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UNIfication of accounts and

marginal costs for Transport Efficiency

Deliverable 4:

Alternative Frameworks for the Integration of Marginal Costs and Transport Accounts

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Executive Summary

1. Marginal cost information and transport accounts are both relatively new but important tools for policy making in the transport domain. The definition of these tools differs across EU countries and these tools are sometimes presented as alternative paradigms for transport pricing policies. The role of this deliverable is to analyse – from a conceptual point of view – the use of these tools for policy making.

2. We address the following questions:
- How useful is marginal cost information when capacity is not optimal, when there are important distortions in the rest of the economy, when the regulator has no precise idea of the marginal costs and when distribution of income matters?
- Do member states actually use social marginal cost pricing as their transport pricing doctrine?
- Which type of transport accounts is useful to monitor the economic efficiency effects and the distributional effects of transport policy?
- How can national accounting experience contribute to better transport accounts?

Basic transport pricing and investment principles (Chapter 3)

3. The basic economic principles are well known in the case of an omniscient policy maker. Short run marginal social cost (SRMSC) pricing is the benchmark for an efficient transport pricing policy. This principle holds when there are no other price distortions in the economy and no income distribution concerns. The SRMSC contains the marginal resource costs, marginal infrastructure costs, scarcity or external congestion costs and external environmental and accident costs. The SRMSC principle ensures that the existing infrastructure is used as efficiently as possible. Whether the infrastructure is at an efficient level or not and whether it is optimally maintained or not has an impact on the level of the SRMSC but not on the SRMSC pricing principle.

4. To determine an efficient investment level requires a cost-benefit analysis that trades off the benefits of infrastructure extension (discounted sum of saved user costs, including time, saved external accident and environmental costs, reduced maintenance costs) and the costs of an infrastructure extension (investment costs). This rule only holds if there is SRMSC pricing and if there are no other distortions in the economy.

5. The pricing and investment rules get more complicated in the presence of budget constraints or when there are restrictions on the available policy instruments (e.g., when prices cannot be tailored to each transport market separately). In those cases SRMSC pricing is no longer optimal. However, the resulting “constrained” pricing rules are based on carefully balanced deviations from the SRMSC. This implies that SRMSC information remains crucial. This also implies that average cost pricing is an inefficient way of achieving balanced budgets.

6. Which budget constraints make sense for the transport sector? Budget constraints are motivated by two concerns. First, they are meaningful ways to limit the use of general tax revenues by the transport sector. Collecting tax revenue in other sectors is costly because these taxes create economic distortions. The two types of inefficiencies (pricing above SRMSC in the transport sector versus creating a wedge between marginal social costs and prices in other sectors) need to be balanced. This can be done using a shadow cost of public funds that should ideally be computed at the level of the economy, and whose value depends on which tax instrument is used to recycle the net tax revenues

from the transport sector. In the absence of equity concerns, balancing inefficiencies in the transport sector with the rest of the economy also implies that extra tax revenues collected in the transport sector should be used to reduce existing tax inefficiencies in the rest of the economy in the form of lower labour taxes.

7. Budget constraints can also be of interest when the policy maker does not know the costs of the firm. Transport infrastructure firms often have a monopoly position because of increasing returns to scale and they have an information advantage on their absolute cost levels. Moreover, transport infrastructure firms are almost always multi-product firms and determining the marginal costs in a multi-product firm with joint costs is difficult. In that case, governments have to design contracts for the transport firm that contain sufficient incentives for cost minimisation and for efficient pricing and investment. In order to induce the firm to minimise costs a price cap plus a fixed subsidy may be preferable to a cost of service approach where prices always cover realised costs. It may also be more efficient to leave the pricing decisions for the different products with the firm and put a cap only on the average price index. SRMSC information will again be crucial for the pricing decisions of the transport firm and for the regulator.

8. Including income distribution concerns in transport pricing policies is a tough problem. Income distribution concerns can be best met by considering a wider set of instruments than transport prices and subsidies. There are two important criteria for the appropriateness of subsidies or lower taxes on a given good. First, there is the relative consumption of that good by low-income classes together with a low price elasticity. The latter is important in order to limit the resource allocation losses of distorted prices. Second, there is the way this subsidy or lower tax is financed: who pays the higher taxes on other goods will depend again on who consumes these other goods and the price elasticity of these other goods matters to keep efficiency losses down. This requires analysing the effects in the rest of the economy. Therefore a general equilibrium assessment would be ideal.

How do current pricing doctrines relate to the economic theory?(Chapter 4)

9. Confronting these theoretical insights with current pricing doctrines in a selection of European countries, we find that practice differs strongly from the theoretical principles. Most often one refers to principles more akin to long run marginal cost, such as “development cost”, “average cost” or “full cost” allocation. This is mainly motivated by concerns about the difficulty and manipulability of SRMSC calculations and by equity concerns. These concerns are understandable. However, they can be addressed by standard economic theory. No recourse is needed to other pricing principles that are more arbitrary and less efficient.
Peak load pricing has become current practice in all utility sectors that have been deregulated and that are forced to use their infrastructure more efficiently, for example in the case of electricity production, telecommunications, movie theatres, etc.

Transport accounts as a tool for monitoring the efficiency and equity effects of transport policies (Chapter 5)

10. In order to measure the economic efficiency effects of transport policies, business-type accounts are insufficient. Adding external environmental and accident costs and taking into account different types of tax revenues, as is done in social accounts and the UNITE pilot accounts, does not solve the problem completely. This implies that

balancing the social account for a transport mode or the transport sector as a whole is in general not an objective one should aim at. What is needed for a correct welfare analysis is an account that reports the different elements of a social cost-benefit analysis. This means that the gross generalised consumer surplus (total willingness to pay for trips) and the total time and other user costs have to be included in order to have a correct welfare account. Moreover, the government revenue and the producer surplus need to be weighted by the marginal cost of public funds.

11. There are two major differences between transport accounts information and marginal cost information that need to be kept in mind. Transport accounts include mostly ex-post information on realised costs and are rather aggregated (total cost of a firm/sector). Marginal cost information is forward looking (what costs can one avoid?) and much more detailed (per product). For transport accounts to be useful as policy tool, one has to be able to simulate changes in future transport accounts in function of policy. Ideally, transport accounts can then generate marginal cost information.

12. Business-type accounts or social accounts also do not allow measurement of the distributional effects of transport policies. A transport account by mode that is balanced is not really relevant for income distribution for two reasons. First, every mode is used by different income groups. Second, a transport account does not report all impacts on welfare: elements such as time losses and other user costs are missing, as well as the willingness to pay for trips. What is needed is to extend the social account to a welfare account and to segment the account information by income group, including who pays or receives the subsidies or taxes of the transport sector.

13. Firms use aggregated accounts to inform their shareholders and the tax authorities about their performance. The detailed cost accounting is used by the firm and its divisions to improve pricing and investment decisions. One could envisage a similar division of roles for aggregate and detailed transport accounts. The (corrected) aggregate transport account can then be used to judge the overall transport policy while the detailed information can be used for the pricing and investment decisions by different regions and modes. The aggregation of profits of different production units is obviously a much easier task than the aggregation of welfare effects of different modes and regions.

Can national accounting experience contribute to the construction of transport accounts?(Chapter 6)

14. There is a well-established experience with National Accounting. This information is intensively used for macro-economic policy making and in some countries it has been extended to cover environmental components. Are national accounts a useful basis for transport policy making and are they a good basis for more detailed transport accounts? There are three messages for the transport accounts.

- Transport accounts need to be consistent with the National Accounts, which are an accounting framework for the overall economy
- The transport activities are not very well represented in most national accounts. The value added of the transport sector in the national accounts does not take into consideration the transport services organised by non-transport sectors and by the households themselves. For this reason the present national accounts are not a useful basis for transport policy and need to be extended by means of Transport Satellite Accounts before they can be of use.

- Such a system of satellite accounts allows constructing a Social Accounting Matrix (SAM) which is supportive of the use of welfare accounts. This SAM is also the necessary information for a general equilibrium model. As we know, this is the ideal instrument to assess the efficiency and equity effects of transport policies.
- Finally, ongoing research on green accounting can contribute to the incorporation of environmental and accident costs in the social and welfare accounts.

What are the information needs for a good transport policy?

15. To summarise, our analysis shows that good transport policy-making requires an extensive set of information:

- detailed, link-based marginal cost information that can serve as the basis for profit maximising or regulated transport firms to compute optimal transport pricing;
- transport accounts, as an input to more aggregated welfare accounts and as a monitoring tool;
- a breakdown of information according to income group (relative consumption of goods, monetary valuation of externalities, labour supply, etc.) to assess distributional effects of policies.

The three categories of information are crucial if one wants to make a good evaluation of transport policies. They form a crucial input in partial equilibrium models that are an important tool for analysing detailed transport policy reforms. The scope is broader in the case of general equilibrium models. These combine the marginal cost and accounts information with Social Accounting Matrices and are suited more for a strategic analysis of policy reforms, explicitly taking into account the links between the transport sectors and the rest of the economy. They can deal with issues of income distribution because they integrate the way in which deficits or surpluses in the transport sector are financed or used.

Issues not covered

Topics that were not discussed and that warrant further research include the implementation of transport pricing (e.g., the choice of instruments, technical implementation) and the impact of transport policies on land use. The deliverable also provides no information about the magnitude of welfare differences between various pricing regimes. This will be explored in the further stages of the UNITE project, where partial and general equilibrium models will be used to assess the welfare impacts of alternative charging principles.

1 Introduction

1.1 Study Context and Purpose of the Deliverable

In this deliverable we analyse how marginal cost and transport accounts information can be used for transport policy. The analysis is conceptual. There is a need for clear concepts and principles because many countries use different types of transport accounts and have different ideas about the role of marginal costs in pricing. The emphasis in this deliverable is not on the construction of transport accounts but on the potential use or misuse for policy. The construction of accounts is explained in Link et al. (2000)[1].

1.2 The Structure of the Deliverable

The deliverable contains five major parts.

Chapter 2 motivates the need for an integration framework for social marginal cost pricing and transport accounts. It introduces the various policy questions that are discussed in more detail in the next chapters. This chapter is non-technical.

The more technical Chapter 3 starts by explaining basic transport pricing and investment principles. The principles are important to guide the use of the marginal cost information that is collected in the UNITE consortium. The theory is well known in the case of perfect information for the government, but is more difficult when there are multiple outputs, budget constraints or imperfect information. Things also become more complex when decisions are not taken by a planner but by institutions (Ministers, Parliament, administration, firms, etc.) and the decision power is distributed over these different institutions. The transport sector is most often also analysed in isolation and we show why a more global view on the economy can generate useful insights.

Chapter 4 confronts these theoretical insights with current pricing and cost-recovery doctrines in different member states and finds that practice differs strongly from the principles we advance in Chapter 3. We first analyse the main concerns behind these doctrines and then show that a correct use of economic theory gives proper answers to these concerns.

In Chapter 5 we analyse how transport accounts can help to monitor the efficiency and distributional effects of transport policy. Does an increasing surplus on a transport account tell us that our transport policy is successful? What type of transport accounts does one need for this? How should one evaluate the distributional effects of transport policies? The recommendations are based on theoretical insights presented in Chapter 3.

Chapter 6 deals with the possibilities to use national accounting techniques to improve the present transport accounts.

Finally, Chapter 7 summarises the results and concludes.

[1] Link, H., L. Stewart, M. Maibach, T. Sansom and J. Nellthorp (2000) The Accounts Approach. UNITE (UNIfication of accounts and marginal costs for Transport Efficiency) Deliverable 2. Funded by 5th Framework RTD Programme. ITS, University of Leeds, Leeds, October 2000.

2 Integration framework for social marginal cost pricing and transport accounts

2.1 Transport accounts and pricing

Transport accounts and marginal cost pricing are both important tools of transport policy. In order to illustrate the different interactions we use a very simple example. Imagine a railway infrastructure company or a road authority that manages only one important link. In Table 1 we represent the annual account of costs and revenues for this company. We assume that there are no environmental or accident costs. This account gives us factual information about the different types of costs of infrastructure. On pricing it only tells us whether, this year, total costs are covered by user charges or not. Assume that important subsidies exist.

Table 1: Transport account of an infrastructure company

COSTS	REVENUES
Capital costs (depreciation and interest)	User Charges
Maintenance costs	Subsidies
Operation costs	
TOTAL COSTS	TOTAL REVENUES

2.1.1 <u>Pricing at average cost versus pricing at marginal cost</u>

A naive use of this table is to try to achieve a break-even situation between charges and costs by charging average costs to all users of the infrastructure. To assess the effects of this pricing strategy we use Figure 1. In this figure we have plotted the demand function for the transport services as well as the marginal cost MC (taken here as a constant and consisting of mainly avoidable maintenance costs), the average cost function AC(X) and finally the current price P. The average cost is a function of the quantity produced X because with the important fixed costs we assume here, the mark-up over variable costs that is needed to cover the fixed costs declines with output. With current charge level P, the number of (standard)vehicles or trains equals X1. The subsidy needed in Table 1 is equal to (AC(X1) – P) X1.

Charging average cost AC* results in a new level of users X2 because some users will forego the service when the price is increased. Table 1 is no longer correct now. We have less output and less avoidable maintenance costs on the cost side. On the revenue side we have higher user charges and a subsidy is no longer needed. The subsidy has disappeared but is this better in terms of economic efficiency? Probably not. To see why, let us count the economic costs and benefits for society as a whole when a switch is made from output level X1 to X2. The real costs that are saved are equal to area C, the avoided maintenance costs. The cost of moving to level X2 are the lost benefits of the disappeared trains or vehicles. These can be measured by the area under the demand function between X2 and X1. This area equals areas C+D+A. Comparing costs and benefits we see that society as a whole has lost benefits equal to D+A. This is a pure loss to society that corresponds to the difference between the willingness to pay for the service and the avoidable costs. In the absence of distortionary taxes in the rest of the economy it is the cost to society of removing the subsidy. Economic benefits are maximised when the price equals the avoidable or marginal cost of the last user. This would lead to higher output level X3. Compared to the initial price P and output level

X1, there is a net gain for society equal to area B. There is a net gain because the willingness to pay (or "value") of the users is higher than the extra costs.

In this example, the maximum economic benefits can only be reached by running a deficit even larger than the one that initially existed. This raises two issues:

- The first issue is that subsidies need to be financed out of taxes and that raising tax money also creates economic losses. This point is correct and can be integrated into the analysis by adding an extra cost to public money. This is an important issue discussed in Section 3.4.1.
- The second issue is that a firm for which deficits are automatically covered by subsidies is likely to become very sloppy in minimising costs and that we end up creating economic inefficiencies on the production side. This point is important but has more to do with the way in which subsidies are allocated. If the subsidy is allocated in the form of an amount that is fixed a priori and if the selling price is fixed too, the firm will continue to minimize costs because lower costs mean higher profits. This institutional issue is developed further in Section 3.6.

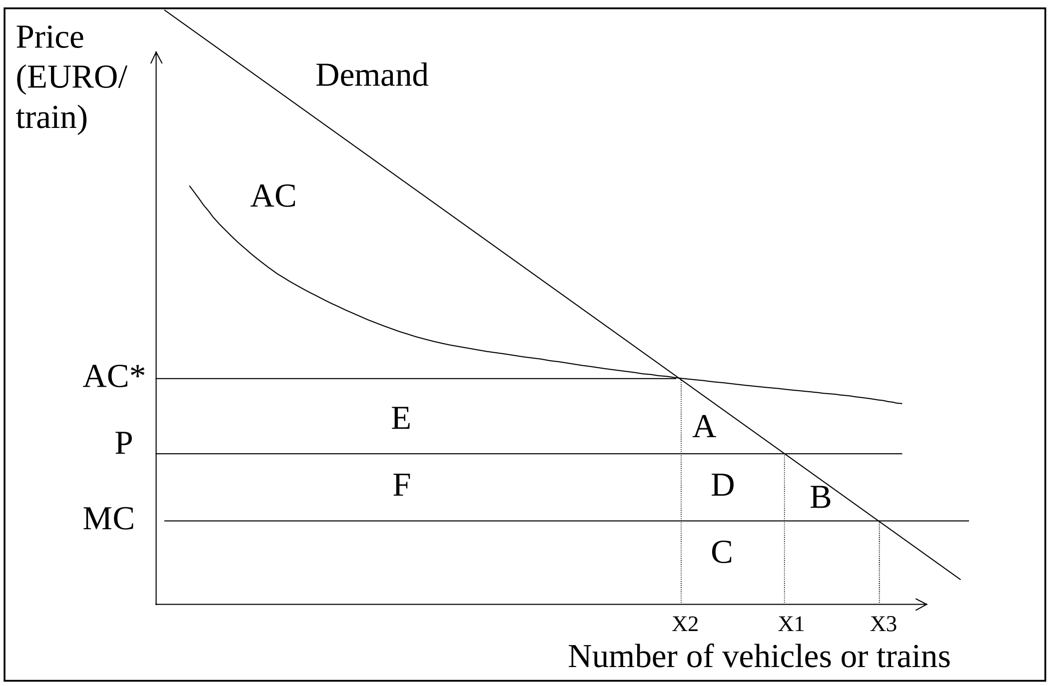

Figure 1: Average and marginal cost pricing

2.1.2 <u>Pricing in a multi-product firm</u>

The first example assumed that the infrastructure supplier produced only one type of service. All that is to be decided in terms of pricing is one price level per train or per vehicle. Most infrastructure suppliers produce many different services: passenger and freight trains, services in peak or in off-peak periods, in remote areas with low capacity utilisation and in areas where capacity is scarce. In general this does not show up in the aggregate account of the infrastructure supplier. However, it is important for pricing for two reasons.

First, different services can have different marginal costs. This is illustrated in Figure 2. Consider a heavily loaded freight train and a passenger train. To make it simple assume that the freight train causes twice as much maintenance costs as the passenger train and that the demand function for both services is identical. Assume that initially we use the same charge for both types of trains equal to the average marginal cost MC. This gives us a level of use for each type of train equal to X1. Even in this situation we can improve economic efficiency by charging freight trains their real marginal cost $MC_{Freight}$ and doing the same for passenger trains: charge them MC_{Pass}. The economic gain of doing this will consist for freight trains of the triangle A. This is the net cost saving of having fewer freight trains (saving $MC_{Freight}$ but loosing user benefits). For passenger trains, there is an expansion of output. The net benefit equals area B that corresponds to the benefit to the new users minus the marginal cost of more passenger trains.

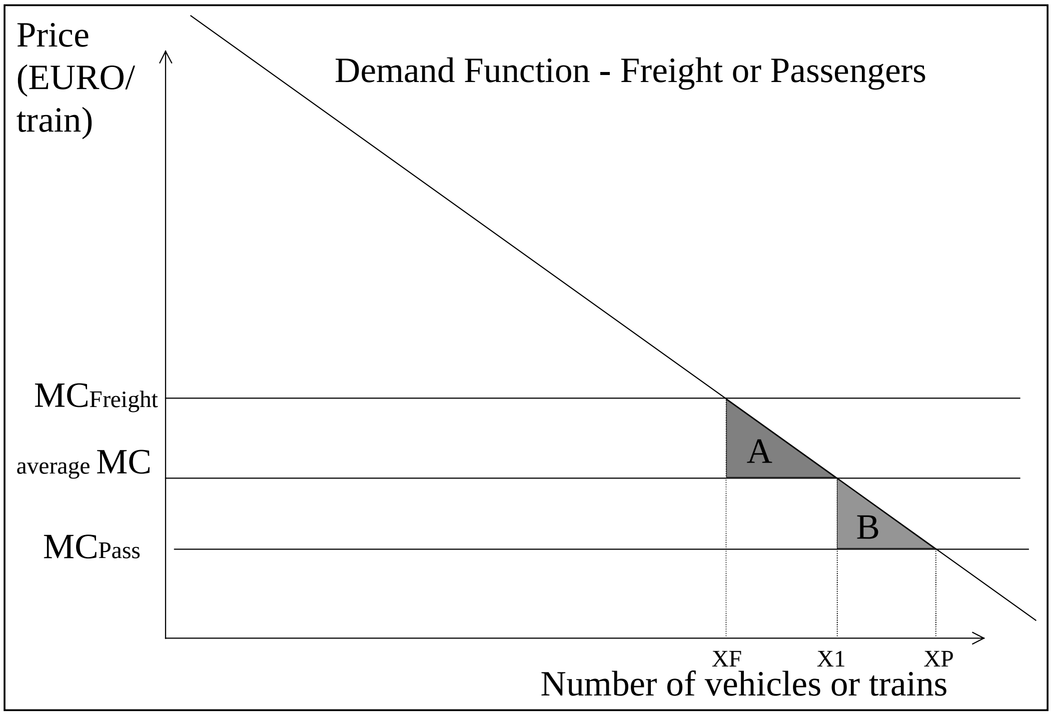

Figure 2: Losses from insufficient differentiation in pricing

The second reason is that, even if marginal costs of two types of customers are identical, pricing both groups differently can be beneficial when total subsidies are restricted. Figure 3 shows an example where infrastructure is used by freight and passenger trains but where the demand for freight trains is much more price-elastic than the demand for passenger trains. We start initially from ideal marginal cost pricing and the volume of freight and passenger trains equals X1 for both of them. Assume that fixed costs have to be covered because subsidies are restricted. One way of doing this is to charge the same price to all users that is equal to the average cost. In Figure 3 this is the price level “one price” and the quantities XF and XP. This solution generates important economic losses: the volume of freight transport diminishes sharply because they switch to other modes. A better solution exists: to charge a higher mark-up for the inelastic passenger demand. By way of illustration we show a solution where the same total net revenues are generated by charging a higher price for passenger transport only and by leaving the charge for freight trains at the MC. There will be a large benefit in efficiency for the freight transport market in comparison with average cost pricing (the large shaded area on Figure 3) and a small additional loss in efficiency for the passenger trains market (the small shaded area). Other solutions to the revenue constraint exist: one could use two-part tariffs, declining block tariffs etc. The problem of optimal pricing under constraints is discussed in Section 3.2.

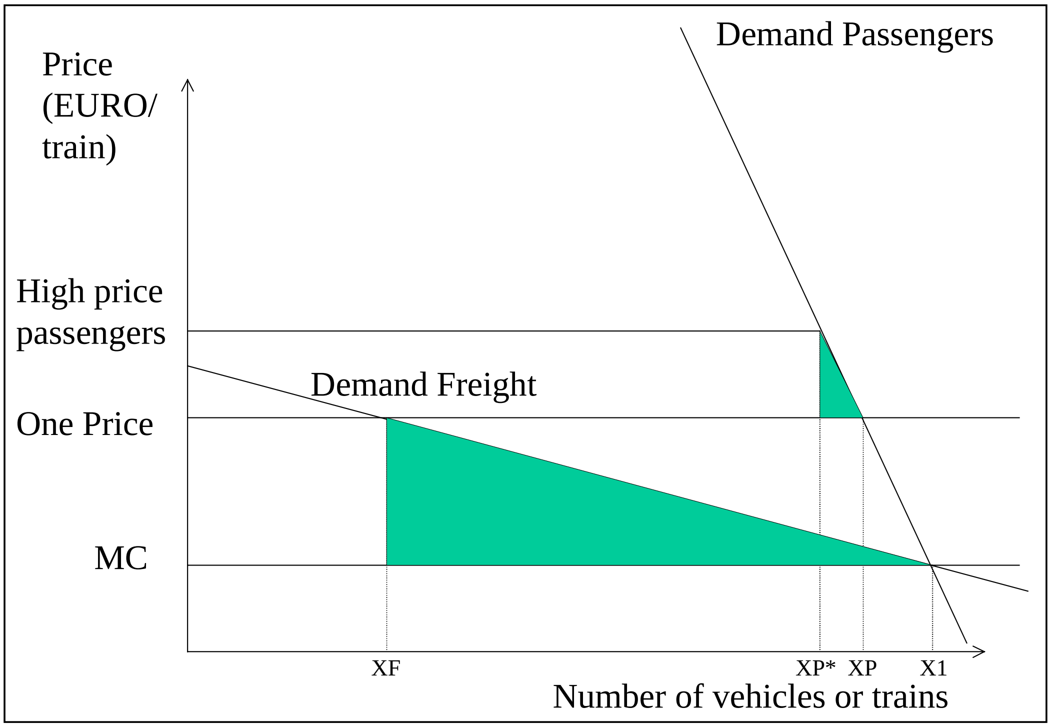

Figure 3: Efficient price discrimination in the presence of a revenue constraint

The pricing solutions discussed here may look fancy and difficult to implement. They might not be yet very common in the transport world, but they are normal business practice if one looks at examples like theater tickets, fastfood meals or telephone charges. What is important to understand is that although optimal prices are mostly different from the marginal costs, the marginal cost information is crucial to compute the optimal deviaton from marginal cost pricing. It is interesting to know whether marginal cost pricing (or optimal deviations of marginal cost pricing) is generally accepted in the transport sector. In Chapter 4 it is shown that in most EU countries, marginal costs are not the benchmark for transport pricing.

An important difference with the practices in non transport sectors is that there can be important interactions with substitute transport modes. When prices on these modes cannot be set correctly there are reasons to deviate from optimal prices for each mode. This problem is discussed in more detail in Section 3.3.

2.1.3 Transport accounts as a monitoring tool for price regulators

In general, transport organisations have better information to design good pricing policies than the transport authorities themselves. The pricing behaviour of transport infrastructure providers is usually monitored by a transport authority to avoid excessive rates, to take into account cross effects on other transport markets and to meet revenue raising (or maximum subsidy) targets.

What is needed are transport accounts that monitor the financial performance (development of variable and fixed costs, cost recovery, financial result)of the transport firm in a transparent way. Another type of transport pricing constraint can result from European Union regulations that limit the use of certain tolls to the level of infrastructure costs. This constraint is one of the ways of limiting the misuse of tolls by one region to export taxes to another region.

Both problems are briefly discussed in Section 3.6.

2.1.4 <u>Observations</u>

We have shown that the cost side of a transport account for one mode is an aggregate of the costs of supplying different services. The revenue side of the account combines with cost data to yield the net financial result but this is not a satisfactory indicator of economic efficiency. Whether a deficit or a subsidy is a more efficient result depends on many factors:

- the difference between the average and the marginal cost,
- the cost of government funds,
- the incentives for cost minimisation,
- pricing on related markets.

These elements can be taken into account by extending the social transport accounts to aggregate welfare accounts for the transport modes.

Moreover, a given surplus can be the result of very different combinations of pricing on the different markets served by that mode. Some of these combinations can be very inefficient. This does not show up in the revenue side of an aggregated transport account. For this reason, an aggregate transport account as such cannot be a basis for good transport pricing. In a private firm things are no different: an intelligent firm will base its pricing decisions on detailed cost accounting information and consult its marketing department to understand what will be the effect of changes in pricing. A policy maker will need the same type of details to judge the efficiency of the pricing decisions taken by a transport infrastructure provider. The aggregate transport and welfare accounts on their own do not provide sufficient information to evaluate transport policies. They need to be supplemented by disaggregate information.

Transport firms need clear incentives to minimize costs. Break-even constraints and subsidies that are fixed a priori, as well as price regulations, are among the policy instruments to achieve that goal. Aggregate transport accounts have an important function to play here.

Firms use aggregated accounts to inform their shareholders and the tax authorities about their performance. The detailed cost accounting is used by the firm and its divisions to improve pricing and investment decisions. One could envisage a similar division of roles for aggregate and detailed transport accounts. The (corrected) aggregate transport account can then be used to judge the overall transport policy while the detailed information can be used for the pricing and investment decisions by different regions and modes. The aggregation of profits of different production units is obviously a much easier task than the aggregation of welfare effects of different modes and regions.

2.2 Transport accounts as a basis for a forward looking policy modelling tool

National accounts are the basis for macro-economic modelling. Macro-economic models are used to optimise national or European economic policies to reach goals such as full employment, high growth levels and low inflation. National accounts report the results of macro-economic policies in the past and provide inputs for the models. The question that arises is whether transport accounts can fulfill a similar role.

Business-type transport accounts do not allow measurement of the welfare effect of a given transport pricing policy or investment policy. Simply adding external environmental and accident costs and taking into account different types of tax revenues does not solve the problem. What is needed is an account that reports the main economic objectives of a transport policy. This means that the generalised consumer surplus has to be taken into consideration and that changes in travel time costs need to be reported in order to have a correct welfare account (see Table 2).

Table 2: Welfare transport accounts and the goal of transport policy

WELFARE COSTS	WELFARE REVENUES
Capital costs (depreciation and interest)	User Charges
Maintenance costs	Subsidies
Operation costs	User benefits
Environmental and Accident costs	
Money costs and time costs for user	
NET WELFARE EFFECT[a]	
TOTAL COSTS	TOTAL REVENUES

[a] The net welfare effect ensures that the welfare account is balanced, i.e. that total revenues equal total costs.

How to adapt transport accounts to maximise their use in welfare analysis is discussed in more detail in Chapter 5. In this chapter we also study the possible use of transport information to study the distributional impact of pricing policies. We show that simple transport accounts by mode and income class are useful but need to be augmented to assess the distributional impact of transport policies.

3 What does economic theory say about optimal transport pricing and transport investment?

3.1 Introduction

This chapter summarises the existing theory concerning optimal transport pricing and investment. This theory is needed to know how to use the marginal cost information that is collected in the UNITE project. Sections 3.2 and 3.3 analyse these policies in a partial equilibrium framework. This means that the transport market is studied in isolation from the rest of the economy. Section 3.2 considers one transport market, while Section 3.3 extends the analysis to several interrelated transport markets. Section 3.4 shows that it is possible to incorporate some general equilibrium aspects (taking into consideration the interactions with the rest of the economy) in the partial equilibrium framework. However, this approach suffers from a number of limitations. Therefore, Section 3.5 turns to a full general equilibrium analysis of transport policies. In all of these sections it is assumed that decisions are made by an omniscient planner. This assumption is relaxed in Section 3.6 where the role of institutions and imperfect information is considered.

3.2 Optimal pricing and investment for one transport market

This section discusses optimal pricing and investment rules in a partial equilibrium framework with one transport market. As an example we take the market for road transport by one type of car, with all traffic uniformly distributed within the year and with fixed road capacity.

The simplest formal approach of one transport market consists of distinguishing four types of agents:

- *N* identical transport users,
- the transport producers,
- the government and
- the victims of external effects other than congestion (air pollution, noise, accidents).

We consider a market with a uniform demand for transport over time. The total volume of transport use is denoted by *X*, CAP gives the total capacity of the transport market. The transport users determine their use as a function of the generalised cost[2] *g* that equals the sum of the producer price *p*, the unit time costs *hT* and taxes *t*.

$$g = p + hT + t$$

T represents the time needed per unit of transport service. The time needed per unit of transport service *T*(*X*,*CAP*) is a function of the total transport demand *X* relative to total capacity *CAP*. *h* is the value of travel time.

The transport users have an objective function *CS*(*x*(*g*)) that represents their consumer surplus (this is the overall difference between the willingness-to-pay to be able to use the transport service at quantity *x* and the generalised cost *g* that is paid). Their only decision variable is the quantity *x* of transport services consumed.

[2] Appendix B explains the theoretical background for using the generalised cost concept.

The producers of transport services have to decide on the producer price *p*, on the capacity *CAP* of the transport infrastructure and on the durability *D* of the infrastructure. They are subject to external cost regulation *m* (e.g., concerning air pollution or safety). The total costs of transport service provision consist of maintenance and running costs *C*(*X*,*D*,*CAP*,*m*) and of capital costs for the infrastructure *r*.*K*(*CAP*,*D*). We assume that the infrastructure has an infinite life so that *r* represents the rate of interest.

The suppliers of transport services maximise profits by setting producer prices *p* and choosing capacity *CAP*, as well as the durability level *D*. Their profit, also called producer surplus *PS*, equals:

$$PS = pX - C(X, D, CAP, m) - rK(CAP, D)$$

The government decides on the tax rate *t* and on the external cost regulation *m* that affects total external costs (excluding congestion). The net revenue received by the government from the transport market equals the sum of the indirect tax revenue *TR*=*Xt* and the profit made by the transport production sector. Alternatively, should the private sector run a deficit, this would be financed by the public sector. A unit of government revenue has a social value of $1+\lambda$. $1+\lambda$ is the marginal cost of public funds and represents the marginal welfare cost of raising a unit of tax revenue. This is a reduced form formulation that may be used in a partial equilibrium framework. In a first best economy in which the government can make use of perfect lump sum transfers and taxes, λ equals zero. In a second best economy with distortionary taxes λ is different from zero. As is discussed in Section 3.4.1, the value of λ depends on the way in which the government uses the revenue from the transport sector, or the way in which the transport deficit is financed.

In addition to congestion, transport imposes other external costs of which air pollution, accidents and noise are the most important. The victims of these external costs are passive agents by assumption. They experience a total external cost *ECNC*(*X*,*CAP*,*m*) that is a function of the volume of transport services, the infrastructure capacity and the regulation *m* that is in place.

The welfare indicator we use for the transport market equals:

$$W = N.CS + (1+\lambda)(TR + PS) - ECNC \qquad (1)$$

In an equilibrium for the transport market, the demand for transport services equals the supply. This is reflected in the use of the same notation *X* for total demand and total supply.

As we are concerned about the reform of transport taxes and prices, it is useful to examine briefly the optimal transport prices, taxes, capacity, durability and environmental regulation decisions. By optimal we mean the decisions an omniscient planner would take if he maximises total welfare as given by expression (1). In our analysis we omit any possible corner solutions. A corner solution that is ruled out is not to produce the good at all.

3.2.1 The producer price and the indirect tax

The government can set both producer price *p* and indirect tax *t*. Both instruments are jointly determined since they are equivalent in our model.

The joint optimality condition for the producer price and the indirect tax is given by[3]:

$$p = C_X + \left(\frac{ECNC_X + ECC_X}{1+\lambda} - \frac{\lambda}{1+\lambda}\frac{g}{\varepsilon_{gg}} - t \right. \qquad (2)$$

$C_X = \partial C / \partial X$ is the marginal short run production cost,
$ECNC_X = \partial ECNC / \partial X$ represents the marginal external cost (other than congestion) and $ECC_X = XhT_X$ is the marginal external congestion cost ($T_X = \partial T / \partial X$). ε_{gg} is the own generalised price elasticity of the demand for *x*.

We consider four different cases.

λ = 0, no externalities

First, we consider the case when λ equals zero and there are no external effects. In this situation no tax is called for ($t = 0$) and the optimal producer price equals the "short run" marginal production cost C_X comprising the marginal running and operating cost.

λ > 0, no externalities

In the absence of external costs, but with $\lambda > 0$, the optimality condition becomes:

$$p = C_X + \left(-\frac{\lambda}{1+\lambda}\frac{g}{\varepsilon_{gg}} - t \right.$$

The price paid by the consumers will be larger than the marginal production cost if $\lambda/(1+\lambda)>0$ (since $\varepsilon_{gg}<0$). If the government can set the tax rate at the level

$$t = -\frac{\lambda}{1+\lambda}\frac{g}{\varepsilon_{gg}}$$

then $p = C_X$.

λ = 0, externalities

Next, we introduce different types of external costs, but assume that λ equals zero. If these external costs are covered by the tax on consumers (if $t = ECC_X + ECNC_X$), producer prices equal the marginal production cost. If the tax is lower than the marginal external costs, the producer price exceeds the marginal production costs in order to

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[3] For the derivations, see Appendix C.

correct for the externalities. Conversely, *t* will be smaller than the marginal external costs if the producer price exceeds the marginal production costs.

$\lambda > 0$, externalities

Finally, we consider the most general case when $\lambda > 0$ and in the presence of externalities. When $p = C_X$ the optimal tax is given by

$$t = \frac{ECC_X + ECNC_X}{1+\lambda} - \frac{\lambda}{1+\lambda}\frac{g}{\varepsilon_{gg}} \tag{3}$$

The tax fulfils two functions. The first one is to correct for external costs. This is reflected in the first term of (3), also called the Pigouvian term. Secondly, it raises tax revenue, which gives rise to the second term in (3), the so-called non-Pigouvian or Ramsey term. As there are two objectives and only one instrument, the two objectives are weighted by λ, the marginal cost of public funds – 1. The more valuable public revenue is, the more important the Ramsey term becomes and the less weight is given to the Pigouvian term. With $p>C_X$, the optimal *t* is lower. This could be the case with monopoly pricing. In that case one has an interest not to add the full externality tax.

All of these rules hold whatever the investment and regulation policy is. These other policies may affect the values of the marginal production cost and the value of the marginal external costs but do not affect the optimal tax and producer price rules. However, the results are valid only if there are no price distortions on other markets.

3.2.2 Optimal transport capacity level

The optimal capacity level has to satisfy the following equation[4]:

$$C_{CAP} + rK_{CAP} = -\frac{Xh\frac{dT}{dCAP} + ECNC_{CAP}}{1+\lambda} + N\frac{\partial x}{\partial g}h\frac{dT}{dCAP}\left[t + p - C_X - \frac{ECNC_X}{1+\lambda}\right] \tag{4}$$

with $C_{CAP} = \partial C/\partial CAP$ and $K_{CAP} = \partial K/\partial CAP$. The left-hand side represents the marginal cost of a capacity extension. It equals the sum of the marginal operation costs of the transport service and the marginal cost of leasing the capacity. The right hand side represents the marginal benefits of the capacity expansion. The first term represents the savings in external costs due to higher capacity, including the effect of capacity expansion on transport demand[5]. The last term on the RHS in (4) is a correction term that takes into account the level of pricing and taxation.

If pricing and taxation are optimal (if (2) holds), then the optimality condition for capacity becomes:

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[4] see Appendix C for the derivations.

[5] The full effect of a change in capacity on the unit time requirements equals the direct effect, corrected by the impact of the capacity expansion on transport demand:

$$\frac{dT}{dCAP} = \frac{\partial T}{\partial CAP}\Bigg/\left(1 - N\frac{\partial x}{\partial g}h\frac{\partial T}{\partial X}\right)$$

$$C_{CAP} + rK_{CAP} = -\frac{Xh\frac{\partial T}{\partial CAP} + ECNC_{CAP}}{1+\lambda} - \frac{\lambda}{1+\lambda}\frac{g}{\varepsilon_{gg}} N \frac{\partial x}{\partial g} h \frac{dT}{dCAP}$$

The RHS gives the social marginal benefit of capacity expansion. The first term on the RHS gives the benefit of the externality reduction, for a given level of transport demand, corrected by the marginal cost of public funds. The second term gives the impact of the capacity expansion on the Ramsey tax revenue. If a capacity expansion increases the demand for taxed transport, this increases tax revenue, which is beneficial. In a first best economy ($\lambda = 0$), the last term drops out and the marginal benefit of capacity expansion equals the benefit of the externality reduction (uncorrected for the marginal cost of public funds).

The second term in (4) implies that whenever the consumer price is too high compared to the social optimal price, there is an extra benefit for capacity expansion. This is because an increase in capacity would help to bring the volume of transport to a higher and more optimal level.

3.2.3 <u>Optimal durability of capacity investments</u>

The optimal level of durability (quality of road surface or tracks) is obtained when the extra capital cost of better durability equals the reduction in maintenance costs (with $C_D = \partial C/\partial D$ and $K_D = \partial K/\partial D$).

$$C_D = -rK_D \qquad (5)$$

3.2.4 <u>Optimal environmental regulation</u>

In our simple model, the environmental and safety regulation affects, by assumption, only the direct costs of supplying transport services (cleaner and safer cars, less noisy trains...) as well as the environmental and accident damage itself.

At the optimal level of regulation there is equality between the marginal social cost of cleaner and safer vehicles (corrected by the marginal cost of public funds) and the savings in environmental and accident costs.

$$C_m(1+\lambda) = -ECNC_m \qquad (6)$$

with $C_m = \partial C/\partial m$ and $ECNC_m = \partial ECNC/\partial m$. In our simple model set-up, this rule holds irrespective of the pricing and investment rules that have been followed.

3.2.5 <u>Global optimum requirement</u>

When there is no corner solution, the global optimum is attained when (2) to (6) are satisfied. Note that each of these rules continues to hold, irrespective of whether the other rules are applied. However, one must be aware that the results will be different if not all control variables are at their optimum value. If there are corner solutions, the first order optimality conditions are insufficient and one needs to compare values of the objective function for different policies.

3.2.6 Reform of instruments, starting from non optimal values

Up to now we discussed optimal policies. In transport policy one is often interested in the welfare change that can be obtained by a change of one variable, keeping the other policy variables at an arbitrary level. This can be checked using the first order conditions discussed above, where effects have been grouped in marginal benefit and marginal cost effects of a small change in the policy variables.

3.3 Optimal pricing and investment for two related transport markets

In general there are substitution possibilities between several transport modes. One can choose between travelling in peak or in off-peak, travelling by car or by bus, one can take a motorway rather than a national road to go from A to B etc.
Dealing with several modes makes optimal pricing more difficult and one needs a more sophisticated system of accounts to monitor the welfare effects of a given policy.

If one takes an example with only 2 modes (say car and bus in the peak period), the welfare criterion of the policy maker becomes:

$$W = N\,CS\left(x_1\left(g_1,g_2\right),x_2\left(g_1,g_2\right)\right)+\left(1+\lambda\right)\left(\sum_{j=1,2} TR_j + PS_j \quad - ECNC \right. \qquad (7)$$

with the same notation as before, the symbols now being indexed (j=1,2) for the transport modes. The external air pollution and accident costs are given by:

$$ECNC = ECNC(X_1, X_2, CAP_1, CAP_2, m_1, m_2)$$

The demand for each mode is now also influenced by the price of the substitute mode.

The speed-flow relationship for both modes is a function of the transport volumes on both markets. The marginal congestion cost can differ among the two transport modes, as is reflected by Φ_{jk}.

$$T^j = T^j\left(\sum_{k=1,2} \Phi_{jk} X_k, CAP_j \right)$$

One can derive an optimal producer pricing rule, optimal tax rule, optimal regulation etc. We will limit ourselves to the rule for the optimal producer prices and taxes. For commodity k we get the following rule[6]:

[6] The derivations are given in Appendix D.

$$p_k = C^k_{X_k} + \left(\frac{ECNC_{X_k} + X_k\, h_k\, T^k_{X_k} + X_j\, h_j\, T^j_{X_k}}{1+\lambda} - \frac{\lambda}{1+\lambda} \frac{g_k}{\varepsilon_{kk}} - t_k \right.$$
$$\left. + \frac{\varepsilon_{jk}\ x_j}{\varepsilon_{kk}\ x_k} \left[p_j - C^j_{X_j} + \left(\frac{ECNC_{X_j} + X_k\, h_k\, T^k_{X_j} + X_j\, h_j\, T^j_{X_j}}{1+\lambda} - t_j \right) \right. \right. \qquad j \neq k \tag{8}$$

To give more insight in the mechanisms behind this rule, we consider a number of special cases.

No cross-price effects

If we assume that the demand for each mode does not depend on the price of the other mode (ε_{kj}=0 for $k\neq j$), the last term in (8) drops out. Expression (8) then is similar to (2). The only difference is that the marginal external costs now include the effect of the total use of mode *k* on the speed of mode *j*.

Cross-price effects, no externalities, $\lambda > 0$

The second case is when the demands for the two transport modes are interrelated, λ is positive, but there are no externalities. With $p_i = C^i_{X_i}$ we then obtain the Ramsey tax rule[7]:

$$\sum_{j=12} t_j S_{kj} = -\theta x_k \qquad k = 1,2 \tag{9}$$

S_{kj} gives the compensated change in demand for commodity *k* with respect to the generalised price of commodity *j*.

Cross-price effects, externalities, $\lambda = 0$

In the presence of externalities, but with λ equal to zero, the tax on each good should equal the marginal external costs if $p_j = C^j_{X_j}$

$$t_j = ECNC_{X_j} + \sum_{k=1,2} X_k h_k \frac{\partial T_k}{\partial X_j} \qquad j = 1,2$$

However, pricing at social marginal cost in one market is only optimal if one has marginal social cost pricing on the other market. If this is not the case, the marginal social cost pricing rule has to be corrected for the induced inefficiency effects (positive or negative) on the second market. If both transport modes are substitutes, one needs to have on both markets, optimal taxes either above or below marginal external costs.

[7] The derivations are described in Appendix D.

The general intuition for judging price reform in one transport market is that the benefits of any price increase, measured on that market, are biased upwards if the price on the substitute market is too low.

3.4 Incorporating general equilibrium aspects in a partial equilibrium framework: the marginal cost of public funds and the distributional impact of price changes

The assumption than the marginal cost of public funds equals unity and its implication that welfare changes can be assessed by examining *CS*+(*TR*+*PS*)+*ECNC* is only valid under very specific conditions. Whenever these conditions do not hold, economic theory tells us we need a more elaborated analysis.

There are three important conditions (see Mass-Colell et al., 1995)[8]:

- *individual preferences are quasi-linear*:
  This implies that income effects (associated to price or tax changes) do not affect the demand for transport. This assumption guarantees that the way the producer surplus or tax revenues on the transport market are redistributed over the population does not affect the equilibrium on the transport market.

- *the prices of the other goods are undistorted*:
  their price equals the marginal production cost; this assumption is needed because any change in the transport market will affect the quantities of other goods (via price and income effects). The social value of these changes can only be approximated via the sum of *CS*+(*TR*+*PS*)+*ECNC* if the precise allocation of this change in real income over different goods is not important. This will only be the case if there are no important taxes or no important external effects for the non-transport goods.

- *The government can make use of perfect (lump-sum) instruments to redistribute income*
  In combination with the first hypothesis this assumption guarantees that the policy maker does not have to worry about the distributional incidence of a change in the transport market because he can always change it at no cost because lump sum taxes and subsidies do not affect economic efficiency.

It is clear that these assumptions never hold: there exist taxes and other distortions in the economy and the policy maker has only imperfect instruments to distribute income. There are two ways out: either adapt and qualify the partial equilibrium analysis or switch to a general equilibrium analysis.

The major distortion in the rest of the economy to be taken into account is the taxation of labour. The combined tax rate on labour[9] is in Europe 60% or more and labour

[8] Mas-Colell, A., M.D. Whinston and J.R. Green (1995) *Microeconomic Theory*. Oxford University Press, New York.

[9] The combined tax rate on labour includes the social security contributions, the marginal income tax rate and the average indirect tax rate on consumption. All these elements contribute to the wedge on the labour market.

supply varies as a function of the wage rate[10]. The major reason why we have this distortion is the income distribution goal.

The presence of distortionary taxes can be incorporated in the partial equilibrium framework by weighing the sum of the tax revenue and the producer surplus by the marginal cost of public funds, as we have done in (1) and (7). This is possible if the way in which the net tax revenues are used by the policy maker is fixed. Section 3.4.1 discusses the determinants of the marginal cost of public funds. Section 3.4.2 discusses how to take into account distributional considerations in the partial equilibrium framework.

3.4.1 <u>What is the value of extra tax revenue?</u>

In the welfare functions (1) and (7) the tax revenue and the transport deficits/surplus are valued at the marginal cost of public funds. This is a reduced form formulation that may be used in a partial equilibrium framework. It allows incorporating the broader economic effects of a change in transport taxes.

This section deals with the value of the marginal cost of public funds parameter.

In a first best economy, when the government can make use of perfect lump sum instruments, the marginal cost of public funds equals unity. In a second-best economy it will generally be different from one, except in very specific cases.

In our discussion we assume first that the net increase in transport tax revenue is used to reduce the most important distortionary tax: the labour income tax. At the end of this section we will consider other recycling strategies. The discussion here refers to the efficiency case only. Sections 3.4.2. and 3.5.2. consider the case where equity considerations come into play. A possible implication of this could be that reducing the labour income tax is no longer a socially desirable recycling strategy.

With a fixed labour supply the marginal cost of public funds on labour equals unity when the labour income tax is used as the recycling instrument. Indeed, in this case there is no extra inefficiency created by raising revenue from labour taxes. This is the simplest case.

In reality, labour supply is affected by the net wage rate and the labour income tax creates distortions. The value of the marginal cost of public funds then depends on the relative importance of the benefits of a lower labour income tax in comparison with the costs of a higher transport tax (see Bovenberg and De Mooij, 1998; Goulder et al., 1999;

[10] The aggregate labour supply elasticity is small. The large general equilibrium models in the Shoven-Whalley tradition generally have a central estimate of 0.15 for the uncompensated wage elasticity (see, e.g., Ballard et al. (1985)). The same value is used in the TRENEN models (De Borger and Proost (2001)).

Parry and Bento, 1999)[11]. Both factors are discussed in more detail in the following paragraphs.

(i) Benefits of a lower labour income tax

(i.a) Tax recycling effect

Returning the transport tax revenue by means of a lower labour income tax has a direct benefit on the labour market. The labour income tax is a distortionary tax: raising one EURO of revenue by means of this tax has a social welfare cost higher than 1 EURO. This additional cost can be avoided if the labour income tax is reduced. This effect, which the literature refers to as the tax recycling effect, is not represented in a pure partial equilibrium framework.

(i.b) Tax shifting effect

When not all individuals supply labour, but all individuals consume transport goods, an increase in the transport tax recycled via a decrease in labour taxes means shifting taxes from labour income to non-labour income. If ψ is the share of individuals not supplying labour then the labour taxes can be reduced by ψ additional EURO per EURO of revenue generated by the transport taxes, which adds to the first beneficial effect. This effect is not taken into account in the pure partial equilibrium framework.

(ii) Costs of a higher transport tax

(ii.a) Direct costs

With elastic transport demand a higher transport tax causes direct distortions on the transport market. These effects are taken into account in the partial equilibrium framework. Therefore they do not need to be included in the determination of the marginal cost of public funds.
However, a higher transport tax also has indirect effects that are not incorporated in the pure partial equilibrium analysis. These include:

(ii.b) Tax interaction effect

Higher transport taxes reduce the purchasing power of the net wage, which reduces the labour supply and hence labour income tax revenue. This is an indirect cost of the transport tax.
Ongoing research work for the MC-ICAM project shows that welfare increases when the externality taxes can be differentiated by trip motive. The reason is that a lower tax

[11] Bovenberg, A.L. and R.A. De Mooij, R.A. (1998) "Environmental Taxes, International Capital Mobility and Inefficient Tax Systems: Tax Burden vs. Tax Shifting", *International Tax and Public Finance*, vol. 5, no. 1, 7-39.
Goulder, L.H., I. Parry, R. Williams III and D. Burtraw (1999) "The Cost-Effectiveness of Alternative Instruments for Environmental Protection in a Second-Best Setting", Journal of Public Economics, vol. 72, no. 3, 329-360.
Parry, I.W.H. and A.M. Bento (1999) *Revenue Recycling and the Welfare Effects of Road Pricing*, RFF Discussion paper no. 99-45. Resources for the Future, Washington, D.C.

on commuting transport reduces the tax interaction effect: one mitigates the labour disincentive effect of commuting taxes.

(ii.c) Complementarity effect

When transport is complementary to work trips (leisure), making transport more expensive has a negative (positive) effect on labour supply and the income of the labour income tax. This is an indirect cost (benefit) of the transport tax. One should be aware that the majority of trips are not work related so that the net complementarity effect (aggregated over all trips) is indeterminate.

When a change in the transport tax is accompanied by a budget neutral change in the labour income tax, the value of the marginal cost of public funds depends on the sum of the benefits of a lower labour income tax [(i.a) and (i.b)] and the indirect costs of the transport tax [(ii.b) and (ii.c)]. The direct costs of the transport tax (ii.a) are already included in the change of the consumer surplus. The first part of Table 3 summarises the impacts of these factors on the marginal cost of public funds.

Of course, other recycling strategies could be followed. The second part of Table 3 summarises the implications of two of them for the marginal cost of public funds: a higher lump sum transfer and using the additional revenue for projects that are not worthwhile. In the first case there is no tax recycling effect. In the second case all revenue is wasted in bad projects and there are no direct benefits related to the use of the tax revenue.

To conclude, valuing tax receipts in the transport sector is important for welfare assessment. Our discussion has shown that attributing a value of 1 to changes of transport revenue is justified only under very strong assumptions. The value of tax revenue can only be determined if one knows the precise use of the revenue collected – which is assumed to be fixed – and if the characteristics of the demand and supply functions are known.

3.4.2 Income distribution concerns in partial equilibrium models

In order to take into account distributional issues, the welfare function can be adapted by using social welfare weights, which are taken as constant and measured in the reference equilibrium. These weights are defined as the relative social marginal utility of income. For this system to work, all the elements of the objective function (distribution of tax revenue and profits, distribution of efficiency gains on the labour market, distribution of the damages of external effects) have to be allocated to different types of individuals. This requires almost the same information basis as a general equilibrium model. An error that is sometimes made is to only consider the distribution of consumer surplus and to omit the distributional effects of revenues or subsidies.

Table 3: Determinants of the marginal cost of public funds $(1+\lambda)$

Recycling instrument = labour income tax

Who supplies labour?	**Net com-plementarity between transport and labour supply?**	**Effects present**	**Marginal cost of public funds**
All individuals	No	Tax interaction Tax recycling	$(1+\lambda) < 1$ tax interaction effect generally is larger than tax recycling effect
All individuals	Yes – transport complement to *labour*	Tax interaction Tax recycling Complementarity	$(1+\lambda) \ll 1$ additional negative effect of transport tax on labour supply
Not all individuals	Yes – transport complement to *leisure*	Tax interaction Tax recycling Complementarity Tax shifting	$(1+\lambda)$ might exceed 1 increased tax on transport paid by non labour income is used to reduce tax on labour

Other recycling instruments

Who supplies labour?	**Net com-plementarity between transport and labour supply?**	**Recycling instrument**	**Effects present**	**Marginal cost of public funds**
All individuals	No	Lump sum transfer	Tax interaction	$(1+\lambda) \ll 1$ positive tax recycling effect is missing
All individuals	No	Bad projects	Tax interaction All revenue is wasted	$(1+\lambda) < 0$ all revenue raised is wasted in bad projects

3.5 The welfare effects of policies in a general equilibrium framework

General equilibrium covers a wide range of techniques. An important assumption is whether the location of firms and households is fixed or not. Endogenous location general equilibrium models are still in the research phase. More progress has been made using general equilibrium models with a good representation of the transport sector and its externalities. What lessons can be drawn for transport policy assessment and accounts?

As a starting point for our discussion we use the literature on marginal policy reforms in the presence of externalities. The rest of the discussion is based on Mayeres and Proost (2001)[12] which looks at the welfare impact of revenue-neutral marginal policy reforms. In a first step, we consider an economy with identical individuals. Later, distributional issues are analysed.

3.5.1 Efficiency

3.5.1.1 The theoretical model

The model considers a Walrasian economy with fixed producer prices. There are N identical individuals and four commodities. Commodity 1 is car transport, commodity 2 is public transport, commodity 3 is a composite non-transport commodity and commodity 4 is leisure. The composite commodity is assumed to be the numéraire and to be untaxed. Car and public transport contribute to an externality Z.

The consumers

The utility of each consumer is defined over his consumption of the four commodities and the level of the externality Z:

$$U = U(x_1, ..., x_4, Z) \qquad \frac{\partial U}{\partial x_k} > 0, \frac{\partial U}{\partial Z} < 0$$

The externality is assumed to enter the utility function in a non-separable way. This implies that it is characterised by a feedback effect: the level of the externality affects the demand for the four commodities. The congestion externality is an example of this type of externality. However, in the text we will indicate how the results change for externalities without this feedback effect (for example, air pollution).
Each individuals faces the following budget constraint:

$$\sum_{k=1}^{3} q_k x_k \leq q_4 l + LS$$

with $l=T^*-x_4$ denoting labour supply. T^* is total time available. LS is a uniform lump sum transfer. q_k represents the consumer price of good k:

[12] Mayeres, I. and S. Proost (2001) "Marginal Tax Reform, Externalities and Income Distribution", *Journal of Public Economics*, vol. 79, 343-363.

$$q_k = p_k + t_k \qquad k = 1,2$$
$$q_3 = p_3$$
$$q_4 = p_4 - t_4$$

Each individual chooses his consumption bundle such that his utility is maximised subject to the budget constraint. We assume that when doing this he ignores his own impact on the externality. The resulting differentiable demand functions are of the form $x_k(q,LS,Z)(\forall k)$. Note that the level of the externality enters the demand function. The maximum utility each individual can achieve when facing the price vector q, the lump sum transfer LS and the externality Z is given by the indirect utility function $V(q,LS,Z)$. In the rest of our discussion we will use:

$$\left.\frac{\partial V}{\partial LS}\right|_Z = \varphi; \quad \left.\frac{\partial V}{\partial t_k}\right|_Z = -\varphi x_k \tag{10}$$

φ is the marginal utility of income. The second expression is Roy's identity. We will also use the definition that

$$\zeta = -\frac{\partial V}{\partial Z} \Big/ \varphi \tag{11}$$

ζ is the marginal willingness-to-pay for a reduction in the externality Z.

The externality

To keep things simple we make the following assumptions:

- we consider only one externality. Relaxing this assumption would not significantly change the analysis and the conclusions, but would imply a heavier notational burden.
- The externality has no impact on production and the production sector does not contribute to the externality. These are crucial assumptions. Relaxing them would imply that we have to leave the framework with fixed producer prices.

The externality is determined by the total consumption of car and public transport. These two transport modes may have a different contribution to Z. The government can reduce the level of the externality by undertaking investments in public abatement (PA_j) for the two transport modes. This reduces the unit impact of car and public transport on the externality. The externality is given by:

$$Z = Z(X_1, X_2, PA_1, PA_2) \quad with \quad X_j = Nx_j; \quad \frac{\partial Z}{\partial X_j} > 0; \quad \frac{\partial Z}{\partial PA_j} < 0 \quad j = 1,2 \tag{12}$$

Production

The production side of the economy is modelled in a very simple way. We assume that the externality has no impact on production. Nor does the production sector contribute to the externality. The producer prices are taken to be fixed. We assume constant returns to scale. This implies that increases in taxes are reflected as consumer price increases and that there are no pure profits.

The government

The government provides public abatement (PA_j, j=1,2) at the unit cost of 1. It collects taxes from the individuals and distributes uniform lump sum transfers. The government requires resources R^* and thus public revenue R for a number of exogenous activities which are kept constant. It faces the following budget constraint:

$$R = \sum_{k=1}^{2} t_k X_k + t_4 L - \sum_{j=1}^{2} PA_j - N.LS \geq R^*$$

The government maximises social welfare, which in this framework is given by

$$W = N.V(q, LS, Z)$$

It can be shown that allocations that are derived from indirect utility functions and that satisfy the government budget constraint, will satisfy the production possibilities constraints (Walras' law combined with fixed producer prices).

3.5.1.2 The welfare impact of revenue neutral marginal policy changes

We start from a given arbitrary equilibrium. Assume that the government decides to change two or more of the three instrument types over which it has control: the taxes t_k, the investment in public abatement PA_j and the uniform lump sum transfer LS. The question that we want to answer is the following:

> How is welfare affected by a marginal change in the government's instruments, given that the policy change is required to be revenue-neutral?

The effect on welfare of the policy change is described by:

$$dW = \sum_{k=1}^{4} \frac{\partial W}{\partial t_k} dt_k + \sum_{j=1}^{2} \frac{\partial W}{\partial PA_j} dPA_j + \frac{\partial W}{\partial LS} dLS \qquad (13)$$

given the restriction that

$$dR = \sum_{k=1}^{4} \frac{\partial R}{\partial t_k} dt_k + \sum_{j=1}^{2} \frac{\partial R}{\partial PA_j} dPA_j + \frac{\partial R}{\partial LS} dLS = 0 \qquad (14)$$

Expression (14) imposes that the policy change is revenue neutral. This means that the welfare assessment takes into account the way in which the government uses the extra revenue generated by a tax increase, or the way in which higher spending on public abatement or transfers is financed. The approach captures the fact that different ways of ensuring revenue neutrality will have different welfare impacts.

In order to make the link with the accounts it is useful to rewrite (13) and (14)[13].

Expression (13) can be written as:

[13] The derivations are given in Appendix E.

$$
\begin{aligned}
\frac{dW}{\varphi} = \; & -\sum_{\substack{k=1\\k\neq3}}^{4} X_k dt_k + NdLS \\
& -N\zeta\sum_{j=1}^{2}\xi\left(\sum_{\substack{k=1\\k\neq3}}^{4}\frac{\partial Z}{\partial X_j}\left.\frac{\partial X_j}{\partial t_k}\right|_Z dt_k + \frac{\partial Z}{\partial X_j}\left.\frac{\partial X_j}{\partial LS}\right|_Z dLS\right) \\
& -N\zeta\sum_{j=1}^{2}\frac{\partial Z}{\partial PA_j}dPA_j
\end{aligned}
\tag{15}
$$

$\left.\frac{\partial X_j}{\partial t_k}\right|_Z$ and $\left.\frac{\partial X_j}{\partial LS}\right|_Z$ give the direct effect of a change in t_k or *LS* on the consumption of commodity *j*, that is, for a given level of the externality. In order to get the full effect of a policy change on consumption, the direct effect must be multiplied by the externality feedback parameter ξ. It is defined as:

$$
\xi = \frac{1}{1-\sum_{k=1}^{2}\frac{\partial Z}{\partial X_k}\frac{\partial X_k}{\partial Z}}
\tag{16}
$$

For externalities that enter preferences in a separable way, ξ equals 1. The total effect of a tax change on consumption then equals the direct effect. In the case of congestion (which has a negative impact on transport demand), the feedback parameter will lie between zero and one.

From (15) we know that the total impact on social welfare, expressed in terms of the numéraire, of a policy change equals the sum of:

- the change in direct welfare, i.e., for a given level of the externality (first line on the RHS of (15))
- the social value of the change in the externality related to the changed consumption of car and public transport (second line on the RHS of (15))
- the social value of the change in the externality related to the change in public abatement for car and public transport (third line on the RHS of (15)).

Expression (14) which restricts the policy changes to those of the revenue-neutral variety, can be rewritten as:

$$
\begin{aligned}
dR = 0 = & \sum_{k=1}^{2}\left(X_k dt_k + t_k\left(\sum_{\substack{n=1\\n\neq3}}^{4}\frac{\partial X_k}{\partial t_n}dt_n + \sum_{j=1}^{2}\frac{\partial X_k}{\partial Z}\frac{\partial Z}{\partial PA_j}dPA_j + \frac{\partial X_k}{\partial LS}dLS\right)\right. \\
& + \left(Ldt_4 + t_4\left(\sum_{\substack{k=1\\k\neq3}}^{4}\frac{\partial L}{\partial t_k}dt_k + \sum_{j=1}^{2}\frac{\partial L}{\partial Z}\frac{\partial Z}{\partial PA_j}dPA_j + \frac{\partial L}{\partial LS}dLS\right)\right) \\
& - \sum_{j=1}^{2}dPA_j - NdLS
\end{aligned}
\tag{17}
$$

or, in a more concise way:

$$dR = 0 = \sum_{\substack{k=1 \\ k\neq 3}}^{4} dR_k - \sum_{j=1}^{2} dPA_j - NdLS \qquad (18)$$

with dR_k standing for the change in tax revenue raised through the tax on commodity *k*.

Expression (18) tells us that the policy instruments should be changed in such a way that the total impact on government revenue is zero. This means that

- the change in tax revenue from the taxed commodities (car transport, public transport, labour) ($\sum_k dR_k$)
- the change in spending on public abatement for car and public transport (- $\sum_j dPA_j$)
- the change in spending on uniform lump sum transfers (-*NdLS*)

should sum to zero.

3.5.2 <u>Equity</u>

Up to now we have assumed in the general equilibrium approach that all individuals are identical. What are the implications of relaxing this assumption?

On the consumers' side of the model, we now have *N* non-identical individuals who differ in their preferences and their earning capacity e^i. Consumption of commodity *k* by consumer *i* is denoted by x_k^i. Total consumption of commodity *k* is denoted by $X_k = \sum_i x_k^i$. The supply of labour by consumer *i* is given by $l^i=e^i(T^*-x_4^i)$. Total labour supply is represented by $L = \sum_i l^i$. Maximising utility subject to the budget constraint results in the demand functions $x_k^i(q,LS,Z)$ and the indirect utility function $V^i(q,LS,Z)$. φ^i is the marginal private utility of income of consumer *i*. ζ^i is consumer *i*'s marginal willingness-to-pay for a reduction in Z.

The government is now assumed to maximise social welfare that is represented by a Bergson-Samuelson type of social welfare function.

$$W = W\left(V^1(q, LS, Z),\ldots,V^N(q, LS, Z)\right)$$

The effect on social welfare of a policy change is given by:

$$\frac{dW}{\bar{\beta}} = -\sum_{\substack{k=1 \\ k\neq 3}}^{4}\sum_{i=1}^{N}\frac{\beta^i}{\bar{\beta}}x_k^i\,dt_k + NdLS$$
$$-\left(\sum_{i=1}^{N}\frac{\beta^i}{\bar{\beta}}\zeta^i \quad \xi \sum_{j=1}^{2}\left(\sum_{\substack{k=1 \\ k\neq 3}}^{4}\frac{\partial Z}{\partial X_j}\frac{\partial X_j}{\partial t_k}\bigg|_Z dt_k + \frac{\partial Z}{\partial X_j}\frac{\partial X_j}{\partial LS}\bigg|_Z dLS \right. \right. \qquad (19)$$
$$-\left(\sum_{i=1}^{N}\frac{\beta^i}{\bar{\beta}}\zeta^i\right)\sum_{j=1}^{2}\frac{\partial Z}{\partial PA_j}dPA_j$$

with

$$\beta^i = \frac{\partial W}{\partial V^i}\varphi^i \quad \text{and} \quad \overline{\beta} = \quad {}_i\beta^i \big/ N$$

β^i is the direct social marginal utility of income accruing to individual *i*. $\overline{\beta}$ is the average direct social marginal utility of income. Expression (19) is similar to (15). The total effect on social welfare, in terms of the numéraire, equals the sum of:

- the change in direct welfare, i.e., for a given level of the externality (first line on the RHS of (19)). The individual consumption is now weighted by the direct social marginal utility of income.
- the social value of the change in the externality related to the changed consumption of car and public transport (second line on the RHS of (19)).
- the social value of the change in the externality related to the change in public abatement for car and public transport (third line on the RHS of (19)).

In the last two terms it is taken into account that different individuals may have a different marginal willingness-to-pay for a reduction in the externality. In order to obtain a social marginal willingness-to-pay for *Z*, the individual MWTP are weighted by the social marginal utility of income.

3.6 Institutions and information

The previous sections assumed an omniscient planner with perfect information on cost and demand functions. This section looks at the implications of relaxing these assumptions. In reality information will be imperfect. Moreover, decisions are not taken by a planner but by institutions (ministers, parliament, administration, firms, etc.) and the decision power is distributed over these different units.

There are two main reason why these different institutions exist (Tirole, 1986)[14]. First, the different institutions keep each other somewhat in balance so as to avoid too strong misuse of power. Second, collecting information is costly and some institutions exist because of their advantage in information processing. The existence of different institutions, each with their decision power, implies that each of them will pursue its own interests. This does not necessarily lead to a welfare optimum. Each of them will use its informational advantage to pursue its own goals.

Returning to our transport sector, what are the major institutional issues that preclude the implementation of optimal pricing and investment? We select three problems. The first is related to the fact that transport services are produced by firms. The second problem is that transport services are organised and regulated on a national or regional basis but are used by consumers and firms from other countries or regions. The third problem is the potential exploitation of transport pricing and investments by interest groups or thin majorities because the policy maker is not necessarily benevolent.

[14] Tirole, J. (1986) "Hierarchies and Bureaucracies: On the Role of Collusion in Organisation", *Journal of Law, Economics and Organisation*, vol. 2, 181-214.

3.6.1 <u>Regulating transport services by firms</u>

There exists a large literature on optimal regulation of firms (for an overview, see Laffont and Tirole (1993) and Vickers and Yarrow (1988); for a discussion of the British transport sector experience, see Glaister (1997))[15]. We will limit ourselves to a few principles.

The problems of firm regulation are due to uncertainty and to imperfect information, two features in the absence of which it is possible for the principal to fix the objectives to reach by the agent and to control and reward their achievement unambiguously. One can distinguish problems of incentives (the principal cannot check whether the agent has provided the correct effort, and must set mechanisms to induce it) and problems of adverse selection, where the principal ignores the characteristics of the agent.

3.6.1.1 Problems of incentives

Usually, one distinguishes two extreme cases: perfect competition and pure monopoly. The extreme case of perfect competition does not look very interesting in the case of roads or railway infrastructure and operation. On any given link, returns to scale in construction and operation are such that perfect competition is not a feasible outcome. We will therefore concentrate on the case of a pure monopoly. This problem has been extensively studied in the literature.

When there is no omniscient planner and no perfect competition (and only one country) there are 3 types of problems to be dealt with in the case of a monopoly:
1. Too high prices will be charged by a profit maximising monopolist.
2. Efficiency in production: the firm will not necessarily put maximum efforts to minimise costs but may pursue other goals (bureaucratic, easy life, etc.), certainly when prices are set on a cost plus basis
3. Not all worthwhile services will be produced. First, some services with very high fixed costs cannot break even but may be worthwhile. Second, there may be a lack of innovation.

These problems are not easy to solve. The two corner solutions for a regulator are a price cap system and a cost of service system.

In a *price cap* system, a maximum price is fixed close to the marginal cost and a fixed subsidy is paid to the firm that receives all revenues and pays all costs. This system gives maximum incentives for the firm to cut costs and so to produce efficiently, but it may be costly for society because the regulator has to give away costly (because of the cost of public funds) rents to the firm. For the regulator it is difficult to minimise these payments because the firm has better information on the costs of the firm. This could be solved by tendering (see Section 3.6.1.2) but this involves other problems.

In a *cost of service* system, the regulator sets the prices and covers the deficits of the firm. The problem with this system is the lack of incentives for the firm to cut costs so

[15] Glaister, S. (1997) “Deregulation and privatisation: the British experience”, in: G. De Rus and C. Nash (eds.), *Recent Developments in Transport Economics.* Ashgate.
Laffont, J.-J. and J. Tirole (1993), *A Theory of Procurement and Regulation.* MIT press, Cambridge.
Vickers, J. and G. Yarrow (1988) *Privatisation, an Economic Analysis*. MIT press.

that the rents given away to the firm can be larger than in the price cap system. A system where a maximum profit constraint or a budget constraint is imposed on the firm are variants of this system.

In theory, the regulator can still set prices equal to social marginal costs (or social marginal costs corrected for the marginal cost of public funds) in both systems. This looks easy in the case of a one-product firm but we know that most transport firms have many products and pricing these correctly is important. It is unlikely that the regulator can set prices correctly for all these products. There is a real risk that prices may be set on a wrong basis because of ignorance (by the political world, cf. Section 4) or to favour particular pressure groups or interests. The result of this can be worse in welfare terms than the outcome with a profit maximising monopolist.

This means that the pricing decisions are probably best to be given primarily to the firm and this is not foreseen in the price cap or in the cost of service regulation. Regulating a multi-product firm is therefore much more difficult.

There exist several solutions. One solution of interest is the Vogelsang and Finsinger (1979)[16] system. In order to understand this mechanism it is useful to return to Section 3.3. Imagine that we have a profit maximising firm rather than a welfare maximising government. It will use Ramsey pricing in order to maximise its profits: it will start by charging marginal costs and add a higher mark up for those goods with a low price elasticity. It is important to see that a monopolist bases its prices on marginal cost information. The mechanism uses this idea. In order to keep prices sufficiently down a restriction on the weighted average of prices is added. The weights in the price index are chosen such as to obtain a solution without excess profits. One way of selecting the weights is to put them equal to the quantities of the previous period. The level of the price index is chosen such that total costs of the previous year are covered.
This mechanism has several drawbacks that are discussed in the literature. We mention it here because it shows how the regulator can use the marginal cost information that is used by profit maximising firms.

3.6.1.2 Problems of adverse selection

Problems of adverse selection occur in infrastructure charging, when the infrastructure manager ignores the characteristics of the users and cannot estimate their transport cost. This point happens mainly in rail and air transport where the infrastructure manager does not have good information on the private values of the operators and cannot estimate the opportunity costs of a service (congestion cost). In that case, in order to fight against adverse selection it needs to implement revelation mechanisms. The simplest and most efficient one is an auction. This device is recommended in situations where a scarce resource has to be allocated to the agents who can extract from it the highest value, this value being private information. Such situations are encountered in the case of air transport (slot allocation), rail transport (pathway conflict solution) and sea transport (berth allocation). In the case of road transport, it is generally assumed that the infrastructure manager can have information on the main private information, i.e. the value of time of the users, which is not a strategic information due to the large

[16] Vogelsang, I. and J. Finsinger (1979) “A Regulatory Adjustment Process for Optimal Pricing by Multi Product Monopoly Firms”, *Bell Journal of Economics*, vol. 10, 157-171.

number of these users and to the possibility of estimating it through revealed or stated preference methods.

Another situation of adverse selection is between the infrastructure manager, considered as the agent, and its regulator, here the principal who has poor information on the technical parameters of the agent and on the market. Such situations are difficult to deal with and the solution depends on the characteristics of the cost function and on the precise type of imperfect information The social surplus maximisation leads to the following best incentive to the agent: efficient supply should not be distorted (i.e. price should equal marginal cost), but supply is lower than the one when the principal has perfect information about agent's characteristics. In some frequent situations, it can be shown (Laffont and Tirole, 1993) that the tariff is based on marginal cost and generally over this marginal cost.

3.6.2 Problems of jurisdictions

Problems of jurisdictions arise first of all in the case of international traffic. Such a situation has been analysed, for example, in the case of international traffic between two countries, this traffic being charged in both countries for the part of the trip it makes in each of them (De Borger, 2001)[17].

The pricing in each country has effects on the tax revenue and on the externalities in the other country. The pricing policy depends on the degree of co-operation or competition between the two countries and on the technical and legal possibility to discriminate between domestic and foreign traffic. It depends also on the hierarchy of environmental goals and budget constraints.

Another point that begins to be addressed by economic analysis is the effect of the hierarchy of jurisdictions. Reasons in favour of such hierarchy are the cost of information transmission and processing, incompleteness of contracts between the centre and the periphery, and a better effort incentive (Caillaud et al., 1996)[18]. On the other hand, taxes by inferior jurisdictions are subject to several drawbacks, especially in the case of source based taxation: tax exporting, competitive tax spill-over, NIMBY and beggar-my-neighbour tax competition induce inefficiencies in state taxes. This point leads to the recommendation to use resident-based taxes by the central government in order to correct these failures (Inman and Rubinfeld, 1996)[19].

[17] De Borger, B. (2001) "Evaluating pricing policies for interregional transport in Belgium": in: B. Borger and S. Proost (eds.), *Reforming Transport Pricing in the European Union – a modelling approach.* Edward Elgar, forthcoming

[18] Caillaud, B., B. Jullien and P. Picard (1996) "Hierarchical Organisation and Incentives", *European Economic Review*, vol. 40, 687-695.

[19] Inman, R.P. and D.L. Rubinfeld (1996) "Designing Tax Policy in Federalist Economies: An Overview", *Journal of Public Economics*, vol. 60, no. 3, 307-334.

3.6.3 Political economy of transport pricing

The sophisticated pricing and subsidy rules are sensitive to exploitation by non-benevolent policy makers. When there are thin majorities and there is an important diversity in the preferences of the users there are two types of problem with decreasing average cost industries[20]. The pricing may be distorted to favour the political majority or specific industries. The second problem is that subsidies may be given to new projects with high fixed costs but that do not meet a cost benefit test. One can imagine several safeguards against these policies. One obvious safeguard is to impose break even constraints. This may however generate high efficiency losses. Transport policy making in the real world should therefore combine in an intelligent way efficient pricing and investment policies and controls on the improper use of subsidies and marginal cost pricing.

[20] Laffont, J..J. (2000), *Incentives and political economy*, Oxford University Press.

4 Pricing doctrines currently used in a selection of member states

The previous chapter gave an overview of the state of the art in the economic literature on transport pricing and investment. This chapter examines to what extent economic theory has influenced transport policy in practice. Section 4.1 gives an overview of pricing doctrines in a selection of European countries. The overview shows that there are large discrepancies between the theoretical principles and the current views about charging. Section 4.2 tries to find out why this is the case. It considers a number of motivations for deviating from the theoretical prescriptions. It is shown that most of the concerns that lead to alternative solutions are valid. However it is argued that economic theory is able to deal with these concerns and that therefore alternative solutions are not called for.

4.1 An overview of pricing doctrines in a selection of European countries

A small survey was made among UNITE partners in order to have an overview of views in a selection of UNITE countries. Three questions were asked:

- What are the differences between the picture given by the theoretical review and the current teaching at universities about transport?
- What are the current doctrines expressed by the political authorities (Government, Parliament, etc.) on the subject of transport infrastructure pricing?
- What is the real situation of present infrastructure pricing?

A summary of the answers is presented in Table 4 to Table 6:[21]

[21] Appendix F presents the full answers to the survey questions.

Table 4: What are the differences between the picture given by the theoretical review and the current teaching at universities about transport?

Country	Answer
Austria	Marginal cost pricing is taught in the context of microeconomics but is not considered as a possible implementation principle. Pricing has been discussed first as a funding generator.
France	Economic theory is taught in the more advanced economics courses in universities; but in other courses (equivalent to MBA) less sophisticated methods are taught; they are based on principles of cost allocation.
Germany	Marginal cost pricing is considered as a theoretically interesting approach but not as an important input for transport pricing in practice. Comments on the White Paper on Infrastructure Charging (CEC, 1998)[22] were very critical from the academic world as well as from representatives of the relevant parts of the public administration.
Ireland	Not known. Transport economics is not widely taught.
Spain	Students generally are shown the main principles of economics theory. But most of transport courses in Spain are more often offered by engineering schools and tend to stress more the technical analysis.
Switzerland	Transport economics is not widely taught. The two national technical universities in Zurich and Lausanne offer courses in transport science, but the approach is rather engineering and planning than economics. In the last years, transport economics has been the subject of two National Research Programmes, which included research on the question of different pricing approaches in transport.
United Kingdom	Advanced theoretical courses cover classical economic theory, but there is still a tendency to teach traditional cost allocation procedures.

[22] Commission of the European Communities (1998) *Fair Payment for Infrastructure Use: A Phased Approach to a Common Transport Infrastructure Charging Framework in the EU*, White Paper, COM (1998) 466 final. European Commission, Brussels.

Table 5: What are the current doctrines expressed by the political authorities (Government, Parliament, etc.) on the subject of transport infrastructure pricing?

Country	Answer
Austria	The priority objective of environmental protection was implemented through regulatory and pricing measures. Nevertheless, pricing measures introduced so far serve first of all for the generation of funds for the general budget and the financing of the transport infrastructure, though a on-going project on road transport infrastructure costs will most probably result in an opening of the discussion about this issue.
France	The doctrine has varied over the years. About twenty years ago, the principle was that freight should pay the marginal cost, and passenger traffic should pay the full cost. More recently, the main stream of ideas shifted towards the use of long run marginal cost principle, based on concerns about the manipulability of short run marginal cost and on (intermodal) equity considerations.
Germany	The current pricing doctrine is dominated by financing issues and not by considerations referring to marginal cost pricing. The discussion on environmental taxation relates more easily to MC pricing.
Ireland	There is no move for pricing of inter-urban road networks (with the exception of tolled bridges, for the purposes of project finance). There is no pressure for road pricing in Dublin, although studies have been commissioned in the past (e.g. with a view to developing finance sources for light rail). For other sectors, there is no political momentum behind changes in charging policy.
Spain	The previous administration launched plans based on publicly financed investments. After 1996, the new government has shifted the balance slightly towards a model of charging infrastructure costs to users.
Switzerland	Recently, it has become clear that short run marginal cost pricing is considered as an interesting economic approach but not as central future guideline. In practical transport policy short run efficiency is not considered as a very important objective of pricing in comparison with financing and environmental objectives. Environmental costs play a role in pricing policy. However, the basic idea of marginal cost pricing is not considered as feasible because of uncertainties in the calculation of marginal costs. Short run marginal cost pricing has become an issue within the context of railway reform (as a baseline for track pricing).
United Kingdom	There is a tradition going back to the 1960s in favour of long run marginal cost pricing, combined with a current strong encouragement towards congestion pricing for both road (delegated to local authorities for urban roads) and rail, which may be taken to indicate a move towards short run marginal costs. There is a minimal interest in charging issues in the ports, aviation or inland waterways sectors.

Table 6: What is the real situation of present infrastructure pricing?

Au	**Road:** The taxation of fuel is not earmarked. There is a purchase tax and an annual vehicle tax. At the local level, there are parking fees. Passengers cars and light goods vehicles (< 12 t) have to buy a vignette to use the motorways. On 5 roads and several tunnels there are road tolls. In addition to the tolls, heavy goods vehicles >12 t pay an annual road user charge ("STRABA"). Furthermore, an eco point system for transit traffic through Austria exists. A distance-related charge ("Maut") for vehicles >3.5 t is planned by 2002 on motorways and other trunk roads for funding the extension and maintenance of the high-ranking road network, operated by a state owned company. **Rail:** The infrastructure access charge is a tariff based on two variable parameters: train-km and gross-ton-km. It is not based on marginal cost estimates. **Air and Inland Waterways:** The level of the charge is derived from total cost estimates and not from marginal cost considerations.
Fr	**Road:** Road is charged through many devices: fuel taxes, toll motorways, vignettes, parking fees. Though not determined by the same authority, their main motivations are financial and not economic. The outcome is that, roughly, road as a whole covers its charges, but with a lot of discrepancies between categories of traffic. **Rail:** Rail transport is subsidised, the infrastructure charges cover about 25% of the total expenses. Charges approximately follow the Ramsey-Boiteux principle. **Air and sea transport:** They roughly pay their expenses, as they are run by (public) firms and do not receive much subsidy from public authorities.
G	**Road:** The main pricing scheme is the taxation of fuel. An annual vehicle tax is levied by the different states in Germany. At the local level parking fees are levied. Heavy goods vehicles using the German motorways pay for the Eurovignette. Only part of the revenues from the duties on fuel is earmarked for the financing of road infrastructure costs. For the short to medium term the approach is to base the financing of infrastructure more on user and less on budgetary funding. Distance-related user charges should be introduced on motorways for heavy goods vehicles (> 12 t), then extended to other road types. The introduction of road pricing for cars has been rejected. The level of the user charge will be derived from estimates of total and not marginal infrastructure costs. In the short- or medium-term buses and light goods vehicles will have to buy a time-dependent vignette to use the German motorways. For road passengers cars a motorway vignette is in discussion. **Rail:** In 1998 a two-part tariff system of infrastructure access charges was introduced. It shows similarities to a marginal cost pricing scheme subject to a budget constraint. However, the German cartel office rejected this pricing system. A new system will have to be elaborated.
Ir	**Road:** generally uncharged. **Rail:** user tariffs have been determined over time, generally maintaining parity with bus and coach services. Infrastructure cost coverage has not been sought, nor has any specific infrastructure pricing policy been developed.

Table 6(ctd): What is the real situation of present infrastructure pricing?

Sp	**Road:** There are no developed pollution or congestion charges, and vehicles pay for the use of roads through taxes on fuel, annual licenses and other charges. **Rail:** the public railway company is in a process of transformation towards a model of separation, but it is not clear yet what are the plans for the agency that in the future will be in charge of managing infrastructure. **Seaport and Airports:** They are generally self-financed through their revenues, so for those modes users cover for infrastructure costs.
Swi	**Road:** the main pricing instruments are: fuel taxes (whose revenues are partly earmarked for the financing of road infrastructure), annual vehicle taxes (levied at the cantonal level), parking fees (levied at the local level), an annual earmarked vignette on cars for the use of the national motorways. A new Heavy Vehicle Fee will be introduced in 2001 the level of which depends on truck characteristics (weight, emission technology, etc.) and on the need to finance rail investments **Rail**: The charge should not be lower than the marginal cost incurred with the use of a “standard” part of the network. In addition, a contribution margin can be levied to contribute to cost recovery. **Inland waterways:** Relevant are only the charges levied in the Rhine harbours of Basle. They are not based on any marginal cost estimates. **Airports :** Landing charges are oriented at financial considerations and include environmental considerations (the noise emissions of the aircraft).
UK	**Road:** annual vehicle licence duty and fuel tax; there is no explicit link between these and costs although relative environmental damage estimates are used to establish differentials. **Rail:** Infrastructure charges for franchised passenger operators are based on a two-part tariff; the rail regulator has recently allowed Railtrack to increase the variable part of the tariff bringing it more into line with marginal cost, but maintaining revenue neutrality. **Airports and seaports:** there is minimal government involvement in charge setting. There is no regulation of port prices, and ports are generally under private ownership in a competitive marketplace. The Civil Aviation Authority regulates airport charges for major airports, with an emphasis on infrastructure cost recovery rather than the application of economic principles for charging.

4.2 Are these pricing doctrines consistent with the theory?

The overview in Table 4 to Table 6 shows that the views about charging are varied and rather different from the teaching of the standard economic theory.

These views are expressed by people who have to deal with the problem of transport management. Historically; engineers played an important part and they developed a corpus of ideas inspired by logic, wise spirit or a sense of equity. Other categories of people interested in the field are civil servants and experts dealing with the subject, as well as professionals of the transport field, who were inspired by accounting practice. On top of that the last class of people concerned by the subject are the political decision-makers.

There is a large consensus on concepts which are different from short run marginal social cost (SRMSC) pricing and more akin to the long run marginal cost (LRMC), itself often quoted. The words “development cost”, “average cost” or “full cost” are put forward. Though they are not always fully described and there are differences from one author to the other, they cover the idea that the users should pay for the expenses they cause to the collectivity.

The “development cost” is a way to have a more precise definition of the idea behind the LRMC. It is the ratio between the discounted sum of the future investments and the discounted sum of the traffic increases[23] that make them necessary.

Other advocated concepts are the concepts of “average cost” or “full cost”. A very wide panoply of calculation procedures have been developed around these concepts. Several options have been discussed about them. The first ones relate to the numerator side. Which expenses have to be distributed across the various categories of traffic: actual transport expenses, the actualised historical construction expenses, or the expenses that would be incurred if it were necessary now to build and operate a modern infrastructure?

Other kinds of considerations relate to the denominator side: how to distribute the cost between the different categories of traffic? An overview of past and current practices learns that two types of solution are often used. The first ones are accounting-type solutions, based on equivalence ratio between traffic categories for the various kinds of cost categories. For instance, pavement thickness is allocated according to the damages caused by axle load (4^{th} power of the axle load according to the AASHTO tests, based on Highway Research Board (1962)[24]). The second ones are based more explicitly on co-operative game theory. The idea is to find an allocation which is in the core of the co-operative game of sharing the cost of the infrastructure, so that no traffic would have interest to leave the coalition to set up its own infrastructure. Procedures such as the weighted average of all possible incremental costs are an example of solutions advocated by the game-theoretic approach (Curien and Gensollen, 1992; Castellano-Pardo and Garcia-Diaz, 1995)[25]. These procedures were the dominant doctrine about 20

[23] sometimes also the entire traffic, comprising both the increase and the base traffic.

[24] Highway Research Board (1962) *The AASHTO Road Test: Pavement Research.* HRB Special Report 61E. Washington, D.C.

[25] Castellano-Pardo, A. and A. Garcia-Diaz (1995) “Highway Cost Allocation: An Application of the Theory of Non-Atomic Games”, *Transportation Research A*, vol. 29, n. 3.
Curien, N. and M. Gensollen (1992) “L’économie des télécommunications: ouverture et réglementation”, Economica-ENSPTT, Paris.

to 30 years ago in every country. They have still supporters. For instance, in the USA, cost allocation studies based on these principles are regularly published (see Link et al. (2000)).

The ideas that support these concepts are manifold and we will first analyse the main concerns behind these propositions and then show that a correct use of economic theory gives proper answers to these concerns.

A first reason for advocating concepts such as "development cost", "average cost" or "full cost" is related to the difficulties of SRMSC calculations. These calculations are both esoteric, not easy to understand for non-economists, and uncertain, especially as far as external costs are concerned. Therefore, many people think that SRMSC is manipulable: the calculations are uncertain, and lobbies can use this uncertainty to lower or increase the results in the direction of their own interests. In comparison, concepts such as average cost or development cost (this one avoiding the external costs and especially the congestion costs) seem more simple and less uncertain, and therefore less manipulable. Other considerations are based on efficiency considerations for the operator: SRMSC do not screen unprofitable services with high fixed costs which are not incorporated in the charge, and the operator can use this point and the asymmetry of information to manipulate the cost, lowering the marginal cost in order to increase the patronage and gain more subsidies from the public authorities.

Other concerns are related to problems of equity. First, the SRMSC is often seen as not providing enough funds to finance the total expenses. Secondly, SRMSC is not seen as an equitable solution, as it leads to charge high fares on captive users, for instance the commuters who are relatively low-income users, and cannot cope with public service obligations such as low fares for redistribution objectives.

The propositions of average cost, development cost and long run marginal cost try to answer these concerns.

Average cost seems to avoid esoterism and uncertainty in calculations, and also lack of finance and manipulations on fixed costs and subsidies: if fixed costs are too high, the average cost will be high too. Eventually, because of the increase of the charge, the demand will disappear, causing the closure of services whose fixed cost is too high. It solves also some equity problems in the sense that it ensures that transport costs are paid by the users and not by the taxpayers. The problem is that average cost is arbitrary, as there is no non-arbitrary way of allocating the common costs (the procedures that have been already quoted have no logical justification), except if the allocation of common costs is made according to the Ramsey rule, which is based on SRMSC.

The problem of manipulation of SRMSC to search for subsidies is real and average cost is a way to fight against it. But economic theory provides more refined tools to solve this problem, based on SRMSC (see the theory of imperfect information in Section 3.6). It must be noted that in general these tools give values that are larger than the SRMSC, between the SRMSC and the average cost.

The LRMC seems also to be easier to calculate as it does not take into account congestion cost and corresponds more or less to the idea that SRMSC leaves aside the investments and that it is necessary to take them into account. When saying this, people are not fully aware that LRMC equals SRMSC in the optimal situation and does not exist in other situations.

The development cost relies on the same reasons. It looks smart and is attractive because it seems to combine several nice features (the word marginal is avoided, the reference to investment, the relation to the expenses). It avoids the objection not to be defined when the situation is not optimal, but it has no real justification.

In conclusion, it appears that many of the concerns that lead to alternative solutions are quite valid. In the previous section, starting from the first best situation where SRMSC is the optimal charging, we have progressively introduced the real features of the world. It is shown that the economic theory is able to deal with these problems of uncertainty of determination, efficiency and incentive considerations and equity concerns. The use of alternative solutions is therefore not called for.

The point is that a proper adaptation of the SRMSC principle allows to take these concerns into account properly, while the other procedures are much less adapted and more awkward. In the end these are more arbitrary because they do not give a logical and unambiguous solution to the problem of common and fixed cost allocation. Profit maximising firms have userstood much better the optimal deviations from marginal cost pricing than many transport policy makers. In this sense privatisation of transport infrastructure firms could lead to better pricing.

Nevertheless, it appears that in situations where the economies of scale are not too important, when externalities are not important and when the real world is not too far from the optimum, all these concepts are close to each other. In those cases it may be thought that, as they are first approximations of the optimum, it may be sensible to use them as substitutes without too much error if this substitution allows for a better political acceptance.

A typical situation where economies of scale are not important, where external effects are not important and where the real world is not far from perfect competition is the case of inland waterways. In the case of air transport operations, there are external effects, but competition may work rather well (there are frequently oligopolies, oscillating between Cournot, which is suboptimal and Bertrand, which is optimal) and economies of scale are not important. It is the same in the case of road freight transport. In the case of rail freight transport operations, one may argue that there is a kind of competition through road transport, there are no large economies of scale, but the world around is far from perfect (due to the imperfect taxation of the competitive mode, road transport).

5 Can current transport accounts be useful to monitor the efficiency and distributional impact of transport policies

5.1 What do we mean by a transport account?

In the UNITE consortium, the pilot transport accounts are defined as a structured set of information on costs and revenues that can be combined in different ways. Different combinations are used in different countries at present. In order to relate marginal cost pricing and accounts we need to select some particular types of accounts.

We are interested in two types of transport accounts. The first is a "business" type of account, the second is a "social" type of account.

In the business account, the total expenditures are compared with total income. Income and expenditures are defined by the current institutional structure.

Table 7: A typical business account

COSTS	INCOME
+ Variable costs (maintenance,..)	+ Revenues, taxes and fees allocated to firm
+ Real depreciation of capital stock	+ Net subsidy*
+ Interest on capital stock	
TOTAL COSTS	TOTAL COSTS

* balancing item

In terms of the welfare measure presented in (1) the business account only gives information about the producer surplus *PS*. The business account does not provide information about the other components of welfare.

Social accounts differ from business-type accounts because they also include government tax revenue and external environmental and accident costs. The UNITE pilot accounts belong to this type of accounts.

Table 8: A typical social account

SOCIAL COSTS	SOCIAL INCOME
+ Variable costs (maintenance,..)	+ Revenues, taxes and fees allocated to the producers and the government
+ Real depreciation of capital stock	+ Net social subsidy*
+ Interest on capital stock	
+ Environmental damage and external accident costs	
TOTAL SOCIAL COSTS	TOTAL SOCIAL INCOME

* balancing item

Are these two types of account useful for a policy maker?

5.2 Transport accounts to measure the efficiency of transport policies – one transport market

For the omniscient[26] (benevolent[27]) policy maker, neither a business account, nor a social account are immediately useful for implementing optimal policies or for tracking the transport policies. The reason is obvious: not all the different components of his welfare function ($CS+(1+\lambda)(TR+PS)+ECNC$) (see (1)) are present in the two types of account. In the social accounts, which is the most elaborate of the two, the following elements are missing:

- the (generalised) consumer surplus of the users of the transport system
- the correction by the marginal cost of public funds.

In our discussion we limit ourselves to the case of one decision maker. The level of aggregation of the accounts depends on the level of decision making, reflecting the differences in the welfare function and the available instruments of the different hierarchical levels (see also the discussion in section 3.6.2).

In the case of one transport market the following welfare account could measure welfare changes in welfare correctly:

Table 9: A typical welfare account (one transport market)

WELFARE COSTS	WELFARE BENEFIT
+ variable costs (maintenance,..)[b]	+ Revenues and fees allocated to producer[b]
+ real depreciation of capital stock[b]	+ Tax revenue allocated to government[b]
+ interest on capital stock[b]	+ Gross generalised consumer surplus
+ environmental, accident damage	
+ total time and other user costs	
+ Net welfare contribution[a]	
TOTAL WELFARE COSTS	TOTAL WELFARE BENEFITS

[a] balancing item
[b] corrected by the marginal cost of public funds

The major difference with the social and business account is that the net benefits of the users are now taken into account. This is indeed the criterion we use in cost benefit analysis. The additional information requirements are substantial, but necessary if one wants to make a correct evaluation.

In order to implement optimal transport policies, the omniscient policy maker needs much more information than the net social subsidy in the social account of Section 5.1 or the net welfare contribution in the welfare account. What he needs are marginal costs, marginal environmental and congestion costs as well as marginal investment costs. This information cannot be derived from the welfare account as such.

[26] This is to be considered as a thought experiment. An omniscient policy maker does not need any accounts by definition.

[27] It may be that the transport authority has a different objective function than the government. Another approach is a political economy approach in which the transport policy is the result of a political mechanism that weights the interests of different social groups.

The welfare account can only be used to check whether welfare has improved, not to compute marginal social costs as total costs and benefits are reported. There is also a difference in the level of aggregation used to construct welfare accounts and marginal social costs. It is very important to tailor prices to the costs of the different transport services (time and space dependency etc.). Welfare accounts can probably not be constructed with the same level of detail because many of the costs are joint costs.

In principle, the welfare account could be developed into a set of parallel accounts by income group. Because of the welfare weights (see Section 3.4.2), these accounts per income group do not necessarily sum to the original welfare account.

Of course, the omniscient planner does not exist and the regulator will have to use a mechanism of the type price-cap or weighted price cap (of the Vogelsang and Finsinger (1979) type) or a cost of service system (see Section 3.6.1.1). What is the role of the different types of accounts in these cases?

Business type of accounts are needed to know the total costs that need to be covered by a subsidy. Once the price cap is in place, and the regulation system is credible for the monopolist, the change over time of total business costs can be a good indicator of changes in total resource costs. As in the case of an omniscient planner, completing business accounts with consumer surplus information and external cost information can be a good welfare indicator. When the price cap is not considered credible, the reporting of business costs is part of the negotiation strategy to obtain new price caps and traditional business accounts are not a reliable guide for a welfare analysis because the reported costs are manipulated.

In the case of a cost of service system business type of accounts are needed to make the system work. Because there are poor incentives for cost minimisation, traditional accounts based on reported costs are not a good guide for a welfare assessment of policy changes.

5.3 Transport accounts to measure the efficiency of transport policies – two interrelated transport markets

It is clear from the outset that in the case of two transport markets, neither a pure business nor a pure social account per mode is sufficient for a welfare assessment of transport policies. The more interesting question is what changes in the welfare account are needed to assess transport policies.

When we attempt to use a welfare account for one mode as in the following table, we face two problems:

- The first problem is technical: a generalised consumer surplus does in general not exist. A surplus for road users can only be defined if the consumer price of the substitute mode is kept constant. We can solve this by switching to utility function type of surplus measures (equivalent variation etc.) that take into account all price changes simultaneously.
- The second problem is that most elements of the welfare account for one mode depend on policy options for the other mode. A typical example are subsidies for public transport in the peak that decrease road congestion. The public transport welfare account will deteriorate while the road welfare account will improve. There is one special case where each mode can select its policy independently: when the

other modes are all priced at marginal social cost but this is the exception not the rule. In general, a welfare assessment of transport policies needs information on changes in all modes.

Table 10: A welfare account for 1 mode (for example, road transport)

WELFARE COSTS	WELFARE BENEFITS
+ variable costs of road transport[b]	+ Revenues, taxes and fees of road transport allocated to producer of road services[b]
+ real depreciation of capital stock of road transport[b]	+ Tax revenue of road mode allocated to government[b]
+ interest on capital stock of road transport[b]	+ Gross generalised consumer surplus for road transport
+ environmental and accident damage of road transport	
+ total time and other user costs of road transport	
+ Net welfare contribution of road transport[a]	
TOTAL WELFARE COSTS	TOTAL WELFARE BENEFITS

[a] balancing item
[b] corrected by the marginal cost of public funds

5.4 The welfare accounts in a general equilibrium framework

In a general equilibrium framework we need a different and more expanded set of accounts. For this we can base ourselves on expressions (15) and (18). The notation used here is the same as in Section 3.5.

Assume that we start from an arbitrary equilibrium in the economy presented in Section 3.5. In this economy there were four commodities: two transport modes, a non-taxed composite consumer good and leisure. The impact of marginal policy changes on the welfare accounts of the two transport commodities (car and public transport) can be represented in the following way:

Table 11: The impact of policy changes on the welfare account of the transport commodity *j* (*j*=1,2)

change in COSTS	change in BENEFITS
dPA_j: change in government spending on infrastructure[b]	dR_j: change in tax revenue raised by tax on commodity *j*[b]
social value of change in externalities (congestion, air pollution, accidents...) caused by change in consumption of commodity *j* (taking into account the effect on the externalities of the change in infrastructure for both transport modes)	$-X_j dt_j$: change in direct welfare
Net welfare gain market *j*	

[a] balancing item
[b] NOT corrected for the marginal cost of public funds

Note that the change in spending on infrastructure and tax revenue are not corrected by the marginal cost of public funds. The reason is that the marginal cost of public funds is no longer exogenous in this model. The welfare effect of recycling the tax revenue/financing higher spending will be determined endogenously and will depend on the way in which revenue-neutrality is obtained.

In order to make a complete welfare assessment, one needs to take into account which non-transport instruments are used to ensure revenue-neutrality. The labour income tax or the lump sum transfer may be used for this purpose. The welfare impacts of this are not included in the welfare accounts for the two transport commodities. Even if the non-transport instruments are unchanged, and revenue neutrality is ensured by the transport instruments, one needs to take into account the effect of the transport policies on the labour income tax revenue.

Therefore, one needs supplementary information, which could be presented by means of two additional welfare accounts: one for the labour market and one for the lump sum transfer.

Table 12: The welfare account for the labour market

change in COSTS	change in BENEFITS
	dR_4: change in labour tax revenue
	$-X_4dt_4$: direct welfare effect of change in labour tax
Net welfare gain labour market[a]	

[a] balancing item

Table 13: The welfare account for the lump sum transfer

change in COSTS	change in BENEFITS
	$-NdLS$: change in spending on lump sum transfer
	$NdLS$: direct welfare effect of change in lump sum transfer
Net welfare gain lump sum transfer[a]	

[a] balancing item

For a complete welfare assessment of revenue neutral marginal policy changes, one has to include:

- the direct welfare impacts on the labour market and those related to the change in the lump sum transfer. In terms of the notation of expression (15) the following two elements have to be added: $-X_4dt_4$ and $NdLS$.
- The accompanying changes in labour tax revenue and government spending on the lump sum transfer. This means that the following two elements need to be added: dR_4 and $-NdLS$.

Adding these four terms to the sum of the net welfare gain on the transport markets and using the restriction that $dR=0$ (see expression (18)), one can easily check that the total welfare impact corresponds with (15).

5.5 Transport accounts to measure the distributional effect of transport policies – general equilibrium framework

In an economy with non-identical individuals the welfare accounts of the previous section need to be adapted. The change in direct welfare of the income groups should now be weighted by the direct social marginal utility of income.

The social value of the change in the externalities now takes into account that different individuals may have a different marginal willingness-to-pay for a reduction in the externalities. In order to obtain the social MWTP the individual MWTP should be weighted by the social marginal utility of income.

Based on expressions (18) and (19) the changes in welfare now need to be evaluated with the following accounts:

Table 14: The impact of policy changes on the welfare account of the transport commodity *j* (*j*=1,2)

change in COSTS	change in BENEFITS
dPA_j: change in government spending on infrastructure[b]	dR_j: change in tax revenue raised by tax on commodity j[b]
social value of change in externalities (congestion, air pollution, accidents...) caused by change in consumption of commodity *j* (taking into account the effect on the externalities of the change in infrastructure for both transport modes) (individual MWTP for a reduction in the externalities is weighted by the social marginal utility of income)	$-\sum_{i=1}^{N}\frac{\beta^i}{\overline{\beta}}x_m^i dt_m$: weighted change in direct welfare
net welfare gain market j[a]	

[a] balancing item
[b] NOT corrected for the marginal cost of public funds

Table 15: The welfare account for the labour market

change in COSTS	change in BENEFITS
	dR_4: change in labour tax revenue
	$-\sum_{i=1}^{N}\frac{\beta^i}{\overline{\beta}}x_4^i dt_4$: direct welfare effect of change in labour tax
Net welfare gain labour market[a]	

[a] balancing item

Table 16: The welfare account for the lump sum transfer

change in COSTS	change in BENEFITS
	-*N*d*LS*: change in spending on lump sum transfer
	*N*d*LS*: direct welfare effect of change in lump sum transfer
Net welfare gain lump sum transfer[a]	

[a] balancing item

6 National accounting experience to improve current transport accounts

This chapter explores the extent to which national accounting experience can contribute to the framework discussed in Chapters 3 and 5. The following main points come out of the analysis:

- National accounts offer an accounting scheme for the economy as a whole. They can be interpreted as a collection of business-type accounts for the various actors in the economy. The business-type components in the transport accounts should be consistent with the national accounting information.
- Transport activities are not well represented in standard national accounts and input-output tables. For example, the value added of the transport sector in the national accounts does not take into account the transport services organised by the non-transport sectors (own-account transport) and by households. Section 6.1 describes how the transport activities can be represented in a better way by means of Transport Satellite Accounts. The methodological insights of this process are directly useful for the construction of the UNITE pilot accounts.
- The third point concerns a more indirect contribution of national accounts to infrastructure charging. A good system of satellite accounts allows to construct a Social Accounting Matrix (SAM). The SAM gives the necessary information for a general equilibrium model. As discussed in Chapter 5 this is the ideal instrument to assess the welfare and equity effects of transport policies. The construction of a traditional SAM is explored in Section 6.2. Section 6.2.2 briefly discusses the current developments on the integration of environmental and accident costs in the SAM framework.
- Finally, ongoing research on green accounting can contribute to the incorporation of environmental and accident costs in the social and welfare accounts.

6.1 A better representation of transport activities in the national accounts[28]

The standard Input-Output representation of the national economy shows – for a given year – the flows of goods and services between the several sectors in which the economy is divided: industries, final consumption, gross final capital formation, external trade. The source of data for Input-Output tables is the System of National Accounts (SNA). Input-Output tables are usually presented in the form of a matrix of interindustry transactions. A schematic I-O account is shown below:

<table>
<tr><td></td><td>Intermediate Transactions</td><td colspan="3">Final Demand</td><td></td></tr>
<tr><td></td><td>Industries</td><td>Households</td><td>Government</td><td>Other</td><td>Total sales</td></tr>
<tr><td>Industries</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Wages and salaries</td><td></td><td colspan="3" rowspan="3">Total Value Added = Final Demand = GDP</td><td></td></tr>
<tr><td>Profits</td><td></td><td></td></tr>
<tr><td>Other</td><td></td><td></td></tr>
<tr><td>Total costs</td><td></td><td></td><td></td><td></td><td></td></tr>
</table>

Based on definitions adopted in the SNA, economic flows in the I-O accounts are evaluated using the following price concepts:

[28] Appendix G discusses in more detail how transport activities are measured in the standard national accounting framework.

Purchaser's price (which includes non-deductible VAT)	
less trade and transport margins	
less non-deductible VAT-type taxes	**Producer's price**
less taxes on products other than VAT	
plus subsidies on products payable/receivable by their producers	**Basic price**

Thus, the difference in the I-O framework between the purchasers' prices and the basic prices of products is made up of:

- taxes on production and imports, such as for instance taxes on fuels;
- less subsidies;
- plus trade margins and any transport charge paid separately by the purchasers in taking delivery at the required time and place. These are relevant only for goods and not for services, as these are supplied directly from the producer to the user.

The recommended method of evaluation of product flows is at basic prices. These record the amounts available to the producer, and their use is equivalent to the valuation at factor costs recommended for the UNITE transport accounts (see Link et al., 2000).

6.1.1 The standard I-O representation of transport activities

The entries in input-output accounts are often valued in producer's prices, while the purchaser incurs the producer's price plus trade and transportation margins (the purchaser's or consumer's price). The conventional rule in most input-output studies is to assign all transportation margins on inputs to the entry for "transport sector". But transportation margins do not tell the full story. Commercial freight transport services enter directly as intermediate inputs to all the industries, as well as any other sector. In addition, a substantial part of freight transport costs – those related to own-account transport – are embedded in the intermediate consumption of other goods (e.g. fuel) provided by non-transport sectors.

The standard I-O representation of transport activities explicitly shows the costs of transport services only when these are paid separately by the purchaser (transport margins) or enter as an input in the intermediate consumption of industries (commercial transport services), while own-account transport costs remain hidden in the outlays for other non-transport inputs.

6.1.2 The treatment of taxes and subsidies in the standard I-O accounts

The difference between producer's and basic prices is created by taxes and subsidies on products. The I-O scheme of accounts presented above is based on the assumption that an industry produces one and only one distinct commodity or service. Only the classification of economic activities by industry is considered. An alternative way of constructing input-output tables that more accurately account for secondary production is to present industrial data according to two distinct classification schemes: i) industry accounts and ii) commodity accounts. The latter classification identifies detailed categories of goods and services that are produced as primary or secondary products, in different mixes, by the various industries. This classification is relevant for taxes and subsidies that are usually related to specific quantities or values of goods and services. The standard I-O accounts can now be sketched as follows:

		Goods and services	Production	Final demand	Total revenues
		Products	Industries	Households, Government, Other	
Goods and services	Products	Trade and transport margins	Intermediate consumption at purchaser's price (use matrix)	Final demand at purchaser's price	Total revenues of products at purchaser's price
Production	Industries	Output at basic price (supply matrix)			Total revenues of industries at basic prices
Value Added	Wage and salaries Profits Other		Gross Value added at basic prices	Gross Value Added + Taxes – Subsidies = Total Final Demand = GDP	
Tax and Subsidies		Taxes on products less subsidies			
Total costs		Total cost of products at purchaser's price	Total cost of industries at basic price		

6.1.3 <u>The representation of transport activities in the Transport Satellite Accounts</u>

Transport Satellite Accounts (TSA)[29]offer the possibility to render fully explicit the components of transport services hidden in the standard I-O framework. These TSA expand the analytical capacity of national accounting for transport in a flexible manner, without overburdening or disrupting the central system. They typically allow for:

- the provision of a full accounting of transport;
- the use of complementary or alternative concepts, as for example when the concept of production is enlarged to include households services;
- extended coverage of costs and benefits of transport;
- further analysis of data by means of relevant indicators and aggregates;
- linkage of physical data sources and analysis to the monetary accounting system.

At the core of TSA we have I-O supply and use tables where producers of transport services, connected goods and services, and other products are identified. Producers of transport services are presented in detail, using the standard distinction between:

- <u>market producers</u>, which produce transport services for sale at prices which are economically significant;
- <u>non-market producers</u>, which supply most of the transport activities they produce without charge or at prices which are not economically significant
- <u>own-account producers</u>, who produce transport services for direct use by the owners of the enterprises in which they are produced.

To avoid double counting, the value of own-account transport activities that is allocated in the TSA to the transport sector must be subtracted from the intermediate consumption of the "other (non-transport) producers". These other non-transport producers can all be grouped together, unless it is useful to show the main providers of intermediate inputs (e.g. production of fuels) or fixed capital (e.g. production of transport means) to transport services, or suppliers of certain connected goods and services, separately.

[29] Appendix G describes the pilot TSA for the US, France and Switzerland.

Table 17 shows how the different categories of transport activities could be included in a system of TSA. This allocation reflects a complete separation of infrastructure building, maintenance and operation costs and supplier operating costs. The last column in Table 17 indicates the source of the data in the national accounts.
Infrastructure operators are assigned to the "non market producers" category because they cannot sell their output at economically significant market prices. On the contrary, the suppliers of transport services are assigned to "market producers", because they sell their services at economically significant prices (even if at times heavily subsidised).
Table 17 also considers the own-account transport activities of households (private car driving) and business units (transport of goods with firm owned vehicles). Households own-account transport can be isolated from private consumption totals, while business own-account transport must be subtracted from the intermediate consumption of industries.

Table 17: Allocation of transport activities in the ideal I-O framework

Market producers	Non market producers	Own-account producers	Moved from:
	Infrastructure costs of:		
	National roads		State expenses
	Regional roads		Regional expenses
	Local roads		Local expenses
	National rail		National rail operator (°)
	Regional rail		Regional rail operator (°)
	Local rail/metro		Local rail operator (°)
	Inland waterways		State expenses
	Ports		Port authority accounts
	Airports		Airport operators
	Freight platforms		Freight platform operators
Supplier operating cost for:			
Passenger road transport			
- *National bus services*			
- *Regional bus services*			
- *Local bus services*			
For-hire road transport of goods			
Passenger transport by rail			
- *National rail*			National rail operator (°)
- *Regional rail*			Regional rail operator (°)
- *Local rail/metro*			Local rail operator (°)
Freight transport by rail			National rail operator (°)
Inland waterways			
Short sea shipping			Maritime companies
Air transport			
		User costs of:	
		Household private car transport	Private consumption
		Business own-account transport	Intermediate consumption

(°) whenever operators are vertically integrated

Some of these changes are GDP-neutral, because they only entail a redistribution of output and value added among the industries, without changing the total for the national economy. The production boundary and the concepts of consumption and capital formation used in the SNA central framework are left unchanged. This would be the case for, e.g., the re-allocation of own-account transport from non-transport sectors to a "new" transport sector. Other changes have an impact on GDP. For example, including transport services provided by households for their own use in the transport production sector, enlarges the production boundary, moving within the production sector activities that in the SNA central framework are classified as final demand. The exact implications of these changes for the level and composition of GDP cannot be easily ascertained, unless a clear criterion to estimate the value of the output produced by a new households' (self-)production of transport is provided.

The allocation of the other items in Table 17 does not substantially diverge from the current national accounting experience. In fact, all private operated commercial freight and passenger transport services for the different modes are classified as market producers. Also state, regional and local public transport services are classified as market services, because fares are considered economically significant. Moreover, the tendency towards privatisation of public transport is rendering this service even more market oriented. Finally, non-market producers include state, regional and local government's maintenance, management and control of transport infrastructure, whenever these activities are owned and operated by the government free of direct charges.

What is the concrete relevance of the TSA for our purposes? They provide aggregate information on the purely economic elements in the business, social and welfare accounts. This is important as a consistency check. Secondly, the methodology for constructing the TSA is useful for the construction of the UNITE accounts. However, for policy purposes they provide insufficient information, for the same reasons as the business and social accounts. Finally, another role of the TSA is described in the next section.

6.2 Integration of TSA with Social Accounting Matrices

TSA are a first step towards a better representation of transport activities in the national accounts. A second step is to integrate these satellite accounts into an overall Social Accounting Matrix (SAM) of the national economy. A SAM plays a crucial role in the construction of Applied General Equilibrium models that are the empirical correlates of the theoretical general equilibrium models. These are the ideal instrument to assess the efficiency and equity of impacts of transport policies.

6.2.1 What is a SAM?

A SAM can be defined as a numerical representation of the economic cycle with emphasis on distributive aspects. At a glance, a SAM shows how sectoral value added accrues to production factors (labour, land, capital) and their institutional owners (households, government, other institutions); how incomes, corrected for net current transfers, are spent; and how expenditures on commodities lead to sectoral production and value added, closing the circle. The transactions, aggregated for a total national economy in a particular year, appear in a matrix format, showing receipts on the rows and outlays in the columns. Five types of transactions are distinguished: supply and use of goods and services, production of output and value added, distribution of income, use of income, and capital transactions. The matrix shows the detail of all these transactions inside the national economy and with the rest of the world. Each account is represented by a row and column pair, which represent complete balances, in the sense that total incomings (row sums) equal total outgoings (column sums).

The starting point to build a SAM is the I-O framework discussed so far. A simplified[30] template of a SAM is shown in Table 18. A SAM includes not only production flows based on industry and product classification, as in the I-O accounts (reproduced in the first two rows and columns of Table 18), but also several rounds of income distribution, until the final usage for consumption or saving. New consolidated accounts added in the SAM are:

- three consolidated accounts (*generation of income, allocation of income, secondary distribution of income*), which show how the net value added generated by industries is distributed, in different stages, to the institutions. The generation of income account maps a first phase, giving total income earned by the institutions as providers of primary inputs. The subsequent accounts - allocation of primary income and secondary distribution - map the redistribution of income among the institutions caused by property income flows, income and wealth tax flows, net social contributions and other current transfers (including, e.g., subsidies from central to local governments to finance public transport operation). The final result is the distribution of net disposable income by institutions;
- the *use of income account,* which records spending of net disposable income: final consumption expenditures on goods and services and net saving;
- the *capital account*, which presents by row the availability of capital funds for the institutions, and by column the allocation of these funds among changes in inventories, capital transfers and net fixed capital formation;
- the *fixed capital formation account*, which records by row the investments of the institutions in the industries and by column the purchase of capital goods by the industries

Each of the accounts included in a SAM can be tailored, selecting the desired detail for the classification of products, industries and institutional sectors (e.g., different government levels). The actual appearance and completeness of the SAM is heavily dependent on the data available in the national context. SAMs incorporating transport activities are not yet widely constructed (for an example, see Mayeres (1999))[31] and certainly not by statistical offices. The first pilot experiences of TSA can provide a basis for the development of the SAM.

6.2.2 Traditional SAM versus extended SAM

The SAM scheme can be further expanded, adding two rows and columns to account for, respectively, the impacts of transport and other economic activities on the environment (natural assets) and on safety for humans (human assets). National accounts aggregates can be amended to treat natural and human resources as capital in the production of goods and services, and to record the cost of using – i.e. depleting and

[30] financial and rest of the world accounts of the full template are excluded

[31] Mayeres, I. (1999) *The Control of Transport Externalities: A General Equilibrium Analysis*, Ph.D. Dissertation, Faculty of Economics and Applied Economics, K.U.Leuven.

degrading – those resources. This can be done based on current developments in the green accounting research field, which are converging towards a standard System of Environmental Economic Accounts (SEEA), sponsored by the United Nations Statistical Division. However, the SEEA should be considered as work-in-progress, as many of its elements continue to be discussed.

As regards the environmental impacts, the extended scheme will allow to account for two main processes: i) accumulation of economic non-produced natural assets, i.e. the transfer of natural assets to economic uses which changes the stock level of non-produced economic assets (e.g. the transfer of land to economic uses, the net additions to proven mineral reserves etc.); ii) uses of non produced natural assets by depletion and degradation consequent to production activities (e.g. the effects of emission of residuals on the quality of air, water etc.). If in the accounts a monetary evaluation of environmental impacts is used, an environmentally adjusted net domestic product (EDP) and other environmentally adjusted concepts concerning the capital stocks of the economy can be derived. Similar concepts can be finally applied to include the effects of accidents on human well-being.

The ongoing research in this field can provide insights for the treatment of environmental and accident costs in the social and welfare accounts.

Table 18: Simplified template of a Social Accounting Matrix

		Goods and services	Production	Generation of income	Allocation of primary income	Secondary distribution of income	Use of disposable income	Capital	Fixed Capital Formation	TOTAL RECEIPTS
		(Products)	*(Industries)*	*(Value Added categories)*	*(Institutions)*	*(Institutions)*	*(Institutions)*	*(Institutions)*	*(Industries)*	
Goods and services	*(Products)*	Trade and transport margins	Intermediate consumption (use matrix)				Final consumption expenditure	Changes in inventories	Gross fixed capital formation	
Production	*(Industries)*	Output (supply matrix)								
Generation of income	*Wage and salaries Profits Other*		Net Value Added							
Allocation of primary income	*(Institutions)*	Taxes on products less subsidies		Net generated income	Property income flows					
Secondary distribution of income	*(Institutions)*				Net national income	Taxes on labour, wealth, social contributions, current transfers				
Use of disp. income	*(Institutions)*					Net disposable income				
Capital	*(Institutions)*						Net saving	Capital transfers		
Fixed capital formation	*(Industries)*		Consumption of fixed capital					Net fixed capital formation		
TOTAL OUTLAYS										

7 Conclusions

Questions and structure

1. In this deliverable we analyse how marginal cost and transport accounts information can be used for transport policy. The analysis is conceptual. There is a need for clear concepts and principles because many countries use different types of transport accounts and have different ideas about the role of marginal costs in pricing. We address five types of issues.

– The deliverable starts by explaining basic transport pricing and investment principles. These principles are well known in the case of perfect information for the government but are less clear when there are multiple outputs, budget constraints and when there is asymmetric information for the transport agency. The transport sector is most often also analysed in isolation and we show why a more global view of the economy can generate useful insights.

– Next, we confront these theoretical insights with current pricing and cost-recovery doctrines in different member states and find that practice differs strongly from the theoretical principles for efficient pricing. We give an overview of the concerns giving rise to this practice and show that these may be addressed by standard economic theory.

– In a third part we analyse how transport accounts can help to monitor the efficiency effects of transport policy. Does an increasing surplus in a transport account tell us that our transport policy is successful? What type of transport account does one need for this?

– Transport accounts by mode are sometimes also used to keep track of distributional effects of transport policy. The extent to which this is possible is the next question that we address.

– National accounts are the cornerstone of macro-economic models, is the national accounting methodology a useful starting point to improve the transport accounts?

Transport pricing principles

2. In economics, short run marginal social cost (SRMSC) pricing is the benchmark for an efficient transport pricing policy. This principle holds when there are no other price distortions in the economy and when there are no income distribution concerns. The short run social marginal cost contains the marginal resource costs, marginal infrastructure costs, scarcity or external congestion costs and external environmental and accident costs. The SRMSC principle makes sure that the existing infrastructure is used as efficiently as possible. Whether the infrastructure is at an efficient level and is optimally maintained will affect the level of the SRMSC but not the principle.

3. To determine an efficient investment level requires a cost-benefit analysis that trades off the benefits of infrastructure extension (discounted sum of saved user costs, including time, saved external accident and environmental costs, reduced maintenance costs) and the costs of an infrastructure extension (investment costs). This rule only holds if there is SRMSC pricing and if there are no other distortions in the economy.

4. These pricing and investment benchmarks cannot generally be used because there are price distortions in other markets and because there are concerns about income distribution. This implies that SRMSC pricing is no longer optimal but also that any “constrained” pricing rule will be based on carefully balanced deviations from the SRMSC.

5. This can easily be demonstrated in the case of budget constraints for a given mode. In this case, prices for an output should receive a mark up on top of the SRMSC that will be larger for those products that have a low elasticity of demand.

6. When prices cannot be tailored to each transport market separately, the optimal pricing rule will again balance the deviations of the common price with the SRMSC of the different markets while giving a higher weight to the price elastic markets. This allows to minimise the welfare losses caused by the pricing restrictions.

7. In competitive markets, prices will tend to the short run marginal cost (SRMC) and need only be supplemented by externality taxes to obtain SRMSC pricing. Transport infrastructure markets are not necessarily competitive because of the existence of fixed costs or increasing returns to scale. For monopoly markets, prices will be larger than the SRMC and will not take external effects into account. The monopolist will use SRMC information to compute profit maximising prices. He applies the same principles as a transport agency subject to a budget constraint. When the policy maker does not have perfect information on the marginal cost and the demand structure, he needs to rely on price regulation and externality taxes to implement better transport prices.

8. The transport agency can choose between several types of price regulations. The two extremes are a price-cap and cost of service regulation. In pure cost of service regulation, the transport agency covers all costs made by the transport supplier, including a normal profit margin and the transport agency sets optimal prices. If the transport agency can use subsidies, the prices can be set equal to the SRMSC. The major problem will be to induce sufficient cost reductions from the side of the transport supplier who has no incentive to limit costs.

9. The other regulation alternative is to use a price cap: the transport agency sets prices according to the SRMSC pricing rule, gives a fixed subsidy to the transport firm to cover its expected deficit but gives away all the profits to the transport firm. The firm has now an incentive to reduce its costs because any cost reduction results in an equivalent profit increase. In some cases the government can auction the right to supply a given transport service at predetermined output prices.

10. Setting up good price regulation schemes under imperfect information is a complex task because the regulator does not know the marginal costs. Determining the marginal costs in a multi-product firm with joint costs is difficult. It may be more efficient to leave the pricing decisions with the firms and put a cap only on the average price index.

11. There are two reasons why the government cannot look at transport pricing issues in isolation and without considering the rest of the economy. Price distortions exist on other markets and there is also a concern for income distribution. One of the most important price distortions in an economy is the taxation of labour (via income taxes, social security contributions and VAT). This has several implications for the pricing of transport. First, any subsidy to the transport sector has to be funded by relying on extra labour taxes. The cost of a EURO of extra tax revenue can be high. Conversely, an increase in tax receipts in the transport sector should be devoted primarily to a decrease of existing labour taxes. Secondly, for transport goods that are a complement to labour, e.g. transport to work, the optimal price could be lower than the SRMSC.

12. Income distribution concerns are important for policy makers. Income distribution concerns can be best met by considering a wider set of instruments than transport prices and subsidies. An important criterion for the appropriateness of subsidies or lower taxes on a given good is the relative consumption of that good by low-income classes together with a low price elasticity. The latter is important in order to limit the resource allocation losses of distorted prices. In order to judge the income distribution effects of certain subsidies or taxes in the transport sector financed by tax revenue on other goods it is crucial to know who consumes these other goods.

Current transport pricing doctrines in the member states

13. In the European countries that have been surveyed (Austria, France, Germany, Ireland, Spain, Switzerland, United Kingdom), the pricing doctrine used is in general different from SRMSC pricing. Most often one refers to principles more akin to long run marginal cost, such as “development cost”, “average cost” or “full cost” allocation. This is mainly motivated by concerns about the difficulties and manipulability of SRMSC calculations and by equity concerns. These concerns are valid. However, they can be addressed by standard economic theory. No recourse is needed to other pricing principles that are more arbitrary.

The use of transport accounts to monitor the efficiency of transport policies

14. Business-type accounts do not allow measurement of the welfare effect of a given pricing or investment policy. Adding external environmental and accident costs and taking into account different types of tax revenues does not solve the problem. What is needed is an account that reports the different elements integrated in a cost-benefit analysis. This means that the generalised consumer surplus has to be taken into consideration and that changes in travel time costs need to be reported in order to have a correct welfare account.

15. Firms use aggregated accounts to inform their shareholders and the tax authorities about their performance. The detailed cost accounting is used by the firm and its divisions to improve pricing and investment decisions. One could envisage a similar division of roles for aggregate and detailed transport accounts. The (corrected) aggregate transport account can then be used to judge the overall transport policy while the detailed information can be used for the pricing and investment decisions by different regions and modes. The aggregation of profits of different production units is obviously a much easier task than the aggregation of welfare effects of different modes and regions.

Can one measure distributional effects with transport accounts?

16. Business-type accounts or social accounts do not allow measurement of the distributional effects of transport policies. Instead, one has to use welfare accounts that are adapted by applying social welfare weights to information segmented by income group.

The use of national accounting experience to improve transport accounts

17. National accounting experience has three messages for the transport accounts. The first message is that transport accounts need to be consistent with the National Accounts, which are an accounting framework for the overall economy. The second message is that the transport activities are not very well represented in most national accounts. The value added of the transport sector in the national accounts does not take into consideration the transport services organised by non-production sectors and by the households themselves. For this reason the present national accounts are not a useful basis for transport policy and need to be extended by means of Transport Satellite Accounts. Finally, such a system of satellite accounts allows to construct a Social Accounting Matrix (SAM) which is supportive of the use of welfare accounts. This SAM is the necessary information for a general equilibrium model. As we know, this is the ideal instrument to assess the welfare and equity effects of transport policies.

Concluding remarks

18. This deliverable has not been able to consider all aspects of infrastructure charging. Topics that were not discussed and that warrant further research include the implementation of transport pricing (e.g., the choice of instruments, technical implementation) and the impact of transport policies on land use. The deliverable also provides no information about the magnitude of welfare differences between various pricing regimes. This will be explored in the further stages of the UNITE project, where partial and general equilibrium models will be used to assess the welfare impacts of alternative charging principles.

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Appendix A: A list of abbreviations and symbols

List of abbreviations

EDP	environmentally adjusted net domestic product
GDP	gross domestic product
I-O	input-output
LRMC	long run marginal cost
SAM	social accounting matrix
SEEA	system of environmental economic accounts
SNA	system of national accounts
SRMSC	short run marginal social cost
TSA	transport satellite accounts
VAT	value added tax

List of symbols

Section 2

MC	marginal cost
AC	average cost
P	price
X	quantity produced

Sections 3.2 – 3.4

j, k, n:	indices for transport markets
ε_{gg}	own generalised price elasticity of the demand for x
ε_{kj}	cross-price elasticity of demand for commodity k w.r.t. the generalised price of commodity j
$1+\lambda$	marginal cost of public funds
Φ_{jk}	parameter reflecting the congestive effect of mode k
ψ	the share of individuals not supplying labour
C	maintenance and running costs of transport infrastructure
CAP	the total capacity of the transport market
CS	consumer surplus
D	durability of the transport infrastructure
ECC_X	marginal external congestion cost of transport use
$ECNC$	total external cost other than congestion
g	generalised cost
h	the value of travel time
m	external cost regulation
N	number of transport users
p	producer price
PS	producer surplus
r	the interest rate

rK capital costs for the infrastructure
S_{kj} compensated change in the demand for commodity k w.r.t. the generalised price of good j
t tax rate
T the time needed per unit of transport service
TR indirect tax revenue
W social welfare
x individual quantity of transport services consumed
X total volume of transport use

Section 3.5

i index for consumers
j, k indices for commodities

$\overline{\beta}$ the average direct social marginal utility of income
β^i direct social marginal utility of income accruing to individual i
ζ the marginal willingness-to-pay for a reduction in the externality Z.
ξ externality feedback parameter
φ marginal utility of income

e^i earning capacity of consumer i
l individual labour supply
L total labour supply
LS uniform lump sum transfer
N the number of individuals
PA_j investments in public abatement for transport mode j
q_k the consumer price of commodity k
R public revenue
R_j public revenue raised by the tax on commodity j
R^* resources required by the government
T^* total time available
t_k tax rate of commodity k
U utility
V indirect utility
W social welfare
x_k individual consumption of commodity k
X_k total consumption of commodity k
Z externality

Section 5

i index for consumers
j index for commodities

$\overline{\beta}$ the average direct social marginal utility of income
β^i direct social marginal utility of income accruing to individual i

LS uniform lump sum transfer

N	the number of individuals
PA_j	investments in public abatement for transport mode *j*
R_j	public revenue raised by the tax on commodity *j*
t_j	tax rate of commodity *j*
x^i_j	individual consumption of commodity *j* by individual *i*
X_j	total consumption of commodity *j*
Z	externality

Appendix B

j	index of commodities
k	index of acticities
φ	marginal utility of income
μ	marginal utility of time
α	the proportion of saved travel time that is used for leisure
ρ	the proportion of saved travel time that is used for work
γ	the ratio between productivity of work during travel and usual productivity
ν_k	Lagrange multiplier associated with the time allocation constraint for commodity *k*
f	the value of a marginal time saving for professional trips
$h_{\overline{T_k}}$	value of a marginal time saving for activity *k* (or the value of time for activity *k*)
q_j	consumer price of good *j*
PM	the usual productivity at work
T^*	total time available
T_j	time needed for the consumption of one unit of good *j*
t_w	the income tax rate
T_w	time spent in work
$\overline{T_k}$	minimal time for activity *k*
U	utility
V	indirect utility
VL	the disuse of travel
VW	the difference between disuse of travel and disuse of work
w	hourly wage rate
x_j	consumption of good *j*
y	income

Appendix B: Generalised cost as a shortcut

It is acknowledged that transport decisions are based, not only on price of transport, but also on quality of service considerations, such as comfort, reliability, and time spent. In order to take into account these factors, the concept of generalised cost of transport has been devised and introduced in the consumer's behaviour theory. It is an extension of the concept of price in this classical theory. This Appendix is devoted to the definition of the concept. A first sub-section recalls the role of prices in the classical consumer's behaviour theory, a second subsection is devoted to the introduction of time in this theory and, finally, a third one introduces the concept of generalised cost.

B.1. The role of prices in the classical consumer's behaviour theory

In the classical consumer's behaviour theory, each consumer is endowed with a utility function that depends on the quantities of each available commodity that the agent consumes. This function is increasing in each of its arguments and generally assumed to be non-convex (this assumption ensures that the following optimisation process has no corner solution). The consumer aims at maximising his utility under the constraint of his income *y*:

$$\begin{aligned} &Max \quad U(x_1,...,x_I) \\ &s.t. \quad \sum_{j=1}^{I} q_j x_j \leq y \end{aligned}$$

The solution of this program provides the demand functions. Under the assumptions that the utility function is quasi-linear, for instance in the case of three goods,

$$U = x_1 + u(x_2, x_3)$$

It can be shown that the demand functions of x_2 and x_3 do not depend on income. Besides, the maximum value reached by *U*, which is called the indirect utility function, has a simple expression:

$$V(q_2, q_3, y) = y + \upsilon(q_2, q_3)$$

B.2. Introducing the value of time

In this extension of the previous classical theory, the analysis takes into account the fact that consumption takes time, and that leisure (i.e., spending time without doing anything) has also a utility.

B.2.1. Simple time constraint

In the simplest framework, the assumption is made that consumption of one quantity of a good *k* takes an amount of time T_k, and that total available time is limited. The consumer has to maximise his utility $U(x_1,...,x_I)$ under the constraints:

$$\sum_{j=1}^{I} q_j x_j \leq y \qquad (\varphi)$$

$$\sum_{j=1}^{I} T_j x_j \leq T^* \qquad (\mu)$$

φ and μ are the dual variables linked to these two constraints. It follows that:

$$\frac{\partial U/\partial x_j}{\varphi q_j + \mu T_j} = 1$$

φ represents the marginal utility of income, and similarly μ represents the marginal utility of time. μ/φ may be named the value of time: an increase in the available time by one unit is equivalent to an increase in income by μ/φ.

V, the optimal value for the utility function, depends on the vector of prices q, on the vector of the unit time requirements T, on income y and on total available time T^*.

$$V = V\left(q, T, y, T^*\right)$$

B.2.2. Activity models

It is clear that this model is too crude. In reality, the time devoted to the consumption of a commodity is not proportional to the quantity of the commodity and it does not have the same value for all activities. A more elaborated model makes the assumption that the utility depends on two kinds of arguments: the quantity of consumed commodities x_j and the time spent in various activities T_k (k=1,...,M) and in work (T_w):

$$U = U\left(x_1, \ldots, x_I, T_1, \ldots, T_M, T_w\right)$$

It is assumed to be maximised under the constraints:

$$\sum_{j=1}^{I} q_j x_j - \left(wT_w + y\right) \le 0 \qquad (\varphi)$$

$$Tw + \sum_{k=1}^{M} T_k x_k \le T^* \qquad (\mu)$$

$$\overline{T_k} - T_k \le 0 \;\; \left(\nu_k\right) \;\; k = 1, \ldots, M$$

w is the hourly wage rate, $\overline{T_k}$ is the minimal time for activity k and T^* is the total available time (24 h per day). The optimisation process gives:

$$\frac{\partial U}{\partial T_k} - \mu + \nu_k = 0 \qquad k = 1, \ldots, M$$

$$\frac{\partial U}{\partial T_w} + \lambda w - \mu = 0$$

$$\left(T_k - \overline{T_k}\right)\nu_k = 0 \qquad k = 1, \ldots, M$$

and leads to the indirect utility function:

$$V\left(q, T, w, T^*, y\right)$$

The value of a marginal time saving for activity k (also referred to as the value of time for activity k) is:

$$h_{\overline{T_k}} = -\frac{\partial V}{\partial \overline{T_k}} \Big/ \frac{\partial V}{\partial y} = \frac{\nu_k}{\varphi} = \frac{\mu - \partial U/\partial T_k}{\varphi}$$

or:

$$h_{\overline{T_k}} = \left(w + \frac{\partial U/\partial T_w}{\varphi}\right) - \frac{\partial U/\partial T_k}{\varphi} \qquad \text{(A1)}$$

Two cases may happen :

- If $T_k > \overline{T_k}$, then $h_{\overline{T_k}} = 0$

The marginal value of a time saving for activity *k* is zero. Activity *k* is a pure leisure activity.

- If $T_k = \overline{T_k}$, then $h_{\overline{T_k}} \neq 0$

This is the case for intermediate activities, such as transport. Expression 1 tells that the value of a marginal time saving in activity *k* equals the difference between the marginal value of time devoted to labour (which equals the sum of the wage rate and the marginal utility of labour time, expressed in monetary terms) and the marginal value of time devoted to activity *k*.
It is clear that in that model, the value of time $h_{\overline{T_k}}$ depends on the activity *k*. It also depends on the characteristics of the consumer. In the most current numerical applications, values of time differ according to income, the purpose of travel, as well as the degree of comfort of the mode of transport.

B.2.3. Opportunity models

The previous developments are valid only in the case of consumer's behaviour. Other models are devised in order to introduce the value of time for professional trips or for freight transport. Let us present a model introducing the value of travel time for professional purposes. The analysis is based on the opportunity cost of travel time for the firm (Hensher, 1977)[32]. This value is expressed as:

$$f = (1-\alpha-\rho)PM + \frac{1+\alpha}{1-t_w}VW + \frac{\alpha}{1-t_w}VL + \Delta PM$$

a formula in which the following symbols are used:

α	the proportion of saved travel time that is used for leisure
ρ	the proportion of saved travel time that is used for work
γ	the ratio between productivity of work during travel and usual productivity
PM	the usual productivity at work
VW	the difference between disuse of travel and disuse of work
VL	the disuse of travel
ΔPM	the increase of productivity allowed by the decrease in tiredness due to the reduction in travel time
t_w	the income tax rate.

B.3. The generalised transport cost

Having defined the value of travel time, it is easy to introduce the concept of generalised transport cost. For instance, in the model with the simple time constraint, if x_j represents the quantity of transport, a variation in x_j induces a variation of utility given by:

$$\frac{\partial U}{\partial x_j} = \frac{\partial V}{\partial y} q_j + \frac{\partial V}{\partial T^*} T_j$$

[32] Hensher, D.A. (1977) *Value of Business Travel Time*. Pergamon, Oxford.

and $\left(q_j + \frac{\partial V}{\partial T^*} \Big/ \frac{\partial V}{\partial y} T_j \right)$ appears to play the same role as a price in the classical formulation of consumer's behaviour, with $\left(\frac{\partial V}{\partial T^*} \Big/ \frac{\partial V}{\partial y} \right)$ the value of time.

Similarly, in the activity model, if transport is activity *k*, the monetary cost of which is q_k it appears that:

$$\frac{\partial U}{\partial x_k} = \frac{\partial V}{\partial y} q_k + \frac{\partial V}{\partial \overline{T}_k} T_k = \frac{\partial V}{\partial y} \left(q_k + \frac{\partial V}{\partial \overline{T}_k} \Big/ \frac{\partial V}{\partial y} T_k \right)$$

Here too, it is possible to define a generalised cost, which is the synthesis of the factors which have impact on the utility of transport for the consumer and which influence his decisions. This generalised transport cost is:

$$q_k + \frac{\partial V}{\partial \overline{T}_k} \Big/ \frac{\partial V}{\partial y} T_k$$

The above expression includes only time. It would be easy, following the same reasoning, to include other parameters of quality of service, such as safety, reliability, comfort, and to enrich the expression of the generalised cost with them.

Appendix C: One transport market: derivations

Maximising (1) leads to the following first order conditions for *p*, *CAP*, *D* and *m*:

$$(p) \quad N\frac{\partial CS}{\partial g}\left(1+h\frac{\partial T}{\partial X}N\frac{dx}{dp}\right)+(1+\lambda)\left[N\frac{dx}{dp}\left(t+p-\frac{\partial C}{\partial X}\right)+X\right. \\ -\frac{\partial ECNC}{\partial X}N\frac{dx}{dp}=0 \qquad \text{(A2)}$$

$$(CAP) \quad N\frac{\partial CS}{\partial g}h\frac{dT}{dCAP}+(1+\lambda)N\frac{\partial x}{\partial g}h\frac{dT}{dCAP}\left(t+p-\frac{\partial C}{\partial X}\right. \\ -(1+\lambda)(C_{CAP}+rK_{CAP})-\frac{\partial ECNC}{\partial CAP}-\frac{\partial ECNC}{\partial X}N\frac{\partial x}{\partial g}h\frac{dT}{dCAP} \\ =0 \qquad \text{(A3)}$$

$$(D) \quad -(1+\lambda)\left(\frac{\partial C}{\partial D}+r\frac{\partial K}{\partial D}\right.=0 \qquad \text{(A4)}$$

$$(m) \quad -(1+\lambda)\frac{\partial C}{\partial m}-\frac{\partial ECNC}{\partial m}=0 \qquad \text{(A5)}$$

Derivation of (2):

Start from (A2), divide by $N\frac{dx}{dp}$ and use $\frac{\partial CS}{\partial g}=-x$ and d*x*/d*p*=d*x*/d*g*.

Define $\varepsilon_{gg}=\frac{dx}{dg}\frac{g}{x}$ and $ECC_X=XhT_X$. Substitute and rearrange.

Derivation of (4):

Start from (A3), use $\frac{\partial CS}{\partial g}=-x$ and rearrange.

Appendix D: Two related transport markets: derivations

Maximising (7) with respect to p_k gives the following first order condition:

$$N\frac{\partial CS}{\partial p_k}+(1+\lambda)\left[N\sum_{j=1}^{2}\frac{dx_j}{dg_k}\left(t_j+p_j-\frac{\partial C^j}{\partial X_j}\right)+X_k\right.$$
$$\left.-\sum_{j=1}^{2}\frac{\partial ECNC}{\partial X_j}N\frac{dx_j}{dg_k}=0\right] \qquad \text{(A6)}$$

Derivation of (8):

Use

$$\frac{\partial CS}{\partial p_k}=-x_k-\sum_{j=1}^{2}x_j h_j\left(\sum_{n=1}^{2}\frac{\partial T^j}{\partial X_n}N\frac{dx_n}{dg_k}\right), \qquad \text{(A7)}$$

divide by N and dx_k/dg_k. After rearranging one obtains (8).

Derivation of (9):

The absence of externalities means that in (A6)

$$\frac{\partial ECNC}{\partial X_j}=0 \qquad j=1,2$$

and that $\partial T^j/\partial X_n=0$ in (A7). The first order condition for p_k can then be rewritten as:

$$\lambda x_k+(1+\lambda)\sum_{j=1}^{2}\frac{dx_j}{dq_k}\left(t_j+p_j-\frac{\partial C_j}{\partial X_j}\right)=0$$

Assume that $p_j = C^j_{X_j}$ and use the Slutsky expression:

$$\frac{\partial x_j}{\partial p_k}=S_{jk}-x_k\frac{\partial x_j}{\partial y}$$

Rearranging and using $S_{jk}=S_{kj}$, one obtains (9).

Appendix E: General equilibrium analysis: derivations

Derivation of (15)

Taking the derivative of W with respect to t_k, PA_j and LS, and using (10) and (11) we get:

$$\frac{\partial W}{\partial t_k} = -\varphi\left(X_k + N\zeta \frac{\partial Z}{\partial t_k} \right) \qquad k = 1,...4; k \neq 3 \tag{A8}$$

$$\frac{\partial W}{\partial PA_j} = -N\varphi\zeta \frac{\partial Z}{\partial PA_j} \qquad j = 1,2 \tag{A9}$$

$$\frac{\partial W}{\partial LS} = N\varphi - N\varphi\zeta \frac{\partial Z}{\partial LS} \tag{A10}$$

$\partial Z/\partial t_n$ stands for the full effect of a marginal tax change on the externality. It is obtained based on the definition of the externality (12) and the demand functions $x_n(q,LS,Z)$:

$$\frac{\partial Z}{\partial t_n} = \xi \sum_{k=1}^{2} \frac{\partial Z}{\partial X_k} \left.\frac{\partial X_k}{\partial t_n}\right|_Z \qquad n = 1,2,4 \tag{A11}$$

with ξ defined as in. A similar expression can be derived for $\partial Z/\partial LS$. Substituting these in (A8) to (A10) and substituting the resulting expressions in (13), one obtains (15) after rearranging.

Derivation of (17)

Taking the derivative of R with respect to t_k, PA_j and LS, we get

$$\frac{\partial R}{\partial t_k} = X_k + \sum_{j=1}^{2} t_j \frac{\partial X_j}{\partial t_k} + t_4 \frac{\partial L}{\partial t_k} \qquad k = 1,2 \tag{A12}$$

$$\frac{\partial R}{\partial t_4} = L + \sum_{k=1}^{2} t_k \frac{\partial X_k}{\partial t_4} + t_4 \frac{\partial L}{\partial t_4} \tag{A13}$$

$$\frac{\partial R}{\partial PA_j} = -1 + \sum_{k=1}^{2} t_k \frac{\partial X_k}{\partial Z} \frac{\partial Z}{\partial PA_j} + t_4 \frac{\partial L}{\partial Z} \frac{\partial Z}{\partial PA_j} \qquad j = 1,2 \tag{A14}$$

$$\frac{\partial R}{\partial LS} = -N + \sum_{k=1}^{2} t_k \frac{\partial X_k}{\partial LS} + t_4 \frac{\partial L}{\partial LS} \tag{A15}$$

Substituting these expressions in (14) and rearranging, we get (17).

Appendix F: Current views on infrastructure charging in a selection of UNITE countries

The enquiry was held among UNITE partners in Austria, France, Germany, Ireland, Spain and the United Kingdom (7 respondents in total). The following questions were asked:

- Question 1: What are the differences between the picture given by the theoretical review and the current teaching at universities about transport?
- Question 2: What are the current doctrines expressed by the political authorities (Government, Parliament, etc.) on the subject of transport infrastructure pricing?
- Question 3: What is the real situation of present infrastructure pricing?

The next sections present the answers obtained for each of the reviewed countries:

AUSTRIA

(respondent: S. Suter, ECOPLAN)

Question 1

In Austria, teaching in transport economics and especially transport pricing does not have a long tradition compared with, for example, the situation in the United Kingdom. Marginal cost pricing is taught in the context of micro-economics in general and then applied to transport in the frame of special courses or seminars.

Differences between the picture given in the theoretical review and the current teaching do not refer to the theory but to the judgement of the relevance of marginal cost pricing theory for practical transport policy. The view that marginal cost pricing can and should be implemented in the Austrian transport policy, is not popular among representatives of Austrian universities. In the past, pricing has first of all been discussed in the context of generation of funds, i.e. cost recovery.

Question 2

So far, Austria has considered the environment as a priority issue – particularly in the context of road freight transit traffic – and followed an environment-oriented transport strategy. The main two aims were:

– the reduction of vehicle emissions,
– an increase in railway competitiveness.

At the moment it is difficult to judge whether the new government will pursue this policy or whether there will be a change in the priority setting.

The two objectives were implemented through regulatory measures, e.g. quantitative restrictions for traffic from/to other European States but also pricing measures (see question 3 below). However, pricing measures introduced so far serve first of all the generation of funds for the general budget and the financing of the construction, reconstruction and maintenance of the transport infrastructure.

Efficiency considerations and/or the approach of short-run marginal cost pricing do not influence the discussions about current and future transport pricing policy. Even in the context of the planned implementation of a distance-related road pricing system for lorries (> 3.5 t) on motorways, the derivation of the charge level will most probably be based on financing considerations and not on any marginal cost estimates (see question 3 below).

However, a on-going project on road transport infrastructure costs[33] will most probably result in an opening of the discussion about the future role of marginal cost pricing in the Austrian transport pricing strategy.

[33] Project “Wegekostenrechnung Strasse 2000”, project leader Max Herry, Vienna.

Question 3

Against the background described above it is not astonishing that marginal cost pricing approaches are not found in the current infrastructure pricing schemes in Austria. These schemes look as follows:

- **Road transport**

– The taxation of fuel serves as measure to generate revenues for the national treasury.
– There is a purchase tax whose level is based on the price of the vehicle and the fuel consumption.
– The annual vehicle tax depends on the engine size in the case of passenger cars and on the weight in the case of heavy goods vehicles.
– At the local level, there are parking fees whose revenues flow into the treasury of the local communities.
– Passengers cars and light goods vehicles < 12 t have to buy a vignette to use the motorways. On 5 roads and several tunnels there are road tolls. The revenues from these charges are used for the financing of road infrastructure costs.
– Heavy goods vehicles >12 t have to pay an annual road user charge ("STRABA") and the tolls on the roads and tunnels mentioned above. Furthermore, the eco-point system for transit traffic through Austria is still in force.

The charging system for heavy vehicles will change significantly in the next years because a distance-related charge ("Maut") for vehicles >3.5 t will be introduced on motorways and other trunk roads. The realisation is planned for the year 2002. The objective of the Maut is the generation of revenues to cover the costs of the extension and maintenance of the high-ranking road network. The revenues flow to the "Autobahnen- und Schnellstrassen-Finanzierungs AG" ASFINAG ("Motorway and Expressway Financing Company", a limited company owned by the state of Austria). The vignette for cars < 3.5 t will remain and will not be replaced by a distance-related charge as proposed in the past.

- **Rail transport**

The infrastructure access charge is a tariff based on two variable parameters: train-km and gross-ton-km. It is not based on marginal cost estimates.

- **Inland navigation**

The traffic on the Danube is free of charge. In harbours, there are charges to cover the harbour infrastructure costs. They are based on the handling of cargo (i.e. ATS/ton of handled cargo) and the time spent in the harbour. The level of the charge is derived from total cost estimates and not from marginal cost considerations.

- **Air transport**:

No information received but most probably no large differences compared with the situation in Germany and Switzerland.

FRANCE
(respondent: E. Quinet, ENPC)

Question 1

These principles are taught in the more advanced economics courses in universities. However, in other courses (equivalent to MBA) less sophisticated methods are taught. They are based on principles of cost allocation and focus on the treatment of common costs. The main problem is then to allocate construction costs. Several methods are presented. E.g., for roads they allocate the common costs between the various categories of traffic according to several factors, such as the area of the vehicle, or the so-called “dynamic area”, taking into account the average speed of the vehicle category and the distance between vehicles which is caused by their speed. There is a debate concerning the cost that has to be allocated. Is it the historical cost, or more precisely its yearly component? And how to reckon this yearly component? Or is it the cost of the present hypothetical construction of an infrastructure of that type? Maintenance costs are allocated between vehicles according to engineer ratios such as the power four of the axle-load for heavy repairs of the pavement. In such a procedure, congestion costs are not taken into account. The rail operator, SNCF, has devised very sophisticated procedures, derived from accounting principles, to allocate rail infrastructure costs among the different types of traffic.

Question 2

In the past several bodies or Commissions expressed opinions on the subject of infrastructure pricing. The doctrine has varied over the years. About twenty years ago, the principle was that freight should pay the marginal cost and passenger traffic should pay the full cost. The idea underlying was a kind of utilisation of the Diamond and Mirrlees result. More recently, the main stream of ideas shifted towards the use of full cost principle. Two ideas are behind this shift:

The first one was supported by many scholars: short run marginal cost is easily manipulable, and the operators could use their information advantage to minimise it, thus increasing their traffic and inducing more infrastructure investment than necessary, and furthermore increasing the need of public funds to finance these investments. This change was obvious in the report (“Transport, le prix d’une stratégie”, 1996) of a Commission composed of several experts and of the main administrations concerned by transport (Treasury, Environment, Transport,) which recommended the use of “development cost” (development cost is defined as the ratio between the discounted sum of the future investments on the network and the discounted sum of the increase in traffic which caused these investments. It is a kind of average long term marginal cost and has a meaning only for a sufficient large network). This position is made sensible by the fact that many scholars think that France suffers from over- and not from underinvestment.

The second idea is that equity and fairness are in the public opinion a much greater issue than efficiency. For instance, the French administration regularly (about every five years) edits a report in which the infrastructure costs of the various types of traffic (car, truck of several size, bus...) are calculated. Both marginal (including congestion, safety and environmental damages) and full costs (including environmental damages) are considered, and the emphasis is put on the full cost variant. Another hint: the annual report on transport national accounting puts the emphasis on the balance between the expenses and the revenues of each mode, focusing the interest on equity and fairness considerations above efficiency objectives.

Question 3

The situation of pricing implementation is the result of historical hazard much more than the result of a coherent and sensible will. Road is charged through many devices: fuel taxes, toll motorways, vignettes, parking fees. They are not decided by the same authority, but their main motivations are financial and not economic. The outcome is that, roughly, road as a whole covers its charges, but with a lot of discrepancies between categories of traffic. Air and sea transport roughly pay their expenses, as they are run by (public) firms and do not receive much subsidy from public authorities. Rail transport is subsidised. The infrastructure charges cover about 25% of the total expenses. The time-differentiation is limited: only on half a dozen toll motorways and for some rail services. No charge is dedicated to environmental damages.

GERMANY[34]
(respondent: S. Suter, ECOPLAN)

Question 1

At German universities transport economics is either taught in the frame of general economics or in special seminars, but it is not a discipline by its own. If it is taught, the theory as mentioned in the review is presented. However, marginal cost pricing is discussed as a theoretically interesting approach but it is not considered as an important input for transport pricing in practice. Among the academics no strong advocates voting for an application of marginal cost pricing can be identified.

The discussion of marginal cost pricing was launched by the White Paper on Infrastructure Charging of the Commission. The comments in Germany were very critical from the academic world as well as from representatives of the relevant parts of the public administration[35]. In the case of the latter, the critics may also be influenced by the fact that only a small number of economists works in the Federal and State Ministries of transport. However, persons with other education show difficulties in understanding and sharing the rationale behind efficiency pricing theory.

Question 2

The background of current pricing doctrines is formed by problems in the field of financing transport infrastructure:

- In the case of road transport, the relaxation of the earmarking of the revenues from the duties on fuel has contributed to a considerable lack of funds: it is recognised that by means of "normal" budgetary funding it will not be possible to cover total infrastructure costs as assessed for the period from 1991 to 2012.
- In the case of rail transport, the objective still is that the revenues from infrastructure access charges cover total infrastructure costs. In the last years, the revenues remained by far below the annual costs.

This situation may explain why the current pricing doctrine in Germany is dominated by financing issues and not by considerations referring to marginal cost pricing. Only in September 2000, a Government Commission on Transport Infrastructure Funding ("Pällmann-Commission") presented its theses and recommendations on infrastructure pricing to the Federal Minister of Transport, Building and Housing. The current situation and the foreseeable development in the short- and medium term can be summarised as follows:

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[34] Sources: Information from Heike Link, DIW in Berlin; Wissenschaftlicher Beirat für Verkehr beim BMVBW (2000), Strasseninfrastruktur: Wege zu marktkonformer Finanzierung, in: Internationales Verkehrswesen 5/2000; Regierungskommission Verkehrsinfrastrukturfinanzierung (2000), Schlussbericht; Ministry of Transport, Public Works and Water Management of the Netherlands, Directorate Strategy and Co-ordination (2000), A thematic comparison of transport policy approaches in Europe, Final Report, Rotterdam.
[35] See, for example, Ruidisch P. (2000), Ordnungspolitische Bewertung des EU-Weissbuches aus Deutscher Sicht in Schriftenreihe der Deutschen Verkehrswissenschaftlichen Gesellschaft e.V., Grenzkosten als Grundlage für die Preisbildung im Verkehrsbereich, Band 229.

- **Road transport**

The main approach is to base the future financing of infrastructure more on user and less on budgetary funding. The plans go in the following direction:

– Distance-related user charges should be introduced on motorways for heavy goods vehicles (> 12 t). In the medium or long term the charging system should be extended to other road types. Whereas this extension of the system is little contentious, the opposite is true for the extension to regions (urban areas) and further vehicle types (buses, light goods vehicles or even passengers cars) as proposed by the Government Commission. The introduction of road pricing for cars, for example, was rejected by the Federal Minister immediately after the publication of the report of the Government Commission. The level of the user charge will be derived from estimates of total and not marginal infrastructure costs. Thus, it will be based on top-down and not bottom-up approaches for cost estimation.

– In the short- or medium-term buses and light goods vehicles shall have to buy a time-dependent vignette to use the German motorways.

– For road passengers cars a motorway vignette is under discussion.

With regard to the derivation of the charge levels two core principles are brought forward by the Advisory Board to the Ministry of Transport, Building and Housing:

– Once distance-related charges are introduced, the charge level should be based on efficiency and financing considerations. Therefore, two-part tariffs are favoured. The variable part should ensure the efficient allocation of scarce infrastructure capacity whereas the fix part should ensure cost recovery.

– Environmental concerns should not affect the user charges but should be integrated in the road transport taxation system (fuel tax, vehicle tax). It should be noted that with these types of taxes the necessary differentiation to implement external marginal cost pricing in its “pure sense” is not possible.

To summarise: there are aspects of marginal cost pricing in proposals for future pricing in transport. They are integrated in a broader framework of charging and taxation. As soon as these proposals are discussed at a political level the elements of marginal cost pricing lose and the question of cost recovery gains in importance.

- **Rail transport**:

The infrastructure access charging system in Germany shows some elements of marginal cost pricing (see question 3 below).

- **Inland navigation**:

A charge to finance waterway infrastructure is under discussion. However, the “Mannheimer Act” from 1868, which is still in force, demands that traffic on the Rhine is free of charge.

Question 3

- **Road transport**

– The main “pricing scheme” is the taxation of fuel. A part of the revenues from the duties on fuel is earmarked for the financing of road infrastructure costs.

The extent of this part is subject to decisions taken in the budgeting process of the national government.

- The annual vehicle tax is levied by the different states of Germany. The revenues flow into their treasuries. There is no earmarking. The same applies for revenues from parking fees levied at the local level.
- Even in the case of the Eurovignette for heavy goods vehicles using German motorways there is no earmarking of the revenues for road infrastructure purposes although the Eurovignette is designed as specific charge and not as a tax.

- **Rail transport**

In 1998 a new system of infrastructure access charges was introduced. It shows similarities to a marginal cost pricing scheme that is subject to a budget constraint. The budget constraint here is the objective to achieve full infrastructure cost recovery. In concrete terms, the system consists of a two-part tariff:

- The InfraCard, i.e. the fixed part of the tariff, is the "entrance fee" allowing the use of a well-defined part of the network. The validity of the card reaches from one to ten years. There is a bonus for long-term contracts. The price of the card depends on the length of tracks within the relevant part of the network. The price level is derived from capital costs and basic running costs. The price differs according to the quality of the track.
- Variable track charge: The variable part is levied per train kilometre. Its level depends on the capacity utilisation of the network part considered and the timetable flexibility accepted by the client. It can contain surcharges and discounts to reflect environmental aspects (e.g. low-noise carriages), innovative train systems etc.
- Sporadic users without InfraCard pay a purely variable charge (i.e. the VarioPrice in DEM/train-kilometre) which lies slightly above the combination of InfraCard and variable track charge on average.

The objective of this pricing scheme was to bring it in line with findings of economic pricing theory. However, because of the non-linearity of the fixed part and the resulting undue preference of frequent and long-term users the pricing system was rejected by the German cartel office. A new system will have to be elaborated.

- **Inland navigation**

As in Austria, there are harbour charges that are levied to cover infrastructure costs. The same applies to charges for the use of canals.

REPUBLIC OF IRELAND
(respondent: T. Sansom, ITS)

Question 1

Not known. Transport economics is not widely taught.

Question 2

Although in many fields of transport policy, and policy in general, developments in Ireland occur in parallel with developments in the UK, charging policy does not fit into this picture. E.g. the "Allocation of Road Track Costs" (UK) approach has not been implemented in Ireland in the determination of fuel taxes and/or registration fees.
There is no move for pricing of inter-urban road networks (with the exception of tolled bridges, for the purposes of project finance). There is no pressure for road pricing in Dublin, although studies have been commissioned in the past (e.g. with a view to developing finance sources for light rail).
For other sectors, there is no political momentum behind changes in charging policy.

Question 3

Roads: generally uncharged.
Rail: user tariffs have been determined over time, generally maintaining parity with bus and coach services (which are often competitive in terms of travel time). There are no competing rail operators. For these reasons, infrastructure cost coverage has not been sought, nor has any specific infrastructure pricing policy been developed.
Airports/ ports: no information.

SPAIN
(respondent: G.N. Merchan, EIET)

Question 1

Students generally are shown the main principles on externalities and pricing of infrastructure in presence of asymmetric information and common costs. Partial equilibrium analysis is the usual framework of reference, and rarely the analysis is extended to general equilibrium (not even in theory, and less for applied works). Most transport courses in Spain are offered by engineering schools or departments rather than by economists, therefore they tend to stress more the technical analysis than pricing questions.

Question 2

The previous administration (PSOE government) launched plans for infrastructure modernisation, especially for high-capacity roads, based on free access and publicly financed, according to the traditional model used in Spain (with the exception of a percentage of tolled roads). After 1996, the PP conservative government has shifted slightly the balance towards a model of charging infrastructure costs to users, but still in a very rudimentary way. There are no developed pollution or congestion charges, and vehicles pay for the use of roads through taxes on fuel, annual licenses and other charges. Airports and seaports are generally self-financed through their revenues, so for those modes users cover for infrastructure costs. For railways, the public company RENFE is in a process of transformation towards a model of separation between infrastructure and provision of services, but it is not clear what are the plans for the agency or company that in the future will be in charge of managing infrastructure.

Question 3

Part of this question has been answered above. In addition, the political and administrative structure of Spain has to be considered, since there are 17 regional governments that take decisions and have responsibilities on secondary networks. Each of these governments is autonomous to make its own choices for local taxes and models to be used, and though at present there is no great disparity in the types of taxes and fees charged to transport users (only some variation in the *level* of taxes or annual licences can be found), it can be expected that in the near future there will be different models within the country.

SWITZERLAND
(respondent: S. Suter, ECOPLAN)

Question 1

Transport economics and especially the application of pricing theory in transport is not taught regularly at Swiss universities. A larger offer of courses in transport science can only be found at the two national technical universities in Zurich and Lausanne. However, they approach the subject rather from an engineering and planning point of view. Against this background it is not possible to identify basic differences between the picture given in the theoretical review and the current teaching at universities in Switzerland.

In the last years, transport economics has developed first of all within two National Research Programmes (NRP) of the National Science Foundation, i.e. the NRP25 "Cities and Transport" (1989-1993) and especially the NRP41 "Transport and Environment: Interactions Switzerland – Europe" (1997-2001). In the latter case, the project "Fair and Efficient Pricing in Transport"[36] deals in detail with the question of different pricing approaches in transport. It presents three different pricing scenarios:

- social marginal cost pricing,
- financing,
- environment.

The first scenario starts from the ideas of social marginal cost pricing as described in the theoretical review. The three scenarios are assessed along criteria like short- and long-term efficiency, safety contribution, cost recovery, administrative feasibility etc. The assessment shows that only a combination of the three scenarios is capable to meet the different objectives of transport policy in the best way. In this combination, pricing is still oriented at marginal costs but amended by additional measures to achieve cost recovery. In general, the proposal for pricing of transport in Switzerland is in line with the pricing approaches with budget constraints mentioned in the review.

In another project of the NRP41 the options to introduce road pricing for road passengers transport have been analysed in detail[37]. With regard to marginal cost pricing this report has stressed the limited feasibility to realise under real world conditions the strongly differentiated pricing scheme required to implement social marginal cost pricing.

Question 2

The project mentioned above was presented and discussed at a public conference in autumn 1999. In a statement of a high representative of the relevant ministry[38] it has become clear that short-run social marginal cost pricing is considered as an interesting economic approach but not as central future guideline for pricing in transport in

[36] Maibach M., Schreyer Ch., Banfi S., Iten R., de Haan P. (1999), Faire und effiziente Preise im Verkehr, Ansätze für eine verursachergerechte Verkehrspolitik in der Schweiz, Bericht D3, NFP41 Verkehr und Umwelt, Wechselwirkungen Schweiz - Europa.
[37] Güller P., Maibach M., Neuenschwander R. und Rapp M. (2000), Road Pricing in der Schweiz, Bericht D11, NFP41 Verkehr und Umwelt, Wechselwirkungen Schweiz - Europa.
[38] Dr. H. Werder, secretary general of the Swiss Federal Department for Environment, Transport, Energy and Communications.

Switzerland. This attitude can be explained by the fact that in practical transport policy short-run efficiency is not considered as very important objective of pricing. Rather more important are the two following aspects:

- *Financing*: Switzerland has first of all in the case of road transport a well established system of taxes and fees whose revenues are partly earmarked to cover infrastructure costs. The system results in a comparatively high cost recovery degree. In the case of rail transport a proposal of the government on the financing of the large future infrastructure projects was approved in a public vote in autumn 1999. Against this background, there is very little interest on the side of the political authorities to introduce major changes in this well accepted and implemented pricing and financing system.
- *Environmental objectives*: The central goal of the transport policy in Switzerland is to make transport as whole more sustainable. There is, for example, a clear political will to make road freight transport switch to rail. Thus, Switzerland follows here a standard-price approach where the pricing mechanism is used to achieve well-defined policy goals. In this context, environmental issues or, in concrete terms, external cost estimates play a role as an argument to act in a certain direction. However, the basic idea of marginal cost pricing, that marginal (external) costs can be calculated and then directly be used to derive the relevant price signals is not considered as feasible. It is objected that the uncertainties in the calculation of marginal costs are so high that the cost estimates cannot act as reliable arguments in the policy debate.

In the case of urban road passengers transport there is some discussion to adjust the legal framework to make the introduction of road pricing possible which is currently not the case. However, the driving force for this adjustment is rather the search for new options to finance expensive infrastructure extensions in urban areas than efficiency considerations.

Question 3

According to the situation described above, the present situation of infrastructure pricing reveals only very limited aspects of marginal cost pricing, as the following very brief overview of infrastructure pricing in Switzerland shows.

- **Road transport**

- The main “pricing instrument” is the fuel tax whose revenues are partly earmarked for the financing of road infrastructure cost. A part of the revenues flows into the national treasury.
- Annual vehicle taxes are levied at the cantonal level. The revenues flow in the treasury of the Cantons. There are no taxes on the purchase of vehicles.
- At the local level, parking fees are levied. Normally, other considerations than marginal cost of using parking lots are used to derive the fee level.
- In the case of passenger road transport an annual vignette has to be bought to use the national motorways. The revenues are earmarked to contribute to cost recovery.
- In the case of road freight transport, Switzerland will introduce a new Heavy Vehicle Fee (HVF) in 2001. The HVF is a distance-related fee (mileage tax) levied on the whole road network. The level of the fee (in CHF per kilometre driven) depends on the total weight of the truck and the technical standard with regard to

the emissions of air pollutants. When the introduction of the HVF was first discussed in public, external cost estimates for road freight transport played an important role for the derivation of the primordial fee level. It should be noted that estimates used are average and not marginal cost estimates. Later on, the arguments that the HVF should contribute to a shift of freight transport from road to rail and to the financing of large rail infrastructure on the one hand, and the role of the HVF as an accompanying measure to the increase of the maximum total weight of trucks driving in Switzerland from 28 to 40 tons on the other hand, became much more important in the political debate and in the determination of the fee level than any cost estimates.

- **Rail transport**:

In the case of rail transport the regulation dealing with infrastructure access charges states that the charge should not be lower than the marginal cost incurred with the use of a "standard" part of the network. Included are the following cost components:

- use of energy,
- performance-related maintenance costs,
- share of costs for the staff dealing with traffic control,
- additional staff and maintenance costs at stations.

In addition, a contribution margin can be levied to contribute to cost recovery. The level depends on factors like the quality of the network, environmental issues (e.g. noise), scarcity of slots, speed of the train, etc.

- **Inland navigation**

Relevant are only the charges levied in the Rhine harbours of Basle. They are not based on marginal cost estimates.

- **Air transport**:

On Swiss airports, landing charges have to be paid. They are oriented at financial considerations and include environmental considerations (differentiation according to the noise emissions of the aircraft).

UNITED KINGDOM
(respondent: T. Sansom, ITS)

Question 1

Whilst advanced theoretical courses cover this material, there is still a tendency to teach traditional cost allocation procedures, and to illustrate these, for instance, from road track cost allocation exercises.

Question 2

There is a tradition going back to the 1960s of arguing in favour of long run marginal cost pricing; often this is combined with a belief in constant returns to scale such that total cost allocation procedures are argued to be consistent with derivation of long run marginal cost. This was true for instance of the road track cost allocation exercises which were undertaken from 1968 up until the early 1990s and which in particular informed decisions about heavy goods vehicle taxation.

There is current strong encouragement towards congestion pricing for both road and rail, which may be taken to indicate a move towards short run marginal cost pricing principles, although in part it is no doubt a pragmatic reaction to congestion on both modes.

For inter-urban roads, recent political developments have ruled out the possibility of charging tolls for the foreseeable future. In the case of urban road pricing, the Government has delegated the responsibility for taking forward initiatives to local authorities (e.g. Bristol, Edinburgh and Leeds; and in the case of Greater London, the Mayor of London). At the same time, legislation has been provided, and local government has been granted the right to retain receipts from road pricing, including exceptional powers to retain any value added tax on tolls that traditionally accrues to the Treasury.
There is minimal political interest in addressing charging issues in the ports, aviation or inland waterways sectors

Question 3

For road, there is currently no pricing system other than annual vehicle licence duty and fuel tax, and there is no explicit link between these and costs. For rail, infrastructure charges for franchised passenger operators are based on a two-part tariff. The Rail Regulator has recently allowed Railtrack to increase the variable part of the tariff, bringing it more into line with marginal cost, but maintaining revenue neutrality.

In the rail sector, greater emphasis on short run marginal costs is being driven by a debate between Railtrack and the Office of the Rail Regulator. At the time of privatisation, only a proportion of variable infrastructure use costs was reflected in variable tariffs. In part, this was to contain revenue risks to the infrastructure operator, to maximise Railtrack's sale value. However, post-privatisation, rail patronage and service levels have grown significantly, so that Railtrack believes that it has received inadequate compensation in the past – and that its incentives for providing for growth in the future are too weak. A greater variable element in track access charges in order to reflect underlying costs was thus sought and obtained by Railtrack. Although the Rail Regulator has accepted the principals of a greater variable element, a discussion ensued about the choice of empirical values. The Government's interests are promoted by the Rail Regulator, with minimal involvement from the Department of the Environment, Transport and the Regions.

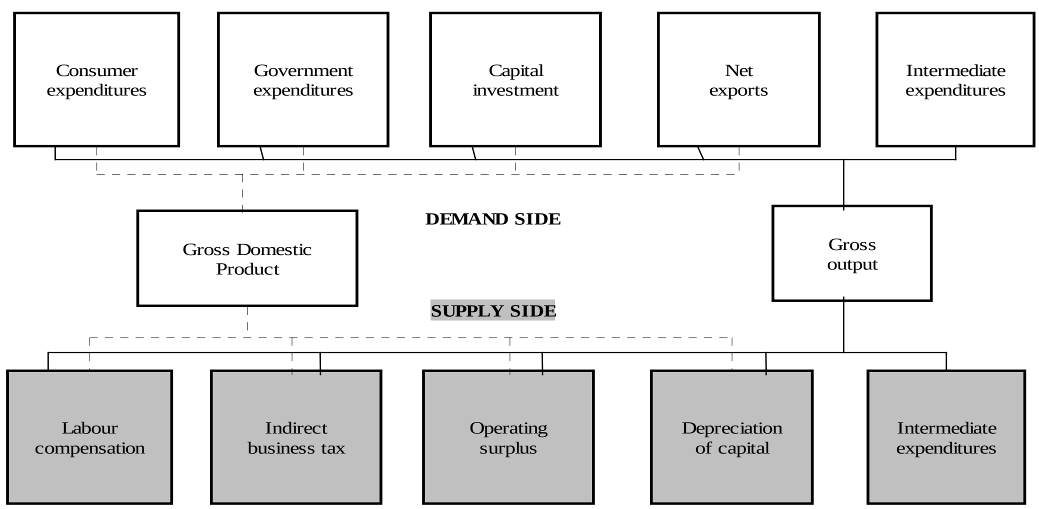
For both airports and ports there is minimal Government involvement in charge setting. There is no regulation of port prices, and ports are generally under private ownership in a competitive marketplace. Airport charges for major airports are regulated by the Civil Aviation Authority, with an emphasis on infrastructure cost recovery rather than the application of economic principles for charging.

Appendix G: Transport activities in the national accounting framework

This Appendix provides more details about some experiences of Transport Satellite Accounts currently elaborated in the U.S.A and France, and Input-Output accounts elaborated in Switzerland. Up to now, these experiences have not taken into consideration external effects such as congestion, accidents and environmental impacts. They provide mostly insights about the full range of transport activities in the national contexts, and more or less complete information on who pays for and who uses transportation. The main concepts used to measure transport activities in the national accounting framework are also summarised below, before presenting the results of the pilot national accounting experiences.

Measuring transport activities in the national accounting framework

The System of National Accounts (SNA)[39] is the appropriate framework for comparable economic measurement of national transportation activities. Within SNA the transport activity is represented as an industry from the supply side perspective, as a component of Gross Domestic Product (GDP) when measured from the demand side, but also as a component of Gross Domestic Demand (GDD).
The major components of GDP from both the supply and the demand side, and their relationship to output, are shown in the figure below:



Source: Xiaoli Han, Bingsong Fang (1998)

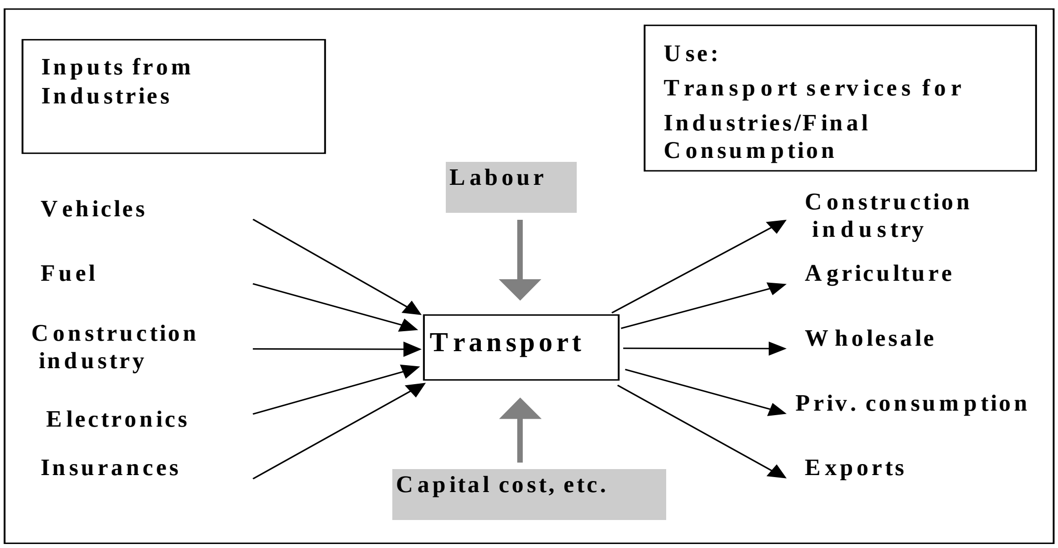
From the demand perspective, the major components of GDP are consumer expenditures, government expenditures, capital investment, and net exports. From the supply perspective, GDP consists of every industry's value added, which includes employees compensation, indirect business taxes (net of subsidies), operating surplus and depreciation of fixed capital. GDP values measured as total value added (supply side) and as total final expenditures (demand side) are identical. This identity between

[39] The basic source for the discussion of the SNA concepts and rules used here is United Nations (1993).

value added and final demand exists only at the national level, and does not hold at the industry level.
On the demand side, specific expenditures items can be identified as transport-related. Some obvious components include purchase of cars and gasoline, government expenditures on highways, and expenditures on railways construction. The total sum of all the transport-related items is directly comparable to GDP, and the ratio to GDP can be used as an indicator of transportation's importance in the national economy. However, this is not a perfect indicator of the importance of transport activity to society, because:

- part of the transport activity is consumed as an intermediate demand and is not measured at all in transportation final demand;
- transport-related final demand covers only transport services purchased in the market, and does not cover transport services provided by consumers to themselves.

From the supply side perspective, transport is considered as a service industry. The difference between the value of transport outputs and the value of intermediate inputs to the transport industry (goods and services such as gasoline and vehicle repair services) is the gross value added of transport industry. Apart from the level of the value added by a sector, also the structure of its contribution to the GDP is interesting, This is indicated by the position of the sector in the input output matrix. It shows which industries contribute to the transport sector and to which industries the transport sector's output goes. Input output analysis is providing the necessary tools for performing such an analysis. The following figure illustrates the structure.



Producing transport services requires various inputs. On the other hand transport services serve as inputs for most other economic sectors. The difference between the revenue created by selling transport services and the sum paid to other sectors for the inputs equals the value added of transport, employing capital and labour to produce these services.
Source: INFRAS, 2000

USA

Recently in the USA, the 1991 Intermodal Surface Transportation Efficiency Act (ISTEA) established the Bureau of Transportation Statistics (BTS) and charged it with carrying out various statistical functions, including compiling, analysing, and publishing a comprehensive set of transportation statistics to provide timely summaries and totals of transportation-related information. Based on this mandate, BTS in its first annual report has in particular recommended that special studies be undertaken to measure total transportation services in a way that is consistent with the national economic accounts. This now has been accomplished issuing the *U.S. Transport Satellite Accounts*, jointly developed by BTS and the Bureau of Economic Analysis (BEA).

As a satellite to the 1992 U.S. benchmark I-O accounts, the TSA primary purpose is to provide a systematic and consistent framework and data set for conducting analytical studies of the role of transportation in the economy on both and industry and commodity basis. The TSA covered all activities related to the use of vehicles (such as trucks, aircraft and boats) and related structures (such as highways, airports and port facilities) for the movement of goods and services. Transportation in the U.S. TSA consists of six groups of for-hire transport industries from the I-O accounts and a single group for own-account transportation. The six for-hire transport industries are: (i) railroads and related services and private passenger land transport grouped together; (ii) motor freight transport and warehousing; (iii) water transport; (iv) air transport; (v) pipelines, freight forwarders and related services; and (vi) State and local government passenger transit.

The explicit measurement of own-account transport is the main novelty of TSA. The magnitude of own-account transportation services was determined by first estimating the inputs used by each industry for its own-account transport activities. These estimates were then used with the I-O supply and use tables to derive the TSA tables. The TSA use table provides in this way information on the amount of own-account transport services produced and used by each industry of the economy, in addition to for-hire transport services.

The final result of this accounting exercise was a new evaluation of the contribution that transport activities represent on the total U.S. economy, including either for-hire and own-account transport activities. Together, these activities accounted for 5% of the U.S. GDP in 1992 – 3,1% from for-hire and 1,9% from own-account transportation services. Also some sectoral results are worth mentioning:

- as concerns use of transportation services by industry, although the manufacturing industry group was the largest user of all transport services, the wholesale and retail industry group was the largest user of own-account transportation services;
- as concerns transportation services cost by commodities, among non-transport commodity groups, agriculture, forestry and fisheries had the highest transport content (8 %), followed by construction (7,7 %), which reflect the general pattern of transport use by industry. For both commodity groups, own-account transport had a larger share in the total transport cost then for hire transport costs;
- I-O multiplier analysis showed that, in general, demand of for-hire transport services is more sensitive to changes in the output levels of good producing industries, such as manufacturing, while demand for own-account transport

services is more sensitive to changes in the output levels of the service industries, such as the wholesale and retail trade industry. In any case, the highest transport multiplier is associated with the demand for agricultural products.

The U.S. TSA provide a more comprehensive picture of all for-hire and most own-account transport activities. However, as additional information becomes available, they could be further improved in many respects:

- currently, the TSA omit own-account transport activities of modes other than truck and bus, such as the business use of automobiles, corporate aircraft, and watercraft;
- the accounts could be expanded to include the service values of government-owned transport capital, such as highway infrastructure, and to include the transport services provided by households for their own use, such as commuting to and from work in a privately owned car. Inclusion of these services in the TSA would result in the expansion of the production boundary beyond that of the I-O accounts;
- the TSA could value own-account transport output as a product of a quantity measure of output and the market price for a similar service. Actually, because the value of own-account transport cannot be measured directly, the TSA currently determine the output of in-house transport by summing the costs of all intermediate inputs and value-added inputs of compensation, indirect business taxes and capital consumption allowances that are used in its production. Although this approach is frequently used to measure the value of own-account types of production, the resulting estimates of output are understated because they do not include profits. As a result, such estimates have limited value for productivity analysis and other similar studies. This alternate approach would require the development of quantity and price estimates of for-hire transport services, to be used in the evaluation of own-account activities.

France

Transport Satellite Accounts in France have been elaborated since 1992, and now an updating to the year 1996 is available (cf. CCTN, 1999). TSA have been developed to answer to the following question: who pays what in the different modes of transport? Addressing this issue implies to analyse in turn several specific aspects, which include: (i) costs of road infrastructure usage by different types of vehicles, (ii) fiscal burdens for the different road users, (iii) subsidies to urban public transport and rail, (iv) financing of ports and airports.
The distinction between commercial and own-account transport production is taken as a starting point, and the TSA explicit aim is to include the latter in the national accounting of transport activities.

The modes of transport analysed include: road, rail, urban public transport, air, sea, inland waterways and pipelines. The aggregate results for the year 1996, showing the total (current + capital) expenditures by institutional sectors financing them (households, companies, government), are reproduced in the table below:

	Households (Gfrancs)	Companies (Gfrancs)	Government (Gfrancs)	Government share	Total (Gfrancs)
Road	622,0	390,6	96,3	9%	1.108,9
Rail	16,7	10,2	27,6	51%	54,5
Urban Public Transport	20,3	24,4	13,2	23%	57,9
Air	22,7	27,7	2,0	4%	52,4
Sea	1,5	28,6	1,0	3%	31,1
Inland waterways	0,4	1,9	1,5	39%	3,7
Pipelines	0,0	2,0	0,0	0%	2,0
TOTAL	683,6	485,4	141,5	11%	1310,6

To estimate these aggregate results the concepts of national expenditure as well as internal expenditure have been used[40]. Although tax receipts are not destined to finance specific budgetary items, it is interesting to consider the breakdown of taxes raised by mode of transport:

	IVA - non deductible (Gfrancs)	Other taxes (Gfrancs)	Total (Gfrancs)
Road	108,3	195,1	303,4
Rail	1,6	3,2	4,8
Urban Public Transport	2,4	2,2	4,6
Air	1,5	3,2	4,7
Sea	0,4	0,6	1,0
Inland waterways	0,2	0,1	0,3
TOTAL	114,5	204,3	318,8

These results have been achieved summing up the estimates produced for the single modes of transport. In particular, road transport includes commercial transport of freight and passengers as well as private transport of households and own-account transport of business units (freight and passenger). A breakdown of current and capital expenditures by type of users and vehicles has been provided, and it is reproduced in the table below:

[40] National expenditure corresponds to the expenses of residents in France and abroad, while internal expenditure is that of residents and non-residents in the France territory. For transport services (primarily air and sea) national expenditures have been computed, while internal expenditure was used to estimate infrastructure expenses (primarily road)

ROAD	**Current expenditures (Gfrancs)**			**Capital expenditures (Gfrancs)**		
	Light vehicles	Heavy vehicles	Total	Light vehicles	Heavy vehicles	Total
Infrastructure users:						
Households	382,2		382,2	189,9		189,9
Companies						
commercial freight	*31,4*	*155,2*	*186,6*	*0,9*	*14,5*	*15,4*
own-account freight	*49,9*	*62,8*	*112,8*	*24,5*	*8,1*	*32,6*
total freight	81,3	218,1	299,4	25,4	22,6	48,0
commercial passenger	*8,8*	*19,9*	*28,8*	*1,5*	*2,8*	*4,4*
own-account passenger	*12,7*	*4,8*	*17,5*	*27,1*	*0,7*	*27,9*
total passenger	21,5	24,8	46,3	28,6	3,6	32,2
Infrastructure operators:						
Toll roads	19,4	12,9	32,3	6,5	13,6	20,1
Government	48,3	33,9	82,2	20,0	22,0	42,0
TOTAL	**552,7**	**289,7**	**842,4**	**270,4**	**61,8**	**332,1**

On the revenue side, fiscal receipts related to road transport have been identified, including revenues accruing from taxes on fuel, non-deductible IVA, taxes on insurance contracts, some specific taxes[41] and other taxes on production. The national aggregates computed for the year 1992 and 1996 are reproduced in the table below:

ROAD FISCAL REVENUES	**1992 (Gfrancs)**	**1996 (Gfrancs)**	**% 92/96**
Fuel Taxes	103,7	133,8	29,1
Insurance Taxes	16,5	19,6	18,8
Specific Taxes	23,2	25,4	9,3
Taxes on production	12,6	16,3	29,8
IVA (non deductible)	91,3	108,3	18,6
TOTAL	**247,2**	**303,4**	**22,7**

As concerns the other transport modes, the following elements are worth of mention:

- **rail**: in France rail service is vertically integrated, with a preponderant rail operator – SNCF – taking care of the infrastructure as well as of rail service operation. This makes it difficult to separate expenditure and revenue flows for the main activities concerned – rail transport of passenger and freight by one side and infrastructure operation by the other – although a basic improvement has been achieved since 1997, with the creation of a separate entity – Réseau Ferré de France (RFF) – which will be in charge of rail infrastructure. Current internal expenditures in 1996 totalled to 29,8 Gfrancs for passenger transport, 10,4 Gfrancs for freight transport and 14,9 Gfrancs for infrastructure maintenance and operation. Total capital expenditure amounts to 20,1 Gfrancs (14,4 for infrastructure and 5,7 for rolling stock).

[41] these include: *permis de conduire, vignette, carte grise, droits de timbre sur le contrats de transport, taxe a l'essieu, taxe sur le voitures particulières et commerciales de société.*

- **urban public transport**: a main distinction is made between the Paris Region (Ile de France) and the rest of the country. Total current expenditure, 48,5 Gfrancs in 1996, was financed by users (42%), companies (40%, thanks to the "versement transport", a charge on the total amount of salaries, paid by employers to transport operators) and government subsidies (18%). The share of users financing of current expenditure is lower in the Paris region (33%) than in the rest of the country (60%).

- **air**: this includes the activity of air companies, airports operation, air traffic control and some ancillary logistic activities for freight transport. The national expenditure for air transport in 1996 was 56 Gfrancs, while the internal expenditure for airports operations amounted to 10,7 Gfrancs.

- **sea**: this includes the activity of maritime companies (sea transport properly), ports operation and other ancillary activities. National current expenditures for sea transport in 1996 was 30,3 Gfrancs (28,3 for freight and 2 for passenger transport), and this was almost completely financed by the users. Total internal expenditure (current + capital) for ports operation amounted to 6.1 Gfrancs, mainly financed by user charges.

For more detailed information on results and methodologies applied, the reader is referred to CCTN (1999). Finally, it is worth to mention a recent experiment aimed to produce more detailed TSA for urban and road transport. TSA have been further developed breaking down the France territory in different classes of urban areas – Paris Region, urban areas with population over 700.000, between 300.000 and 700.000, and below 300.000 inhabitants – and a residual class of rural zones. Hence, road freight and passenger transport activities have been allocated to the different classes of urban zones, to analyse the related expenditures and revenues. Transport within the urban zones has been further analysed, covering passenger trips with different transport modes (road and public transport) as well as freight distribution. The final aim of these "urban" TSA is to provide an answer to the question: what are the expenditures of the different actors for transport activities in the urban environment, for the different transport modes, and who pays for them? Again, further details on results and methodologies applied can be found in CCTN (2000).

Switzerland

The analysis of value added in the Swiss economy has been based on the input output models provided by official sources (Bureau of Federal Statistics). In a recent INFRAS study (Maggi et al.,2000), the underlying matrix has been updated and has been differentiated and extended with respect to several transport sub-sectors. In order to calculate the value added of total transport in Switzerland it was necessary to include work and leisure trips by private cars as a branch of the transport industry. This "sector" was not included separately but has been considered as final demand. The following reproduces the summary of main results included in Maggi et al. (2000).

Amount of value added 1995

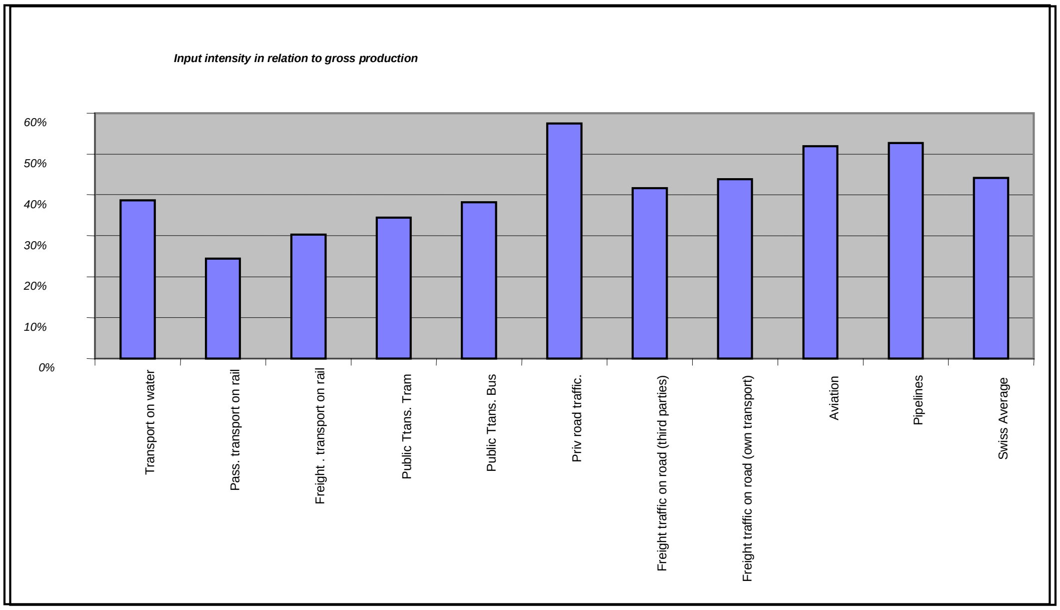
The Swiss transport industry created a gross production value of 58 billion Francs or 8.3% of GDP. Subtracting inputs amounting to 28 billion Francs results in a total value added of 30 billion Francs or 7.6% of total value added in Switzerland. Private road traffic contributes almost half of this figure.

	Gross Production in Mio. CHF	Value added in Mio. CHF	In % of Swiss value added
Transport on water	460	285	0.07%
Passenger transport on rail	6‘570	4‘970	1.28%
Freight transport on rail	2‘300	1‘600	0.41%
Public transport: Tram	500	329	0.09%
Public Transport: Bus	1‘600	990	0.26%
Private road traffic	30‘800	13‘100	3.38%
Freight traffic on road (for third parties)	5‘700	3‘330	0.86%
Freight traffic on road (own transport)	4‘450	2‘500	0.64%
Aviation	5‘130	2‘470	0.64%
Pipelines	110	51	0.01%
Total	58‘000	30‘000	7.6%

Gross production, value added in absolute terms and in percentage of total value added in the Swiss economy in 1995 by sector

Value added and inputs

Among the transport sectors two rail transport industries create the highest value added per unit of input from other sectors. The share of capital and labour in their gross production is highest. All public transport sectors have an above average value added per input, while the road freight transport sector equals the Swiss average with respect to this measure.
The table of input interdependencies allows identifying the distribution of the required inputs among the different transport sectors. The following figure illustrates the input intensities (inputs as a percentage of gross production) for the transport sectors analysed.



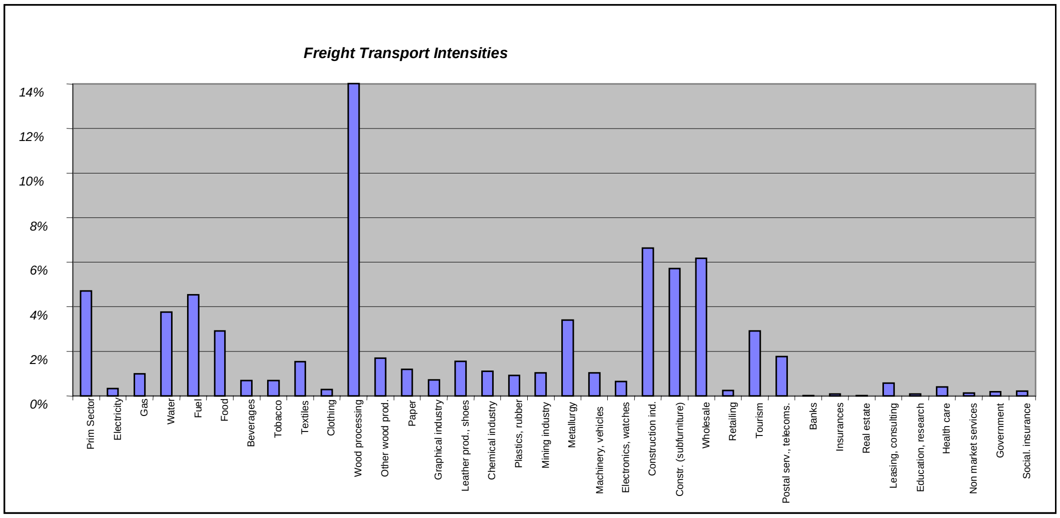
Inputs in relation to gross production for the different transport sectors. The public transport sectors have significantly lower input intensities than the Swiss industry average. Private road transport has the highest intensity with inputs amounting to 58% of gross production.

Intensity of import and labour

With respect to all Swiss industries, the transport sectors show a below average import intensity. Among the transport sectors the share of imported gross production is lower in rail freight transport than in freight transport on road.
All sectors of public transport have an above average labour intensity. This implies that an identical change in final demand across al transport sectors would create the most important employment effects in public transport.

Transport intensity in freight transport

The following figure shows transport cost as a percentage of gross production for Swiss industries.



Freight transport intensities. Wood processing provides an exceptional case. It implies a large amount of transport process carrying goods of low value.

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