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THE ENVIRONMENTAL IMPACT OF TRANSPORT SUBSIDIES

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The environmental impact of transport subsidies

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Abstract

There are two totally different ways of approaching the measurement of transport subsidies. The first is to compare total costs and total revenues, in order to see how far users pay the total costs, and how far explicit or implicit subsidies are provided. Often only money costs are examined, but we will argue that in a sector such as transport, where externalities are very important, total social cost should be examined. The second approach is to consider the relationship between marginal social cost and price, and to regard the failure of price to cover marginal social cost as a subsidy.

The first approach is often seen as important politically and in the consideration of equity issues. It is the second however that is appropriate in the consideration of economic efficiency. In sectors which are broadly characterised by constant returns to scale the two may give a similar picture. Thus it is common to emphasise the first approach to subsidies. In transport, however, both infrastructure and operations are typically characterised by major economies of scale, whilst many externalities, such as congestion and noise, are important and strongly non linear. The result is that marginal and average social cost are highly divergent.

This paper considers evidence on both approaches to the level of subsidy. It presents the results of a study of social costs and revenues from transport for all Western and some Central European countries. It then describes the state of the art methodology for quantification and valuation of the environmental costs of transport, and reports on a review of studies that have considered the implications of inefficient pricing in terms of distorted demand for transport.

It concludes that the removal of subsidies in order to ensure that users bear the total social cost of each mode would not just be economically inefficient but also environmentally damaging. By contrast, pricing reform to achieve prices based on marginal social cost would lead to modest reductions in traffic on the most environmentally damaging modes of transport, and consequently some reduction in environmental damage due to transport.

1. Introduction

The aim of this paper is to examine the degree to which subsidies exist in the transport sector with potentially harmful environmental effects. There are two totally different ways of approaching the measurement of transport subsidies. The first is to compare total social costs and total revenues, in order to see how far users pay the total costs, and how far explicit or implicit subsidies are provided. The second approach is to consider the relationship between marginal social cost and price, and to regard the failure of price to cover marginal social cost as a subsidy.

The first approach is often seen as important politically and in the consideration of equity issues. It is the second however that is appropriate in the consideration of economic efficiency. In sectors which are broadly characterised by constant returns to scale the two may give a similar picture. In transport, however, both infrastructure and operations are typically characterised by major economies of scale, whilst many externalities, such as congestion and noise, are important and strongly non linear. The result is that marginal and average social cost are highly divergent.

In the next section, we consider the types of subsidy that are to be found in the transport sector. We then present the principal elements of transport costs and charges that need to be taken into account in assessing the level of subsidy present. We present evidence on the degree to which such subsidies are present in Western Europe, drawing on the EC 5th framework project UNITE, in which the authors participated. The following sections consider in turn methodologies for modelling the environmental impacts of transport subsidies and the results of such modelling exercises. Finally we discuss briefly the likely impact of the removal of transport subsidies in Europe before reaching our conclusions.

2. What is the nature of transport subsidies?

Whichever approach we wish to take to the examination of transport subsidies, assembling appropriate evidence is not easy. If we wish to examine the relationship between total social cost and total revenue, we have to identify both explicit subsidies and implicit subsidies. Explicit subsidies arise when governments decide to pay grants to providers of a particular activity. For instance, in the transport sector, many organisations receive government grants in return for obligations to provide unprofitable services, or to hold down fares either in general, or for specific groups of people. Also grants are often provided towards unprofitable investments in recognition of the social benefits they offer.

However, when we come to examine the difference between total social cost and total revenue, we find that this is only partly accounted for by explicit subsidies. There are three main reasons for this. The first is that a large proportion of transport infrastructure is provided and paid for by the government, and charges for its use do not cover the total cost of its provision. Indeed in the case of the dominant form of transport, road transport, there is typically no explicit link between charges, which are mostly levied in the form of taxation rather than explicit user charges, and the costs of providing and maintaining the road network. The second is that transport is often accorded favourable tax treatment compared to the rest of the economy. For instance passenger transport is typically exempt from value added tax, or charged at a lower rate than in the rest of the economy. This we will regard as an implicit subsidy to transport. On the other hand, taxes on energy frequently differ between sectors and are zero in some - or even most - non transport sectors. Since energy taxes are seen primarily as charges for externalities which differ between sectors, we will not regard unpaid fuel taxes themselves as a subsidy; rather the subsidy is the failure to equate energy taxes to the externalities caused by the use of energy in the transport sector. The third reason why transport revenues do not cover total social cost is that transport gives rise to substantial external costs, for which there is no corresponding revenue stream.

If we wish to examine the difference between price and marginal social cost we are faced with a different set of problems. Firstly, both transport infrastructure and the supply of scheduled transport services are typically subject to economies of scale, and we need to distinguish between marginal and average cost for both these elements. The fact that marginal cost is below average leads to an a priori case for subsidies for both transport infrastructure and scheduled transport services. Secondly, external costs are often significant, and not constant per unit of output. Whilst it is common to assume that the air pollution costs of transport are constant per unit of output, this is certainly not true of noise or of congestion. In the case of noise costs, additional traffic generally imposes the greatest costs when noise levels are low; as traffic levels build up so the impact on people in terms of the additional annoyance they experience from an additional vehicle declines. Thus marginal noise costs tend to decline as traffic increases. For congestion the relationship is the reverse. Thus at low levels of traffic an additional vehicle has little impact on the speeds of other vehicles, but as congestion increases, so the delays imposed by an additional vehicle rise. The relationship is typically believed to be exponential, with very rapid increases in delay as capacity is reached.

The result is that not only does marginal social cost vary from average social cost, but also it varies enormously with location and time of day. Studies of marginal social cost therefore have to rely on case studies; assembling comprehensive evidence for even one country is very difficult.

We have seen above that some transport subsidies may be justified by economies of scale in the provision of transport infrastructure and services. A further important case for subsidies may arise from second best arguments. There are major barriers to the charging of efficient prices in some sectors, particularly road, where marginal social cost varies widely in time and space, requiring complicated electronic pricing systems to reflect those costs to the users, and where there is enormous opposition from powerful lobby groups to implementing such systems. Likewise there are problems in air transport; for instance, a decision to levy tax on aviation fuel, which is currently untaxed, would require international agreement. If any one country implemented it in isolation, there would be massive opportunities for refuelling elsewhere; even if the European Union introduced such taxes for the entire Union, there would still be potential for planes involved in international transport to refuel elsewhere. To some extent the same problem arises in respect of international road transport. Thus there are massive distortions in prices in some parts of the transport sector which are not easily removed. It is a well known result of second best theory that when some prices are distorted, this should be allowed for in setting prices of related goods. In particular, if certain goods are underpriced then it is best to underprice competing goods as well. Thus for instance, the infrastructure and operating costs of rail transport are generally subsidised. To the extent that this generates additional rail traffic, there are costs in terms of efficiency and indeed in terms of the environment resulting from these subsidies. However, if some of that traffic is diverted from more heavily subsidised and more environmentally damaging modes, then it is possible that there is a net benefit from these rail subsidies, again both in terms of economic efficiency and in terms of the environment.

Other justifications for subsidy also exist. For instance, transport is often regarded as a ‘merit’ good, which should be available to everyone, at least to the extent that it is necessary in order to be able to fulfil the requirements of everyday life, such as getting access to jobs, education, shops and health services. Thus so called socially necessary services are run at locations and times of day when even a strict social cost-benefit analysis might find that the costs exceed the benefits. Also, it is often argued that the provision of transport infrastructure has external benefits in promoting economic development. Although evidence of this is limited, there is some reason to suppose that this could be the case in the presence of market imperfections (SACTRA, 1999)

3. What are the relevant costs and charges in the transport sector?

For empirical evidence on costs and charges this paper will rely heavily on the results of the UNITE project, which is a project funded by the European Commission as part of the 5th framework programme. Table 1 shows the elements of costs and charges in the transport sector considered by UNITE for both the marginal and the average cost approaches to looking at subsidies. The marginal cost approach is concerned solely with the cost of adding additional traffic to the existing infrastructure. Thus initial capital costs are excluded, but marginal infrastructure maintenance and renewal costs must be included. Vehicle operating costs are only included for rail and other public transport vehicles; for the private car, these costs are borne directly by the user, and for road freight, maritime and air it is assumed that the market is sufficiently competitive that all we need to consider is infrastructure and external costs; the market will ensure that the customer pays the operating costs. Of course there are often explicit subsidies to the operating costs of these modes too, and we will comment on these particularly in the case of air transport later in the paper. For congestion and environmental externalities it is of course only the marginal element that is relevant.

Table 1: Summary of Relevant Cost and Revenue Categories

Categories	**Marginal cost approach**	**Average cost analysis**
Costs		
Capital charges	-	✓
Infrastructure maintenance and renewal costs	marginal only	✓
Vehicle operating costs	Public transport only	Public transport only
	-	-
External costs of		
Congestion	✓	-
Scarcity	-	-
Mohring effect	Public transport only	-
Accidents	✓	✓
Air pollution	✓	✓
Noise	Marginal only	✓
Global warming	✓	✓
VAT not paid	Public transport only	Public transport only
Revenues		
Fares and freight tariffs	Public transport only	Public transport only
Fuel duty	✓	✓
VAT on fuel duty	✓	✓
Vehicle excise duty	commercial vehicle only	✓

Key: ✓ = included. Where marginal is assumed to differ from average this is noted by the words 'marginal only' in the marginal cost column.

For the average cost approach, generally the same cost categories apply, but capital charges are included and in each case it is the average cost that is relevant rather than marginal. Congestion is a particularly complicated form of externality. Each user of the mode already bears the average cost of congestion in terms of the average delays resulting from the fact that the transport system in question is congested. Thus it is not appropriate to include congestion in the measurement of average social cost; the average level of congestion is already internalised. On the other hand, the marginal cost of congestion - that is for instance the extra delays to other vehicles caused by the presence of an additional vehicle on the road - may greatly exceed the average delay experienced by all vehicles on the road. Thus the amount by which the marginal cost of congestion exceeds the average is a relevant part of the marginal social cost.

A word of explanation is necessary about two cost categories - scarcity costs and the Mohring effect. Scarcity costs arise on scheduled modes where the infrastructure has limited capacity, and the cost of operating a particular service is that another one cannot run at that time. They are important in principle but very difficult to measure, and were not measured in UNITE. The Mohring effect is the effect whereby an increase of traffic on scheduled public transport leads to higher frequency of service and thus provides an external benefit to existing users. This provides a further general case for subsidising public transport, especially short distance services.

It may reasonably be argued that there are other categories of environmental costs not included here, such as effects on landscape and wildlife. These are mainly impacts of the construction of infrastructure, and therefore not relevant to the marginal cost analysis. However, they should certainly be present in the average cost analysis. Nevertheless it is believed that the major environmental costs are present.

4. How significant are transport subsidies?

4.1 Introduction

The EC 5th framework project UNITE had as part of its remit to compile transport accounts showing social costs and revenues for every country in Western Europe plus some accession states. It also conducted a large number of case studies of marginal social costs.

The accounts provide direct evidence on the following categories of explicit subsidies:
- operating subsidies
- concessionary fares

They do not provide direct evidence on investment grants. In the UNITE accounts an investment time series was used as input data for modelling the capital stock and thus deriving the value of capital costs. Therefore, they are reflected in infrastructure costs (which show the full infrastructure costs including all subsidies) but they cannot be separated and shown as explicit subsidies in the accounts. However, by means of a comparison of costs and revenues, the accounts provide overall evidence on the combined level of the following implicit subsidies:
- underpriced provision of infrastructure
- failure to internalise externalities
- foregone tax revenues

The aim of this section is to provide and analyse quantitative information available on the level of subsidies per mode in the EU countries. A few considerations seem to be necessary before presenting and discussing the results in detail.

First, for reasons of data availability we discuss here only the road and rail sectors, public transport and aviation. Second, the explicit subsidies reported here refer to the national level rather than other administrative levels[1]. Furthermore, we do not include subsidies granted for the vehicle producers although this is another important field of subsidisation in some modes as for example in the aviation sector (in the form of subsidies for research and development), third we present three types of tables referring to the total social costs incurred in the mode (tables 2, 4 and 7), the total revenues including subsidies for concessionary fares and provision of services (tables 3, 5 and 8) and a summary of the explicit and implicit subsidies to public transport as far as they could be quantified (table 6). The reason why we supplement the estimates on subsidies by information on total costs and revenues of transport modes is to enable the reader to evaluate the significance of the overall subsidy level. However, we repeat our warning that some types of subsidy may still be subsumed within these cost and revenue figures, and it is likely that what we have provided is only a lower bound for the overall level of subsidy.

The costs reported in the tables 2, 4 and 8 comprise i) the costs of infrastructure (capital costs and running costs), ii) the part of accident costs that are paid for from public funds (national health insurance costs, police costs, rescue costs, damage to property not covered by insurance, production loss etc.), iii) the cost of supplying the transport service by the provider (for rail transport)[2] and iv) the costs caused by air pollution, noise and global warming. Environmental costs are valued using the methods discussed in the following section. For the revenue tables a distinction between direct user contributions (in the form of tolls, Vignettes, access charges etc.) and transport related taxes (vehicle and fuel taxes) was made. Explicit subsidies as far as they increase revenues (referring mainly to subsidies for concessionary fares) are reported in the revenue tables, too and can be directly taken from there. However, the revenue tables also include indirectly implicit subsidies such as tax exemptions. Note, that the type and structure of revenues differ considerably between transport modes. For road transport, taxes and charges play the major role in raising revenues. The tables for rail transport provide information about user tariffs and in countries where infrastructure access charges are raised, these revenues. For rail transport these two revenues sources are not additive: part of the price of a ticket or freight charge pays track access charges.

4.2 Road transport

Tables 2 and 3 show the total costs and the revenues of road transport for the 17 countries completing the UNITE accounts for the year 1998. The structure of the tables reflects the total cost categories described above.

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[1]This can imply a considerable underreporting for some modes

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

Table 2: Total road transport costs covered by society as a whole
- € million 1998 -

Country	Infrastructure Costs	Air pollution costs	Noise costs	Costs of global warming	External costs of accidents	Total
Austria	4382	833	329	376	1367	7287
Belgium	1570	1671	655	625	877	5398
Denmark	1227	496	[1)]	265	679	2667
Finland	1119	435	112	253	232	2151
France	25520	14087	3989	2611	1528	47735
Germany	26176	8411	6245	3849	14592	59273
Greece	2802	978	266	320	3355	7721
Hungary	6075	1163	180	191	[1)]	7609
Ireland	263[2)]	312	352	165	240	1332
Italy	13645	7229	2784	2324	4145	30126
Luxembourg	105	61	33	36	56	291
Netherlands	4411	1482	311	686	1421	8311
Portugal	1791	472	212	483	501	3459
Spain	6224	2067	2965	1474	2307	15037
Sweden	2172	456	143	383	953	4107
Switzerland	4030	532	521	302	925	6310
UK	12728	5192	5768	2392	1994	28074

[1)] No basic data available for cost estimation. – [2)] National roads only.
Source: Link et al. (2002a,b,c)

Explicit subsidies play an insignificant role for road transport. Explicit subsidies are only granted in some countries where private motorway concessionaires receive risk compensation for example for exchange rate risks (an example is Spain with an amount of €197 million in 1998). Implicit subsidies include the provision of land for new motorway construction from the state to private motorway concessionaires and revenue guarantees (for example in Hungary). However, no consistent and comprehensive information on these types of subsidies are available. In principle there are no tax exemptions for road users. Road transport users pay full fuel and vehicle taxes, in some countries tolls and Vignettes are raised. However, after the fuel blockades in 2000 some countries reimbursed their national haulage industry parts of their fuel taxes paid. For example, the Netherlands granted hauliers a temporary fuel duty rebate, fuel tax was lowered in Italy and France and not raised in line with inflation as originally planned in Spain. The German and British governments did not lower fuel tax for road hauliers but did compensate by reducing other taxes.

Total revenues cover total infrastructure costs in all countries except for Hungary. In more than half of the countries studied, the total revenues exceed the total costs of infrastructure, accidents and the costs of air pollution, global warming and noise. However there are substantial implicit subsidies to road transport in Austria, France, Germany, Greece, Hungary, Spain and Switzerland.

Table 3: Road revenues and taxes
- € million 1998 -

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

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

4.3 Rail

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

Table 4: Total rail transport costs
- € million 1998 -

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

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

As can be seen from table 5, information about the revenues, taxes and subsidies for rail transport is not complete. This is in particular true for implicit subsidies such as tax losses due to reduced tax levels or exemptions. For example, the VAT raised on the price of a train ticket is normally reduced compared to the countries VAT level. The rate of VAT raised also varies for national and international travel making general assumptions or basic calculations to estimate VAT loss impossible. Where VAT lost could be calculated, these results are included in table 5. In contrast to that, fuel and energy taxes are charged for rail transport in several countries. The level of these taxes is given in table 5.

Even without comprehensive estimates on revenue losses due to tax reductions and exemptions it is clear from table 5 that the rail sector is characterised by a high level of subsidy In addition to the high level of subsidies for the provision of services and for concessionary fares are substantial implicit subsidies by the failure of total revenue (including explicit subsidies) to cover total social cost.

Table 5: Rail revenues and subsidies
– € million 1998 –

	Revenues		Taxes	Explicit subsidies		Implicit subsidies	Total[1]
	Ticket and freight revenues	Track, station and other infrastructure charges	Fuel and energy tax	For the provision of services	For concession-ary fares	Lost revenues due to reduced VAT on ticket	
Austria	1277	349	5[2]	1045	619	[3]	2 946
Belgium	908	[4]	0.85	1615	[4]	69	2 524
Denmark	566	20	0	219	30	[3]	815
Finland	533	54	4.8[2]	53	9	37	600
France	6380	946	41	5678	296	[3]	12 395
Germany	8614	4566	251[2]	7175[5]	4244	[3]	20 284
Greece	126	[4]	9[2]	[4]	126	[3]	261
Hungary	84	124	27	295	[4]	[3]	406
Ireland	127	[4]	[4]	42	[4]	[3]	169
Italy	3441[6]	[4]	[4]	1740	1700	[3]	6 881
Luxembourg[7]	100	[4]	0.4	104	[4]	4	204
Netherlands	1210	155	[4]	81	81	[3]	1 372
Portugal	188	[4]	[4]	10	[4]	[3]	198
Spain	1495	[4]	0	1925	[8]	[3]	3 420
Sweden	1325	98	[4]	500	[4]	[3]	1 825
Switzerland	2191	774	[4]	1621	[4]	[3]	3 812
UK	5677	3448	[4]	43	2254	[3]	7 974

[1] Excluding infrastructure charges and implicit subsidies. – [2] Including VAT on fuel tax. – [3] Can not be calculated with the available data. – [4] None recorded within the country account. – [5] Includes financial payments to the Bundeseisen-bahnvermögen, a government body outside of the rail sector which took over past national rail debts, parts of the real estate and some of the former rail staff. – [6] Including revenues of €1517 million from public service contract, which may also be seen as a subsidy. – [7] Revenues, taxes and subsidies from rail owned buses included. – [8] Unknown level of subsidies for concessionary fares included in subsidies for provision of services.

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

The degree to which infrastructure and supplier operating costs are covered by revenue from passengers and freight differs substantially between the countries studied, from a maximum of 65% in the case of Finland to a minimum of 9% in the case of Hungary. The simple unweighted average for all the countries in the study is 37%. Since other social costs for rail are low, this figure is only slightly lowered by including them.

4.4 Public transport with metro, tram and buses

As for rail, explicit subsidies for the provision of services and for concessionary fares play an important role in urban public transport. They are reported in table 5, though not for all countries is information available. As only national subsidies were considered within the project, subsidies granted by municipal and city authorities are generally not included here. Therefore the subsidies reported here can be considered to form a base line or lower limit rather than a comprehensive total of all subsidies granted. It should be noted, while there is no double counting of these subsidies between rail services and urban rail services, subsidies to urban rail may be included within the rail data.

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

Table 6: Explicit subsidies granted for public transport
– € million 1998 –

Country	Explicit subsidies identified	
	For the provision of services	For concessionary fares
Austria	261	:
Belgium	727	:
Denmark	241	:
Finland	131	230
France	1404	3250
Germany	:	1622
Greece	:	193
Hungary	153	:
Ireland	:	:
Italy	:	:
Luxembourg	11	:
Netherlands	:	:
Portugal	33	:
Spain	512[1)]	:
Sweden	:	753
Switzerland	566	:
UK	875	104

[1)] Unknown level of subsidies for concessionary fares included in subsidies for provision of services.
Source: Link et al. (2002a,b,c)

4.5 Aviation

Two major implicit subsidies play an important role within the civil aviation transport sector. These are first an exemption from VAT on the price of international tickets. Second, the failure to impose a kerosene tax equal to the costs that air transport causes. There is currently no comprehensive summary on explicit subsidies for airports in Europe available and it is therefore hard to judge the relevance of these subsidies in quantitative terms. For Germany, a recent study on subsidies in the aviation sector has revealed that airports receive subsidies from several administrative levels (federal government, state governments of the Länder, municipalities) and for several purposes ranging from subsidies for running costs of airports, loans and taking over of debts up to equity participation and capital contributions (see Hopf et al. 2001). This study quantified these airport subsidies as amounting to about € 95 billion in 1998. The major part of this amount (about 60 %) was used for running costs of airports, less than one third was invested and 9 % was granted either as loans or concerned taking over of debts. A study for Amsterdam Schiphol airport found that this airport does currently not receive any subsidy (see IOO 2001). French airports received €32 million explicit subsidies in 1999 which made up approximately 5% of the French Civil Aviation Budget (see Hopf et al. 2001). Furthermore, there is a so-called Intervention Fund for airports and air transport in France (FIATA) which granted €12 million in 2000 for air links justified with “territorial development”.

Explicit subsidies for airlines have considerably declined in the EU during the last decade. The European Commissions report on state aid shows for the aviation sector an amount of € 295 million for 1998 (after € 2425 million in 1994, € 2371 million in 1995, € 1395 million in 1996 and € 1635 million in 1997) (see European Commission 2000). These amounts refer to state aid for airlines only. From this it can be concluded that explicit subsidies to airlines are decreasing and are now of minor importance. However, after the 11th of September 2001 the picture has changed. Airlines in Europe receive financial aid for compensating their losses and the increasing expenses for air traffic safety. Although there is no clear picture on the total amount of subsidies granted, as of March 2002 the EU has allowed direct state aid to be given in UK, Luxembourg, Portugal, Finland, Germany, Belgium, Sweden, Austria, Denmark, France, Spain, Ireland and the Netherlands to compensate the aftermath of the September 11 terrorist attacks.

The costs of supplying air transport are given in table 7. No data regarding the airline operating costs was considered. To our knowledge there is no other European study available on this issue. It also needs to be mentioned that current data regarding noise pollution was difficult to obtain for many countries. This results in either low costs or no costs being calculated at all. As in rail transport, accident costs relate to specific incidents and unlike road accident costs vary greatly between years.

Table 7: Total air transport costs
- € million 1988 –
-

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

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

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

Table 8: Revenues, charges, taxes and subsidies within the aviation sector -€ million-

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

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

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

5. How may the environmental consequences of transport subsidies be modelled?

The following section presents an overview of the environmental consequences of transport, existing studies and approaches for quantification of the associated costs.

5.1 Characterisation of environmental consequences

Transport is a source of considerable environmental damage affecting a wide range of receptors, including human health, flora and fauna, and the built environment. These damages to a large extent represent external costs, as they are not reflected in the market price of transport. The following environmental effects have been identified (see e.g. INFRAS/IWW, 2000, or Friedrich and Bickel, 2001 to mention only two out of the broad literature in this field):

- Air pollution: pollutants (e.g. CO, SO_2, NO_x, etc.) are emitted, partly chemically transformed, and dispersed in the air. When they meet receptors they lead to impacts on human health, plants and animals and building materials.
- Climate change: the emission of greenhouse gases (CO_2, CH_4, N_2O, etc.) causes changes in global and regional climate leading to a number of impacts on human health, ecosystems, agriculture, etc.
- Noise: the emission of noise causes disamenity and impacts on human health. Vibrations lead to amenity losses and damages of buildings.
- Impacts on nature and landscape: existence and use of transport infrastructure impairs ecosystems and changes the landscape.
- Soil and water deterioration: emissions of pollutants into soil (among others heavy metals and oil) and water (e.g. de-icing salts, heavy metals, and oil) harm flora, fauna and human health.
- Effects associated with electricity production: impacts which do not belong to the categories mentioned already – for instance nuclear risks and risks caused by dams for hydro power plants.
- Other effects: e.g. visual intrusion in cities.

With regard to environmental effects, not only the operation of vehicles and vessels has to be considered, but as well up- and downstream processes associated with the transport activity. Each of the processes

- vehicle manufacture,
- vehicle use,
- vehicle maintenance and support,
- vehicle disposal,
- fuel/electricity production,
- infrastructure construction, maintenance and disposal

involves activities causing air pollution, global warming, noise, and so on.

Ideally, environmental costs of all categories should be quantified for all up- and downstream processes. However, this is not always necessary (because the effect is not relevant, or negligible) or possible (because of lacking knowledge or data). Existing studies suggest that environmental costs due to airborne pollution, climate change and noise are the most important ones that can be quantified. In practice the range of processes considered quantitatively is restricted to the effects due to the use of a vehicle or vessel for all cost categories plus effects from airborne pollutants and greenhouse gas emissions for fuel and electricity production.

5.2 Overview of existing studies on costs due to air pollution, global warming and noise

Most early studies on environmental consequences of transport (e.g. IWW/INFRAS (1995)) followed a top-down approach (for an overview of studies see ECMT (1994) and ECMT (1998)). The basis for this type of calculation is a whole geographical unit, a country for example. For such a unit the total cost due to a burden is calculated. This cost is then allocated based on the shares of total pollutant emissions, by vehicle mileage, and so on. But environmental costs of transportation - in particular marginal environmental costs - vary considerably with the technology of the vehicle, train, ship or plane, and site (or route) characteristics. Only a detailed bottom-up calculation allows a close appreciation of such site and technology dependence.

In the ExternE project series (see e.g. European Commission (1999a,b), Friedrich and Bickel (2001)), funded by the European Commission the Impact Pathway Approach (IPA) has been developed, which meets these requirements. In ExternE the impact pathway approach was applied for assessing impacts due to airborne emissions. Starting with the emission of a burden, through its diffusion and chemical conversion in the environment, impacts on the various receptors (humans, crops etc.) are quantified and, finally, valued in monetary terms. In other words, information is generated on three levels: i) the increase in burden (e.g. additional emissions and ambient concentration of SO_2 in $\mu g/m^3$) due to an additional activity (e. g. one additional trip on a specific route with a specific vehicle, train, ship, aircraft), ii) the associated impact (e.g. additional hospital admissions in cases) and iii) the monetary valuation of this impact (e.g. WTP to avoid the additional hospital admissions in Euro). Within the UNITE project the IPA has been extended to the quantification of noise impacts and applied to a number of case studies in Finland, Germany, Italy, and the Netherlands.

The IPA for air pollutants and its results have been applied in a number of research projects and policy application related studies, e.g. INFRAS/IWW (2000), European Commission (1998), AEA (1997). Other studies (e.g. WHO (1999), McCubbin and Delucchi (1996)) as well looked at the chain of ambient pollutant concentrations due to the transport sector, human health impacts and monetary valuation. But in contrast to ExternE, the pathway analysed did not include detailed modelling of vehicle emissions at specific locations.

Damage due to climate change is one of the most important categories of fossil fuel emission related damages, but also amongst the most uncertain and controversial. First estimates were presented by Cline (1992), Fankhauser (1995), Nordhaus (1991), and Titus (1992). Tol (2001) estimated climate change impacts with a dynamic approach consistent with the ExternE methodology.

As modelling of the noise nuisance is a challenging task, most of existing studies do bypass noise modelling and allocate damages to different vehicle categories, based on rough assumptions. Such estimates lead to average costs. ECMT (1998) gives a broad overview of studies carried out in different European countries.

5.3 How do subsidies cause environmental consequences?

Subsidies may be relevant in terms of environmental consequences either directly or indirectly. Directly relevant are the subsidies in form of uninternalised external environmental effects. They can be modelled with existing approaches, ideally the impact pathway approach, which is described below.

Indirectly, subventions can be supposed to cause changes in vehicle fleet composition (e.g. due to scrappage premia or subvention of purchase of cleaner vehicles), traffic demand and traffic volume, compared to the situation without subsidies, resulting in increased or decreased environmental consequences. All types of subsidies except uninternalised external environmental effects belong to this category. The first step in modelling the consequences of this type of subsidy is to estimate the change in environmental burden (e.g. emission of airborne pollutants or noise) resulting from the subsidy. This includes modelling of fleet composition, traffic volume and resulting environmental burdens. In the second step these changes in environmental burdens can be assessed as described below.

5.4 Approach for modelling of marginal and average costs

The top-down approach, quantifying the total costs due to air pollution and then allocating parts of these costs to modes and vehicle categories according to their share in emissions or mileage, does not adequately reflect that impacts are highly site-specific: pollutants cause much higher impacts in densely populated areas, where many receptors are affected, than in sparsely populated areas. Even within the same city receptor densities may vary considerably. Furthermore, top-down estimates rather give average than marginal costs.

The Impact Pathway Approach (IPA) is capable of accounting for such differences. Figure 1 illustrates the procedure which reflects the chain of causal relationships, starting from the pollutant emission through transport and chemical conversion in the atmosphere to the impacts on various receptors, such as human beings, crops, building materials or ecosystems. Welfare losses resulting from these impacts are transferred into monetary values. Based on the concepts of welfare economics, monetary valuation follows the approach of ‘willingness-to-pay’ for improved environmental quality. As the number of impacts caused by a pollutant may be very high, not all impacts can be modelled for all pollutants in detail. For this reason the most important pollutants and damage categories (“priority impact pathways”) are selected for detailed analysis.

This principle of modelling the burden (e.g. emissions), behaviour of the burden (e.g. dispersion), response of receptors (e.g. health damages) and monetary valuation should be applied as far as possible for all impact categories. Where non-linearities of effects are involved it is the only appropriate way of quantifying marginal costs. The Impact Pathway Approach can, and for reasons of consistency between marginal and average cost estimates should, be used to calculate average costs as well.

It is important to note, that, even if marginal costs are estimated, the pollutant or noise emissions from all other sources and the background burden influence the impacts for reactive air pollutants and noise due to non-linearities involved. Therefore the “background level” has to be accounted for. If situations with considerably different background levels (e.g. future scenarios or a scenario without subsidies and therefore different fleet compositions and vehicle mileage) have to be assessed, the changed background levels have to be considered.

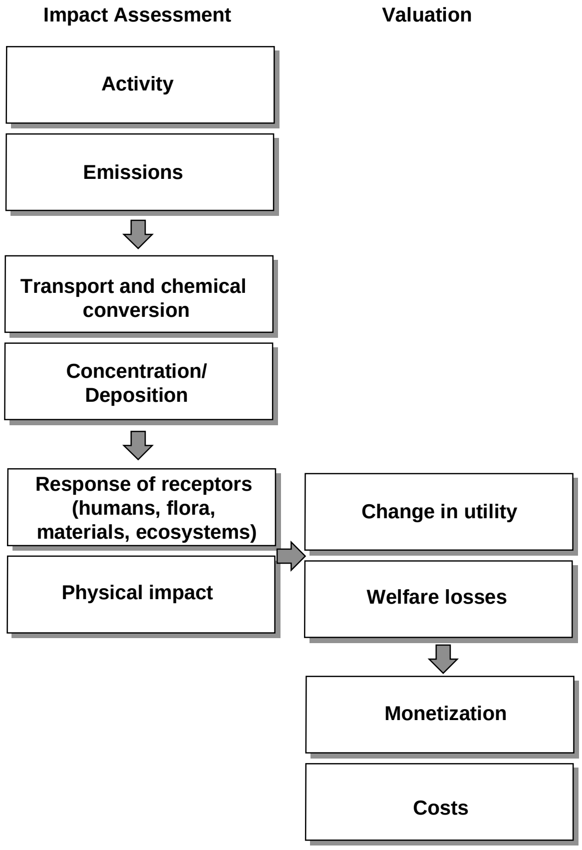

Figure 1 The Impact Pathway Approach for the quantification of external costs caused by air pollution

The principle of the Impact Pathway Approach can be applied to all modes. The character of a burden may differ by mode, as e.g. for noise: roads usually cause a rather constant noise level, while noise from railway lines and airports is characterised by single events with high noise levels. Such differences have to be taken into account and the models used on the respective stage have to be adjusted appropriately. The application of the same approach for all modes ensures consistency of the resulting estimates.

Whereas the Impact Pathway Approach for the quantification of costs due to air pollution and noise is well established, the application to the impacts due to greenhouse gas emissions involves enormous uncertainties. On one hand the consequences of greenhouse gas emissions are independent of location of emission, which simplifies the assessment. However, the calculation of climate change impacts on agriculture, health, energy use, water availability etc. all over the world, extending over many generations implies enormous uncertainties. For this reason, damage cost estimates have to be interpreted very cautiously.

Alternatively, shadow values e.g. for meeting the Kyoto targets in 2010 in the EU can be used for measuring the environmental consequences of greenhouse gas emissions.

5.5 Uncertainties and Gaps

The process of quantifying environmental consequences of subsidies involves considerable uncertainties, which arise from a number of sources, including:

- the variability inherent in any set of input data used for the calculation;
- extrapolation of data from the laboratory to the field;
- extrapolation of exposure-response data or results from contingent valuation studies from one geographical location to another;
- assumptions regarding threshold conditions;
- lack of detailed information with respect to human behaviour and tastes;
- assumptions like the selection of discount rate;
- the need to assume some scenario of the future for any long term impacts.

Generally speaking, the largest uncertainties are those associated with impact assessment and valuation, rather than quantification of emissions and other burdens. Furthermore, there are gaps, i.e. damage categories, where information e.g. on monetary valuation or exposure-response-relationships is lacking, so that no cost estimate can be provided. This means that the outcome of the use of the methods described here is not one specific value describing the external costs with certainty, but rather a range, within which the true value lies.

Despite these uncertainties, the use of the approach described is useful, as

- the knowledge of an order of magnitude of the environmental costs is obviously a better aid for policy decisions than the alternative – having no quantitative information at all;
- the relative importance of different impact pathways is identified (e.g. has benzene in street canyons a higher impact on human health than fine particles?);
- the important parameters or key drivers, that cause high costs, are identified;
- the decision making process becomes more transparent and comprehensible; a rational discussion of the underlying assumptions and political aims is facilitated;
- areas for priority research are identified.

Furthermore, uncertainties in environmental cost estimates reflect the uncertainties in our knowledge about impacts from air pollution, greenhouse gas emissions and noise. This is correct and not a deficiency of the methodology - a scientific method cannot transfer uncertainty into certainty. Only further research (e.g. further contingent valuation studies and epidemiological studies) can help to close gaps and reduce uncertainties.

6. What are the environmental consequences of transport subsidies?

To date, in the context of quantification of environmental consequences of transport subsidies the focus has been put on uninternalised external environmental effects, i.e. the environmental consequences directly caused by subsidies. The most recent work in this field was undertaken in the UNITE project, where total environmental costs due to transport were quantified with a consistent approach for 18 European countries, as well as marginal cost for a number of individual case studies. In the following, selected results are presented. These are based on following assumptions:

- the reference year for background emissions and prices is 1998,
- costs are expressed as factor costs,
- where required a discount rate of 3% was applied.

6.1 Marginal costs

Marginal costs were quantified for specific routes or locations. For this reason the results may vary considerably, even between locations which appear similar. This is in particular the case for air pollution and noise costs in urban areas.

6.1.1 Air pollution

Quantifiable air pollution costs are dominated by health effects, in particular loss of life expectancy. Costs due to crop losses and material degradation are only of minor importance. Diesel vehicles cause considerably higher costs than petrol vehicles, resulting from much higher emissions of primary particles. The difference between both fuel types is highest in urban areas, because primary particles have very high local effects.

Table 9: Marginal costs due to air pollution from road transport in EUR / 100 vkm

Preliminary values	Car Petrol Euro2			Car Diesel Euro2			HGV Diesel Euro2		
	Direct	Fuel prod.	Total	Direct	Fuel prod.	Total	Direct	Fuel prod.	Total
Helsinki	0.12	0.02	0.14	n.a.			n.a.		
Stuttgart	0.25	0.12	0.37	1.45	0.06	1.51	17.52	0.62	18.14
Berlin	0.15	0.12	0.27	0.73	0.06	0.79	10.19	0.62	10.81
Helsinki – Turku	n.a.			n.a.			2.09	0.11	2.20
Basel – Karlsruhe	0.37	0.10	0.47	0.63	0.06	0.69	6.91	0.41	7.32
Strasburg – Neubrandenburg	0.12	0.10	0.22	0.30	0.05	0.35	4.99	0.45	5.44
Milano – Chiasso	0.25 [a)]	n.a.	0.25	1.91 [a)]	n.a.	1.91	6.72 [a)]	n.a.	6.72
[a)] emission standard not specified									

Costs due to indirect emissions from fuel production gain in importance for vehicles complying with stricter emission standards. For petrol cars complying with Euro2 standard or higher the costs from fuel production may reach the same order of magnitude as the costs from exhaust emissions. For diesel vehicles this is usually not the case, because the costs due to exhaust emissions are generally higher, and the costs due to diesel production are lower than for producing petrol.

Further to variations in emission factors the direct costs are determined by the population density close to the emission source, the local meteorology (mainly average wind speed) and by the geographical location within Europe, which is important for the number of the population affected by long-range pollutant transport and the formation of secondary pollutants.

For other modes the relationships between pollutant emission and associated costs are in principle the same as for road transport. Emissions from diesel locomotives, maritime and inland waterway vessels can be treated like emissions from road vehicles, taking into account the character of the route. For these modes however the main part of emissions will occur in extra-urban areas. In the case of electric trains, the marginal costs quantified vary heavily depending on the fuel mix from which the electricity is produced - the lower the share of fossil fuels, the lower the resulting costs. Aircraft emissions are a special case, because most of the emissions take place in high altitudes. Assessment of the resulting impacts is still to be improved, because modelling of dispersion and chemical conversion is not as advanced as for low level emissions. On the other hand impacts due to low level emissions at airports occurring during arrival, ground activities and departure can be assessed with the existing models.

6.1.2 Global warming

Costs due to the emission of greenhouse gases are not location specific, as they are relevant on a global scale. Abatement costs were calculated based on the same monetary value (EUR 20 per tonne of CO_2) for all case studies, which is applicable for all countries of the European Union. This value represents a central estimate of the range of values for meeting the Kyoto targets in 2010 in the EU based on estimates by Capros and Mantzos (2000). As a consequence all the variation is caused by the emission factor of a vehicle, vessel, aircraft, or the underlying electricity production process.

For petrol cars complying with Euro2 emission standard, marginal costs associated to greenhouse gas emissions are higher than the costs due to air pollution; the same holds for the aircraft studied. For Euro2 diesel cars and heavy goods vehicles, global warming costs are generally lower than air pollution costs. The same is the case for trains with electric traction, the maritime passenger ferry, and the container ship on the Rhine.

Table 10: Marginal costs due to greenhouse gas emissions from road transport in EUR / 100 vkm

Preliminary values	Car Petrol Euro2			Car Diesel Euro2			HGV Diesel Euro2		
	Direct	Fuel prod.	Total	Direct	Fuel prod.	Total	Direct	Fuel prod.	Total
Helsinki	0.35	0.06	0.42	n.a.			n.a.		
Stuttgart	0.47	0.08	0.55	0.31	0.04	0.35	3.28	0.41	3.69
Berlin	0.47	0.08	0.55	0.31	0.04	0.35	3.28	0.41	3.69
Helsinki – Turku	n.a.			n.a.			2.40	0.34	2.74
Basel – Karlsruhe	0.37	0.06	0.43	0.32	0.04	0.36	2.18	0.27	2.45
Strasburg – Neubrandenburg	0.38	0.06	0.44	0.27	0.03	0.30	2.41	0.30	2.72
Milano – Chiasso	0.36 [a)]	n.a.	0.36	0.36 [a)]	n.a.	0.36	2.16 [a)]	n.a.	2.16
[a)] emission standard not specified									

6.1.3 Noise

Noise is a very local burden, marginal costs due to noise exposure are mainly determined by the population affected, the time of day (with higher disturbance effects of noise during the night) as well as the number of vehicles and their speeds, and the resulting background noise. The higher the existing background noise level, the lower the costs of an additional vehicle or aircraft.

The following table illustrates the broad variation in noise costs quantified in different case studies. Marginal costs are generally higher at night time than at daytime, with a difference of up to a factor of three. This is due to the higher disturbance effects of noise at night and a lower background noise level. Differences between the case studies are large, reflecting the variability of marginal costs with the detailed population distribution, number and speed of vehicles, share of HGVs, etc.

Table 11: Marginal costs due to noise from road transport in EUR / 100 vkm

Preliminary values	Passenger car		HGV	
	daytime	night time	daytime	night time
Helsinki	0.22	0.53	n.a.	n.a.
Stuttgart	1.50	4.50	25.75	78.25
Berlin	0.47	1.45	7.67	23.33
Helsinki – Turku	n.a.	n.a.	1.58	3.86
Basel – Karlsruhe	0.02	0.03	0.11	0.18
Strasburg – Neubrandenburg (within built-up areas)	0.12	0.19	3.04	5.06
Milano – Chiasso	0.01	0.04	0.09	0.35

Marginal noise costs for an arrival and departure of a Boeing 737-400 at London Heathrow airport amount to almost EUR 59. Marginal noise costs of maritime shipping and inland waterway transport were found to be negligible.

6.2 Average costs

The following table shows average costs for road and rail transport in Finland, Germany and Italy. They represent the average for the whole fleet on all road types all over the country. For rail transport the average for trains with electric and diesel traction is given.

Table 12: Average costs from road and rail transport in EUR / 100 vkm

Preliminary values	Finland				Germany				Italy			
	Air	GW	Noise	Total	Air	GW	Noise	Total	Air	GW	Noise	Total
Road transport												
Motorcycles	n.a.				0.5	0.2	2.7	3.5	1.3	0.2	n.a.	1.5
Passenger Cars [a)]	0.9	0.4	0.2	1.5	0.8	0.5	0.5	1.7	1.2	0.4	n.a.	1.6
Buses	6.9	2.0	1.3	10.2	9.6	1.8	4.1	15.5	6.6	1.8	n.a.	8.4
Light Goods Vehicles	1.2	0.7	1.5	3.4	1.6	0.8	5.3	7.7	1.8	0.6	n.a.	2.4
Heavy Goods Vehicles	4.5	2.2	3.1	9.8	7.2	2.0	3.5	12.6	5.3	1.5	n.a.	6.8
Rail transport												
Passengers	11.0	14.0	41.0	66.0	25.6	15.6	92.2	133.4	42.0	17.0	56.0	115.0
Freight	35.0	24.0	82.0	141.0	20.3	20.7	184.1	225.1	28.0	16.0	112.0	156.0
Air = Air pollution; GW = global warming; [a)] petrol and diesel cars												

For road transport vehicles, differences in air pollution costs arise from the fleet compositions (age and emission standard of vehicles), split of mileage in urban and extra-urban areas and damage potential due to transboundary air pollution in the respective area. In the case of global warming differences are quite small between countries, caused by the average fuel consumption of the vehicle fleet. Noise costs again depend on the fleet composition (age and maintenance of vehicles) and share of mileage in populated areas. However, comparability between countries is restricted for noise costs, because population exposure estimates stem from different sources.

Costs due to air pollution and global warming for rail transport are determined by the share of diesel traction and the power plant mix for electricity production. Concerning comparability between countries the same issue arises as for road transport due to different sources for population exposure.

7. Implications of removal of transport subsidies

It will be clear from the discussion above that action to remove subsidies relative to total costs by charging all modes average costs would have some very counter productive results, especially if external costs were ignored. Whilst in some countries road and air transport would pay more in many they would pay a lot less, leading to large scale generation of additional transport movements by these environmentally damaging modes. Moreover, rail users would generally pay substantially more, leading to traffic diversion to less environmentally friendly modes. The net effect of removing transport subsidies in this simplistic fashion would clearly be very environmentally damaging.

However, removal of transport subsidies in this simplistic sense is rarely seen as something that is sensible to contemplate. Most studies of transport pricing policies have followed the approach adopted by the European Union in its transport policy (European Commission, 2001) of removing subsidies in terms of the difference between price and marginal social cost.

Marginal social cost cannot be estimated readily from the above accounts information. Whilst average environmental and supplier operating cost may give some idea of average marginal cost of these categories of cost throughout the country, in practice they vary widely, for instance between urban and rural areas. For infrastructure and accident costs, marginal cost is usually below average, whilst for congestion it is usually above. Specific studies are therefore needed to estimate marginal costs.

Sansom et al (2001) computed both marginal and average costs for road and rail in Great Britain in 1998; only the marginal cost results are shown here. The following tables provide an illustration of the variability of results between locations and times of day. In tables 13 and 14 it is seen that road vehicles generally pay less than the marginal cost they impose, but that this varies enormously with type of road and time of day. The corresponding results for rail (Tables 14 and 16) show that in the passenger sector, all categories of service are subsidised, although the much lower loadings of regional services mean that the subsidies per passenger kilometre there are much higher than elsewhere; for freight, the commercial policy adopted in Britain at the time means that all services pay slightly more than marginal cost.

Table 13: Marginal Cost and Revenue Analysis by Type of Vehicle and Time of Day (pence/vkm, low valuations)

Categories	Costs										Revenues					Difference
	Infrastructure operating cost & depreciation	Vehicle operating cost (PSV)	Cong-estion	Mohring effect (PSV)	External accident costs	Air pollution	Noise	Climate change	VAT not paid (PSV)	Total	Fares (PSV)	Vehicle excise duty (part)	Fuel duty	Value added tax on fuel duty	Total	Costs - Revenues
Car, peak	0.05	-	13.22	-	0.78	0.18	0.01	0.12	-	14.4	-	-	3.86	0.68	4.5	9.8
Car, off-peak	0.05	-	7.01	-	0.80	0.18	0.01	0.12	-	8.2	-	-	3.86	0.68	4.5	3.6
LDV, peak	0.06	-	13.99	-	0.52	0.76	0.02	0.19	-	15.5	-	-	3.86	0.68	4.5	11.0
LDV, off-peak	0.06	-	7.07	-	0.53	0.68	0.02	0.18	-	8.5	-	-	3.86	0.68	4.5	4.0
HGV-Rigid, peak	3.82	-	26.00	-	1.40	1.84	0.06	0.44	-	33.6	-	2.25	13.11	2.29	17.6	15.9
HGV-Rigid, off-peak	3.77	-	12.75	-	1.39	1.57	0.06	0.43	-	20.0	-	2.25	13.11	2.29	17.6	2.3
HGV-Artic, peak	7.57	-	33.45	-	0.99	1.42	0.07	0.72	-	44.2	-	2.50	14.47	2.53	19.5	24.7
HGV-Artic, off-peak	7.55	-	19.81	-	0.99	1.41	0.08	0.71	-	30.5	-	2.50	14.47	2.53	19.5	11.0
PSV, peak	5.74	78.73	20.31	-14.43	3.82	3.17	0.09	0.58	13.33	111.3	76.19	0.61	5.26	0.92	83.0	28.4
PSV, off-peak	4.93	80.10	12.31	-14.86	3.69	3.15	0.09	0.55	13.49	103.5	77.10	0.61	5.26	0.92	83.9	19.6

Table 14 Marginal Cost and Revenue Analysis – by Area type & Road type (car, pence/ vkm, low cost estimates)

Categories	Costs							Revenues			Difference
	Infrastructure operating cost & depreciation	Cong-estion	External accident costs	Air pollution	Noise	Climate change	Total	Fuel duty	Value added tax on fuel duty	Total	Costs - Revenues
Central London											
Motorway	0.01	53.75	0.01	0.57	0.04	0.11	54.5	3.86	0.68	4.5	49.9
Trunk & Principal	0.04	71.09	1.68	0.77	0.03	0.16	73.8	3.86	0.68	4.5	69.2
Other	0.08	187.79	1.68	0.87	0.04	0.19	190.6	3.86	0.68	4.5	186.1
Inner London											
Motorway	0.01	20.10	0.01	0.42	0.03	0.11	20.7	3.86	0.68	4.5	16.1
Trunk & Principal	0.04	54.13	1.68	0.61	0.04	0.16	56.6	3.86	0.68	4.5	52.1
Other	0.08	94.48	1.68	0.66	0.03	0.17	97.1	3.86	0.68	4.5	92.6
Outer London											
Motorway	0.01	31.09	0.01	0.31	0.02	0.10	31.5	3.86	0.68	4.5	27.0
Trunk & Principal	0.04	28.03	1.68	0.40	0.02	0.14	30.3	3.86	0.68	4.5	25.8
Other	0.08	39.66	1.68	0.45	0.02	0.16	42.0	3.86	0.68	4.5	37.5
Inner Conurbation											
Motorway	0.01	53.90	0.01	0.47	0.02	0.11	54.5	3.86	0.68	4.5	50.0
Trunk & Principal	0.04	33.97	1.68	0.55	0.02	0.14	36.4	3.86	0.68	4.5	31.9
Other	0.08	60.25	1.68	0.66	0.02	0.17	62.9	3.86	0.68	4.5	58.3
Outer Conurbation											
Motorway	0.01	35.23	0.01	0.25	0.02	0.10	35.6	3.86	0.68	4.5	31.1
Trunk & Principal	0.04	12.28	1.68	0.30	0.02	0.12	14.4	3.86	0.68	4.5	9.9
Other	0.08	0.00	1.68	0.32	0.02	0.13	2.2	3.86	0.68	4.5	-2.3
Urban >25 km2											
Trunk & Principal	0.04	10.13	1.68	0.25	0.02	0.12	12.2	3.86	0.68	4.5	7.7
Other	0.08	0.72	1.68	0.26	0.02	0.13	2.9	3.86	0.68	4.5	-1.6
Urban 15-25 km2											
Trunk & Principal	0.04	7.01	1.68	0.25	0.02	0.12	9.1	3.86	0.68	4.5	4.6
Other	0.08	0.00	1.68	0.24	0.02	0.12	2.1	3.86	0.68	4.5	-2.4
Urban 10-15 km2											
Trunk & Principal	0.04	0.00	1.68	0.17	0.02	0.11	2.0	3.86	0.68	4.5	-2.5
Other	0.08	0.00	1.68	0.19	0.02	0.12	2.1	3.86	0.68	4.5	-2.4
Urban 5-10 km2											
Trunk & Principal	0.04	2.94	1.68	0.15	0.02	0.11	4.9	3.86	0.68	4.5	0.4
Other	0.08	0.00	1.68	0.16	0.02	0.12	2.1	3.86	0.68	4.5	-2.5
Urban 0.01-5 km2											
Trunk & Principal	0.04	1.37	1.68	0.13	0.01	0.11	3.3	3.86	0.68	4.5	-1.2
Other	0.08	0.00	1.68	0.14	0.01	0.12	2.0	3.86	0.68	4.5	-2.5
Rural											
Motorway	0.01	4.01	0.01	0.11	0.00	0.13	4.3	3.86	0.68	4.5	-0.3
Trunk & Principal	0.04	8.48	0.30	0.10	0.00	0.11	9.0	3.86	0.68	4.5	4.5
Other	0.08	1.28	0.30	0.10	0.01	0.10	1.9	3.86	0.68	4.5	-2.7

Table 15: Marginal Cost and Revenue Analysis for Rail Freight

£/ train km, low cost estimates

Category	Costs						Revenue	Diff-erence Cost - Revenue
	Marginal infrastructure usage	Vehicle operating cost	Air pollution	Noise	Climate change	Total		
Bulk	1.79	8.60	0.166	0.170	0.131	10.86	13.01	-2.15
Other	0.88	9.70	0.166	0.170	0.131	11.05	13.61	-2.56
Freight Sector	1.19	9.28	0.166	0.170	0.131	10.94	13.41	-2.47

Note: low cost estimates apply to environmental categories only.

Table 16: Marginal Cost and Revenue Analysis for Passenger Rail

£/train km, low cost estimates

Category	Costs										Revenue	Difference
	Marginal infrastructure usage	Vehicle operating	Electricity	Congestion	Mohring Effect	Air pollution	Noise	Climate change	VAT not paid	Total		Costs – Revenue
Inter City	1.116	11.79	0.483	0.15	-1.55	0.279	0.122	0.067	2.46	14.92	14.07	0.85
Regional	0.149	5.04	0.068	0.09	-0.67	0.041	0.042	0.031	0.54	5.33	3.11	2.22
London	0.406	6.68	0.371	0.28	-1.19	0.067	0.088	0.037	1.48	8.22	8.47	-0.25
Passenger sector	0.424	7.07	0.228	0.18	-1.05	0.098	0.076	0.040	1.32	8.38	7.52	0.86

Note: Low cost estimates apply to environmental categories only.

The existing range of pricing policies in most Member States is so varied that it is difficult to generalise about the likely implications of pricing reforms designed to reflect marginal social cost. Pricing based on marginal costs may result in price reductions for some modes as well as price rises for some others because current levels of taxation and charging have to be taken into consideration. To forecast the environmental consequences of such a policy requires either actual experience or a model which can simulate the reactions of transport users to the implied price changes. Evidence is available on the implications of marginal cost pricing from a small number of actual implementations or demonstration projects, and from a much larger number of modelling exercises. Both will be reviewed in this section.

For the use of urban roads, the Norwegian experience is the most valuable. In Norway, special area entry permits are being used in Oslo, Bergen, and Trondheim. Although they are primarily used to raise revenues, there is evidence that there has been some impact on the overall traffic levels in the controlled area. In Oslo, the car traffic reduction is estimated as 8-10%. A form of area pricing system has been in use in Singapore since 1975 with considerable success. From 1998, this was adapted into a more sophisticated electronic charging system, the early results of which show a 15% reduction in overall traffic levels even in a city where heavy taxation and the auctioning of permits to own a car hold car ownership below what would otherwise be expected (Menon, 2000). However, it should be noted that these examples of pricing reform could only be described as having been ‘loosely’ based on principles of marginal cost.

A review of modelling studies for urban road pricing (Nash and Matthews, 2001) indicated that proposed price changes can induce small but significant changes in behaviour (e.g. a 5 to 10% demand reduction) - small changes in behaviour can make a major contribution to the reduction of congestion and other externalities. In some studies a small reduction in demand has been shown to result in the marginal external cost of congestion falling to 20% of the pre-charge level (CES-KUL, 1999).

In contrast, demonstrations of urban road pricing often suggest that unacceptably large price changes may be needed in order to influence behaviour. However, these magnitudes of response should be treated with caution - although these demonstrations have provided valuable evidence on implementation issues, their short-term focus and use of compensation to volunteer participants who chose not to use their car (as opposed to charging those who did) affects the results obtained.

Demonstrations such as the Leicester demonstration in EUROTOLL as well as modelling exercises confirm the main impact of more variable road charging is likely to be travel at different times or by different routes by the same mode - the user’s first preference will often be to continue to use their vehicle, but in a different way (different departure time, route etc.). Provision of park and ride appears to be important in the use of road pricing for promotion of public transport

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

For inter-urban passenger travel in uncongested conditions, it is likely that road-based modes are over-priced - due to the combination of existing charging and taxation systems. For example, the PETS case studies (Sansom and Nash, 2001) suggest that existing prices for inter-urban car broadly reflect and perhaps exceed marginal social cost including all externalities. It is common to find that inter-urban rail and road-based public transport are overpriced, despite generally low taxation to account for externalities. Current fares are often in excess of the marginal cost of providing additional services due to full cost recovery targets in the presence of economies of scale. This forms the main case for a realignment of prices to favour rail transport. The same result may not apply to air transport, however, because of its much higher level of external cost. The main effect of these changes would be to induce minor shifts from air and road to rail transport. (Tables 17 and 18).

For inter-urban freight transport, evidence suggests significant under-charging in many cases for both road and rail-based modes – even in uncongested conditions. Inter-urban road freight is also likely to suffer from distortions due to the variety of pricing regimes in operation in different Member States. The benefits of internalisation for rail freight are again limited by the finding that rail is often underpriced as well. (Tables 19 and 20).

Therefore, pricing reform to reflect marginal social cost in passenger transport would, in general, involve a decrease in prices for inter-urban road and rail transport and increases in the price of urban road-based transport, in particular the private car. For freight transport, the introduction of efficient prices would often lead to increases in prices for both road and rail. In addition, these pricing reforms would result in a substantially greater degree of differentiation and variation in transport prices.

Interestingly, improving service quality and investment in infrastructure appear to be the most important measures for increasing rail modal shares - as opposed to internalisation of externalities for all modes via the pricing mechanism. This is particularly the case for freight transport, according to the case studies in STEMM. (Fowkes, Nash and Tweddle, 1998)

Table 17: Changes in Passenger Prices
(EURO/100 passenger km)
(change compared to 2010 base situation)

Case Study	Cost Est.	Car	Bus	Train	Air
Cross Channel	low high	-2.75 -1.35	- -	-3.00 -2.82	-2.27 -1.16
Finnish	low high	-2.24 -0.49	-2.96 -2.56	-4.06 -4.04	- -
Oslo-Goth	low high	-2.57 -0.49	-1.18 0.51	-1.26 -1.22	-5.71 -4.54
Lisbon	Low high	+1.19 +3.37	-1.72 -1.65	-0.90 -0.87	- -

Source: ITS, 2000, PETS final report

Table 18: Changes in Passenger Demand
(% change compared to 2010 base situation)

Case Study	Cost Estimates	Car	Bus	Train	Air	Total
Cross Channel	Low High	-0.2 -0.7	- -	+7.1 +10.3	-1.7 -2.2	- -
Finnish	Low High	-1.4 -3.2	+3.7 +11.4	+12.1 +20.7	- -	- -
Oslo-Goth	Low High	+21.5 +6.2	=10.5 -4.4	-8.4 +0.2	+6.8 +8.9	+14.6 +4.7
Lisbon	Low High	-29.0 -36.3	+22.2 +25.0	+29.6 +32.0	- -	- -

Source: as Table 17

Table 19: Changes in Freight Prices
(EURO/100 tonne km)
(change compared to 2010 base situation)

Case Study	Cost Estimates	HGV	Train
Cross Channel	low high	+1.21 +2.04	+1.50 +1.61
Finnish	low high	+1.13 +1.58	-0.27 -0.26
Transalpine	low high	-4.80 -1.19	+0.28 +2.02

Source: as Table 17

Table 20: Changes in Freight Demand
(% change compared to 2010 base situation)

Case Study	Cost Estimates	HGV	Train
Cross Channel	low high	+1.2 -1.5	-3.0 +4.0
Finnish	low high	-5.9 -7.9	+7.4 +9.7
Transalpine	low high	+3.1 +0.1	-12.5 -1.7

Source: as Table 17

8. Conclusions

We have seen that the transport sector is the recipient of many subsidies both explicit and implicit. But we have also seen that there is an important distinction between two alternative ways in which subsidies may be measured. Firstly we may compare total revenues and total social costs for each mode of transport. But secondly we may compare prices paid with the marginal social cost.

With both approaches, the results obtained are fairly diverse. In almost all countries revenues from road transport cover the costs of providing and maintaining the infrastructure and in many countries, revenues from road transport cover the total social cost, although in some they do not. By contrast other modes are heavily subsidised. The effect of removing subsidies in total would therefore be to divert traffic from other modes to road. Although there might be some reduction in total transport, the effects of removing subsidies in this way might well have overall consequences which were damaging for the environment. If removal of subsidies was accompanied by removal of surpluses generated from taxes on road transport, the environmental consequences would be greatly worse, as a large increase in road traffic would be produced.

By contrast, road transport often has charges which are below marginal social cost especially in congested areas. Public transport and rail tend to have marginal costs that are well below average costs, due to economies of scale in production and low externalities. Thus the implementation of marginal social cost based pricing to remove subsidies at the margin would generally have environmentally benign results, with reductions of road traffic typically of up to 15% in urban areas, and rather less elsewhere. Air would also typically lose traffic whilst rail would gain. However, even this pattern varies between the member states. In some cases, rail is already so heavily subsidised that marginal social cost pricing would divert traffic from rail to road. This is particularly true of freight.

The implication is that the current failure to implement efficient transport pricing policy is indeed leading to environmental damage, particularly in urban areas. However, the effects of removing those subsidies would not lead to dramatic change, and pricing policy must be seen as just one in a set of instruments for reducing the environmental effects of transport systems, along with investment, emissions standards and traffic management.

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