	0.07%	-0.29%
Non-urban HH	0.23%	0.25%	0.03%
Welfare	0.17%	0.22%	-0.02%
Domestic only			
Urban HH	-0.17%	-0.20%	-0.34%
Non-urban HH	0.23%	0.23%	-0.07%
Welfare	0.17%	0.17%	-0.11%

The simulations show the following effects:
- In general, urban households are affected negatively by the three scenarios, while non-urban households are affected positively if the revenues from the pricing schemes are redistributed with a reduction of a general tax such as the VAT.
- The simulations predict an increase in total welfare if marginal social cost pricing is implemented in transport. Average cost pricing based on financial costs reduces welfare.

- A flexibly formulated total cost recovery scenario can improve welfare. The more flexible the budget constraint is implemented, the higher the welfare gain. Thus, efficiency considerations do not support the statement sometimes appearing in policy debates that there should be no cross-subsidisation between modes.

- Including foreign road transport in the domestic pricing scheme is beneficial. The welfare of the Swiss households is increased if foreign traffic on the Swiss road network contributes more to meeting the budget constraint.

Conclusions from the general equilibrium analysis

The general equilibrium exercises confirm the statements made in the previous UNITE work on the integration of accounts and marginal costs as summarised in Mayeres et al. (2001). Transport accounts as developed within the UNITE project contain information that can serve as important indicators for developments in the transport sector. However, they are not an appropriate instrument to assess the economic efficiency and distributional effects of transport policy reforms. This is because they do not contain all elements which are relevant for a full social cost-benefit analysis.

Both CGE models indicate that average cost pricing based on financial costs reduces social welfare. Moreover, the findings for Belgium show that welfare falls for all income groups considered in the study. This clearly indicates that one should be careful in using transport accounts as a guideline for pricing policies, and that average cost pricing cannot be justified on equity grounds. Simulations for Switzerland show that average cost pricing based on total costs (as defined in the UNITE transport accounts) may improve welfare. Given the initial transport situation in Switzerland (low congestion and the characteristics of the Swiss transport accounts) this measure performs relatively well, but it is worse than marginal social cost pricing.

Marginal social cost pricing generally increases social welfare. The magnitude of the welfare gain depends on the relative importance of the various externalities, on the presence of a budget constraint, and on the flexibility of that constraint.

For countries with a high share of foreign traffic on their road network, the treatment of foreign traffic has a large impact of the welfare gains of scenario with cost recovery constraints. Simulations with the CGE model for Switzerland show that the welfare of the Swiss households can be increased if foreign traffic on the Swiss road network contributes more to the budget constraint.

In general not all groups are affected equally by marginal social cost pricing. The equity impacts depend on how budget neutrality is ensured. The Belgian CGE model, which considers several income groups, shows that when society becomes more inequality averse, the revenue recycling instrument that is more beneficial to the poorer income groups will be preferred. Similar considerations come into play in the Swiss model which considers urban and non-urban residents, rather than income groups. One can conclude that the revenue recycling instruments have an important role to play in enhancing the political acceptability of transport pricing.

4.4 Policy Conclusions

The final task in the UNITE work programme was to consider what policy implications arise as a result of the project. These may be summarised as below.

- Firstly, the *marginal cost* approach provides information for efficient pricing in different traffic situations. Even though pricing policy in transport involves consideration of multiple objectives and constraints, an important starting point for policy is the pattern of efficient prices by mode, area type and route type. The marginal cost case studies provide relevant information to help populate that approach. However, it is unrealistic to expect a comprehensive set of marginal costs to be derived from such an approach on its own. In practice, we need to rely on social accounts data as a generic source of information, and to derive approximate or "average" marginal costs information from such data using such evidence on cost/output relationships as can be found in the literature. It is the use of case study and accounts data together which is likely to be the most practical means of generating practical marginal cost estimates which feed into pricing policy.
- Secondly, the creation and maintenance of a set of consistent social accounts for the transport sector is particularly valuable for monitoring the impacts of policy, including pricing policy. To achieve consistency across modes and countries is a formidable task to which we believe UNITE has made a contribution.
- Thirdly, in practice, pricing policy may involve balancing a mixture of considerations. Efficiency is clearly one but notions of equity, fairness, cost recovery and revenue raising are others. Thus, second-best questions such as how to set efficient prices in relation to marginal cost in the transport sector while achieving a given budgetary result, or how to set transport sector prices in relation to marginal cost given distortions in related sectors elsewhere in the economy are clearly relevant policy issues which may draw on both marginal cost and accounts information and which the integration strand of UNITE has addressed.
- Fourthly, the information both from marginal costs and accounts may provide relevant inputs to other decisions such as decisions on investment and to non-price regulation. The interrelationship between pricing and efficient investment is an issue of considerable policy interest, both in an economic sense and in relation to the case for Trust Funds and other ways of ring-fencing revenues for transport investments. Such issues are likely to be particularly relevant for the accession countries.

5. Overall conclusions

The UNITE project has served to illustrate that a variety of methods are needed in order to estimate marginal social cost, working together to overcome difficulties in the availability of appropriate data. A pragmatic approach, using a combination of cost allocation, econometric and engineering models is needed, with the precise approach differing between cost categories. The most important category of external cost in general for the transport sector is congestion (especially for road transport in urban areas), although various elements of environmental cost can be important particularly in urban areas. Both congestion and environmental costs vary greatly from context to context, so great caution needs to be exercised in transferring results from one context to another. External accident costs appear to be less important than was previously believed, mainly because earlier studies had failed to identify correctly the external element of these costs.

A general warning should be given that many earlier studies of all cost categories used methodologies that would now be considered inappropriate and their results should be used with great care. The main priorities for further research are the treatment of congestion and scarcity in rail and air transport, and the development of better methods for transferring results from one context to another.

The accounts have been shown to yield useful information particularly for monitoring and for the estimation of many categories of marginal cost. They provide crucial evidence on the relative importance of different categories of cost and whether these are reducing or increasing over time. Ideally they would be more disaggregate, giving data for instance for individual cities or types of area rather than purely national data, and extended to give some indicators of changes in user benefits over time, and how this is distributed across the population. Given the amount of work involved in them we do not see it as worthwhile to collect this information every year, since year to year changes are typically small; every 3-5 years would suffice for monitoring purposes.

The key lesson emerging from the work on integration is that both marginal cost estimates and accounts information are needed for a practical approach to pricing policy formulation (and indeed accounts may often provide the basic data for estimating marginal cost). But we should avoid the crude use of accounts information. For instance, consideration of how much revenue to raise within the transport sector needs examination of sources and uses of revenue elsewhere in the economy; the approach of allowing for this by means of a simple shadow price of public funds in the accounts does not allow for the different possibilities in terms of sources and uses of revenue. Even in the presence of budget constraints we should not resort to simple measures such as the use of accounts to implement average cost pricing. Moreover, where budget constraints are needed, they should be implemented flexibly, with provision for cross subsidisation between modes, if they are to do least damage to economic efficiency. The simple imposition of 100% cost recovery rules on all modes is likely to worsen, rather than improve, economic efficiency compared with the status quo.

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7. References

Link, H, et .al,. 2002: UNITE Future approach to accounts UNITE D14, Institute for Transport Studies, University of Leeds

Maibach M et al, 2003: UNITE Policy Perspectives. UNITE D16, Institute for Transport Studies, University of Leeds

Mayeres, I et .al, 2001: UNITE Iintegration approach UNITE D4, Institute for Transport Studies, University of Leeds

Sansom, T, et al, 2001: Surface Transport Costs and Charges, Institute for Transport Studies, University of Leeds

TERM 2001: Are we moving in the right direction? Indicators and environment integration in the EU, European Environmental Agency, Copenhagen 2001

8. List of Deliverables

The following Table (22) shows the UNITE deliverables together with the months due, months first submitted and months finally accepted. The discrepancies between these dates are explained in section 7.

Table 22 List of Deliverables

	Title	Main Contents
D1	The Overall UNITE methodology	outline of overall approach to project, policy issues, technical issues and stakeholder perspectives
D2	Pilot Accounts Approach	structure for the pilot accounts; methodology for cost/benefit/revenue estimation and allocation
D3	Marginal Cost Methodology	core methodologies to be adopted in case studies; outline description of case studies
D4	Alternative Integration Frameworks	theoretical perspectives on alternative approaches to combining accounts/MC information
D5	Pilot Accounts (2 countries)	pilot accounts – De. Ch
D6	Supplier Operating Cost Case Studies	methodology; empirical results
D7	Transport User Cost and Benefit Case Studies	methodology; empirical results
D8	Pilot Accounts (8 countries)	pilot accounts – Au, Dk, Es, Fr, Ie, Nl, Se, UK
D9	Accident Cost Case Studies	methodology; empirical results
D10	Infrastructure Cost Case Studies	methodology; empirical results
D11	Environmental Cost Case Studies	methodology; empirical results
D12	Pilot Accounts (8 countries)	pilot accounts – Be, Ee, Fi, Gr, Hu, It, Lu, Pt
D13	Resultings from Testing Alternative Integration Frameworks	modelling approach; empirical results highlighting pro’s and con’s of alternatives

D14	Future Approaches to Accounts	alternative approaches used in pilot accounts; future approaches
D15	Guidance on Adapting Marginal Cost Estimates	detailed guidance on transferring MC results between contexts
D16	Policy Perspectives on the UNITE research	re-examination of theoretical approaches to integration, accounts and marginal costs; policy conclusions from the research
FR	Final Report for Publication	summary report for the full project

The above reports may be found on the project website, which is http://www.its.leeds.ac.uk/research/index.html