# Dealing with major transport externalities in the EC: Policy options and impacts on energy use

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## 1. SYNOPSIS

This paper analyses the attractiveness of various policy options to deal with major transport externalities in the EC in terms of their impact on economic welfare

## 2. ABSTRACT

This paper argues that a switch from current to efficient policies to internalise external effects from the EC transport sector might bring about significant positive effects on welfare. Policies should be selected on the basis of their welfare impact, or, if environmental benefits cannot be monetised, on the basis of cost-effectiveness. Applying these criteria to the main transport externalities - accidents, congestion, infrastructure costs and air pollution - shows that available first best instruments are likely to comprise congestion charges in combination with efficiently formulated wear taxes, infrastructure construction rules, insurance schemes, standards and circulation taxes. Fuel taxes are critically absent from this list. Both the EC and the Member State level have an important role to play in formulating these policies.

## 3. INTRODUCTION

Accidents, air pollution and congestion have been identified by many researchers as constituting the main external effects of transport. Furthermore, it is alleged that various modes do not fully pay the bill of the infrastructure costs they entail. Numerous articles and policy documents have been written in which these deficiencies are analysed and in which the need for policy action is heralded. It has become conventional wisdom to say that transport users are not paying the full social costs and that hence there is a need to internalise these externalities in the market price. However, at this point the consensus breaks down as there is no communis opinio on how this should be done and which instruments should be used.

Many observers believe that increasing energy efficiency is a key element of any sound transport policy and this belief has been strengthened by the identification of the threat of global warming. It is the aim of this paper to analyse this contention from an economic point of view. In doing so the paper focuses on road transport as, both due to its size and resource intensiveness, this sector is responsible for the bulk of transport externalities. The first question to be addressed is how optimal transport policies with respect to externalities would look. It is here that the economist has something to contribute by pointing to the appropriate yardstick to evaluate policy instruments; i.e. welfare implications. A brief discussion on the concept of welfare effects and efficient policies is provided in Chapter 2. In the next chapter efficient policies to deal with each of the main externalities are briefly discussed. Impacts on economic welfare, transport and energy consumption are analysed. The analysis presented is predominantly qualitative and will need to be followed up by quantitative research with which the differences between various instruments and their impacts can be assessed in a more rigorous way. Chapter 4 looks at second or third best options which are discussed in real life and attempts to assess their welfare penalty as well as consequences for fuel use and mobility. It is here that the issue of promoting energy efficiency for its own sake is dealt with and that some implications for policy making are discussed. Finally, Chapter 5 rounds up the discussion and presents some conclusions.

## 4. EXTERNALITIES AND THE CONCEPT OF EFFICIENT TRANSPORT POLICIES

Externalities imply that in the absence of government intervention market prices faced by individual decision makers do not conform to the marginal costs to society as a whole. Optimal policies restore this equality by adding a charge to activities or commodities that have negative impacts on third parties not taken into account by private agents. This charge should reflect the marginal value of the damage caused. In the case of transport, policies should ensure that transport users pay the full "market" cost for effects they cause. Under well known conditions such a policy leads to a situation in which the total welfare of all members of society is maximised[2] These policies are efficient in the sense that they restore the allocative function of the market mechanism.

This stylised description suggests the following agenda for the efficient policy maker:

1. Identification of externalities
2. Evaluation and monetisation of damage functions
3. Instrument selection: cost-effectiveness and efficient implementation

There are several problems inherent in this process for trannsportation at all three levels which complicate the introduction of such policies.

For example, social costs can develop from unexpected sources. Thus, there is no guarantee that all impacts of transport which might indirectly affect the well-being of third parties are known at present. Global warming is a good example of an externality that was "discovered" recently and did not figure on the list of major transport problems of the Seventies. Furthermore, as we will see in the case of safety discussed in the next chapter, it is not always clear whether the impacts can genuinely be labelled externalities or are in fact partly internal to decision makers.

Table 1 *Broad estimates of various non-internalised externalities and non-covered market costs of road transport (% of GDP)*[1]

| externality | low cost estimate | high cost estimate |
|---|---|---|
| accidents[a] | 0.3 | 1.5 |
| congestion[b] | 0.1 | 1.0[f] |
| air pollution[c] | 0.2 | 1.50 |
| noise[d] | 0.10 | 0.20 |
| infrastructure costs[e] | 0.0 | 0.5 |
| Total | 0.8 | 4.7 |

1) For discussion, see endnote 12

Source: Various studies; e.g.Hansson and Markham (1992), Mackenzie et al. (1992), Button (1990) and Quinet (1989)

Even when the (physical) impact of transport is known, the evaluation and monetisation of damage functions might pose severe problems (see e.g. COWIconsult 1991). In some cases the physical process is not understood well enough to allow an assessment, in others intergenerational aspects are of importance. Damages might differ critically from location to location and even from day to day as many air pollution aspects depend heavily on geographical and climatic conditions. A tonne of HC emissions has a much higher damage impact on a windless summer day in Los Angeles than on a foggy night in San Francisco. Although progress in measuring damages has been made - e.g. by better techniques to evaluate "willingness" to pay -monetisation of transport externalities is still in its infancy.

Various estimates, however, show that monetised externalities of road transport are likely to be quite significant and lie in the range of 1-5% of GDP in modern industrialised economies.

The difficulties inherent in estimating externality costs imply that it might sometimes be necessary to forsake the aim of exactly internalising the externalities. In such cases an alternative strategy may be to define an intermediate *target* for the reduction of externalities; the associated cost estimates of which fall roughly in line with the estimates of externality costs.[3] In this case the question changes to how the target can be reached at least cost, in other words how cost-effective instruments can be selected. Here also welfare effects are of great importance in executing an evaluation as they provide the best measure of the overall costs of policy instruments. The efficiency of various instruments can be assessed in the following way. Each instrument should be introduced to the extent that the impact on the externality is identical. On the benefit side ( = reduced externalities) it can then be stated that all policies have equal impacts.[4] The costs of the policies are likely to differ and can be evaluated by inspecting the change in societal welfare. Under certain conditions (see Varian 1984, pp. 266-268) this change can be approximated by the loss in producer and consumer surpluses corrected for the change in tax revenues (this sum represents the so-called dead-weight loss of taxation).[5] Obviously, also the running costs of the policy instrument itself should be taken into account as resources lost in executing a policy will increase the cost of the instrument chosen.

Hence the cost side can be evaluated as follows:

WELF = CONS + PROD + TAXREV - POLCOST

in which:

| | |
|---|---|
| : | difference between baseline and policy scenario cases |
| WELF: | total societal welfare |
| CONS: | consumer surplus |
| PROD: | producer surplus |
| TAXREV: | revenues from policy instrument |
| POLCOST: | running costs of policy instrument |

The concept of welfare effects to evaluate the costs of transport policies is seldom used. It is useful to point out that it is very different from traditional approaches. For example, it can be contrasted with and shown to diverge strongly from a cost category which is often the basis of "cost analyses" undertaken by public authorities, i. e. "financial costs" or expenses. It is obvious that such induced spending is much easier to measure than welfare effects. However, it should be kept in mind that "expenses" are a much more limited concept and cover only part of the costs caused by the introduction of a new policy instrument. For example, reducing private transport does not necessarily lead to significant outlays and is therefore in the traditional approach often considered to be "for free". However, transport agents appreciate private transport (e.g. because of the relatively low time costs of such travel) and experience this measure as a decrease in their welfare which can be measured by the reduction in the consumer surplus. Thus, welfare effects are the appropriate yardstick to measure the costs of such a policy.

Even when the externality has been identified and monetised it is not always be easy to pinpoint an efficient tax base. A crucial condition is obviously that the charge is tied to the polluting activity or to a close proxy of it. Only when the economic agent can reduce the tax burden by behavioural adjustments in response to the charge can this instrument be labelled truly efficient. This might seem an obvious condition, but establishing the link is not always easy. In the case of NOx emissions, for example, a tax on fuel is a very rough measure as emissions depend not only on the amount of fuel consumed, but also on characteristics of the car such as the fuel/air ratio, the presence of a catalytic converter etc. As will be discussed in the next chapter this calls for an innovative policy design. Obviously there is a strong link with the previous point: the closer the relation between the chargeable event and the externality, the more efficient is the instrument chosen. If, for example, the external costs of congestion and safety were internalised by introducing a lump-sum tax on motorists, then there would be hardly any reduction of the externality even though significant revenues might be raised.

Thus, there are various crucial factors to be taken account when designing efficient transport policies. The next chapter looks at the three main externalities from this perspective and describes how, given technology, optimal policies would look.

## 5. DESIGNING EFFICIENT POLICIES FOR TRANSPORT RELATED AIR POLLUTION, CONGESTION AND SAFETY

### 5.1 Congestion, road damage and other infrastructure costs

Road users cause two types of costs. First, they incur private costs such as money spent on their vehicle, on fuels and their own time costs of travelling. Secondly, they impose costs on others. For example, roads wear is increased, which might have consequences for other road users. Overall travel speeds (congestion) are also affected. In addition, society forsakes interest on the road investment outlays. The latter category of costs are external to the road users and will have no impact on their private decisions unless governments attempt to internalise them.

Policy makers have to address two questions in this respect. The first is how to confront road users with their marginal external costs, thus ensuring efficiency. The second is whether such policies will bring in enough revenue to finance the maintenance and interest costs of the highway system.

A rich literature exists in which these two issues are addressed (see e.g. Mohring and Harwitz 1962; Winston 1985; Newbery 1988; Goodwin1990; Newbery 1990; Winston 1992). In answering the first question the theory of efficient infrastructure planning is touched upon. This theory contains two powerful prescriptions for infrastructure expansion and for pricing which together ensure that the social benefits of the road system are maximised. Expansion should take place until the costs of a marginal infrastructure addition equal the aggregate (i.e. for all transport users) savings in transportation costs (time savings, maintenance etc.).[6] This prescription not only relates to the amount of infrastructure ("capacity"), but also to the thickness (or "durability").

Pricing should ensure that the road user is confronted with the full social marginal costs of travel. It is important to point out that these two prescriptions are interrelated: the evaluation of cost savings due to investments in transport infrastructure should be done at traffic levels which are based on efficient prices. Policy makers should thus "add" the non-internalised social marginal costs to the private marginal costs in order to reach this social optimum. Two elements seem to be of direct relevance: road damage costs and congestion. Road damage costs comprise both the costs to highway authorities of having to repair damaged roads, and the costs to other road users who drive on damaged roads. It appears that if highway authorities employ a "condition-responsive" maintenance strategy in which roads are repaired whenever they reach a predetermined state, the impact of an extra vehicle kilometre on the average state of the road is essentially nil and other road users are, on the whole, not affected (Newbery 1988). This implies that the appropriate marginal maintenance costs to be charged are simply the average maintenance costs. These, in turn, are dependent on the non-weather caused damage to roads (which varies in relation with climate between 20 and 80% of total maintenance costs, Newbery 1988, argues that the appropriate percentage for the UK is 40% ) and have to be allocated to the various road users in relation to the damaging power of their vehicle and the amount of kilometres driven. As the damaging power increases as the third to fourth power of the axle load, virtually all non-weather related maintenance costs should be borne by heavy good vehicles.

Charging for congestion constitutes the second element of an efficient pricing policy. It is well known that on congested roads the impact on traffic speeds of adding an extra car to the vehicle stream can be quite significant. As road users only take their own time losses into account and not those of other road users such a situation is clearly sub-optimal. As figure 1 demonstrates, the optimal policy is to charge road users for the difference between social and private marginal costs at the optimum numbers of vehicles per lane. Numerous analyses of the impacts of road pricing have been made investigating such varied elements as the accurate determination of tolls on various roads, the welfare impacts for different categories of road users, and optimal policies to redistribute tax revenues (e.g. Newbery 1990; Goodwin 1990). Given information on the relation between the number of vehicles per lane and travel speeds on the one hand and traffic demand relations on the other hand, optimal congestion charges can be calculated. These are likely to vary significantly according to time of day and type of road. Various simulations suggest that the reduction of congestion will be very significant (see e.g. DVK 1990) and also that the revenue raising aspect is of major importance.

Under certain condition these revenues are furthermore likely to cover the total road user costs, i.e. the capital plus the maintenance costs (Mohring and Harwitz 1962; Winston 1985; Newbery 1987). The main conditions

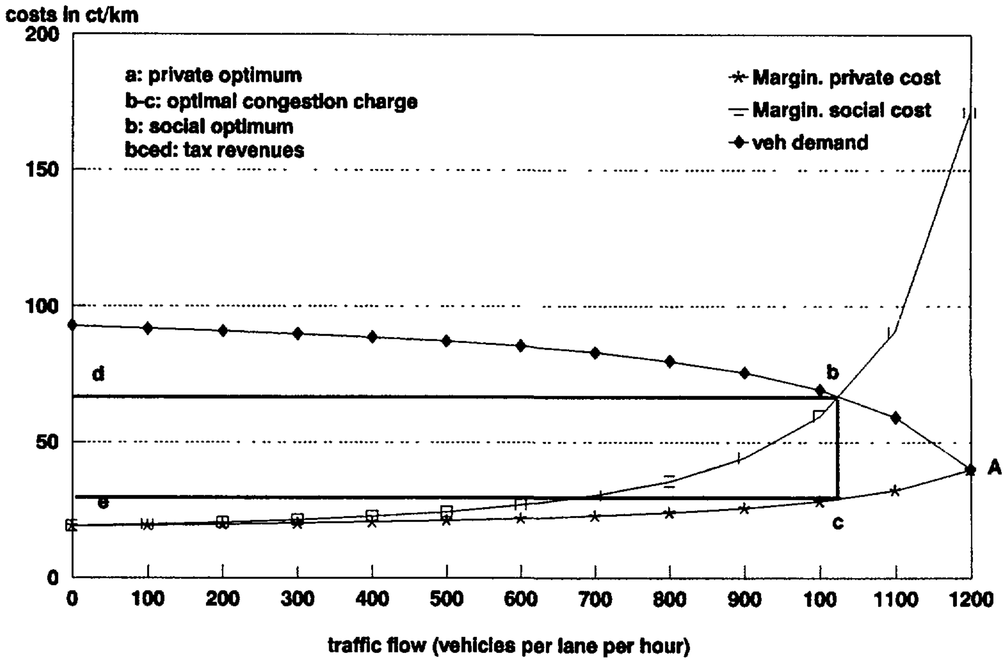


**Figure 1.** *Conjestion pricing*

necessary are that the roads have been constructed according to the above mentioned efficient infrastructure policies and that there are no scale economies in road construction. Although the empirical evidence available supports the latter contention only in average terms and the former condition is not likely to have been met in the past, nevertheless there seems to be a broad correspondence between revenue from optimal congestion charges and total highway expenditure for the one case where an empirical analysis has been carried out, i.e. the UK (Newbery 1988; Newbery 1990).[7]

The welfare impacts of moving from current policies to efficient infrastructure and pricing rules can be very large indeed. An empirical analysis for the USA (Small Winston Evans 1989; Winston 1992) shows that if, in the case of highway durability, both efficient pricing (pavement wear taxes) and efficient investment (with respect to thickness) were adopted an annual welfare gain of nearly 8 bn US $ would accrue. It should be understood that the above mentioned gain only refers to optimal policies in the area of durability and excludes the effects of efficient policies in the field of congestion pricing and capacity optimisation. Moving to efficient policies in all dimensions of infrastructure planning and pricing is thus likely to lead to major welfare gains.

Efficient policies dealing with infrastructure cost recovery and congestion will thus comprise a set of investment and pricing rules in which congestion charges, accompanied by efficient, i.e. axle based, wear charges play a dominant role. Fuel taxes are critically absent from this list: they do not discriminate between place, time, axle weight and (only partially for) kilometres driven and thus give hardly any incentive to reduce congestion or limit road damage. The introduction of efficient policies would lead to a complete restructuring of current road user charges in which revenues from fuel taxes play a dominant role.

It is clear that technological developments (mainly in information technology) have brought the introduction of efficient congestion charges within the realm of the possible. Various experiments have been held (e.g. in Hong Kong) and most were quite successful. Whereas technology has brought down the running costs of this instrument enormously, it seems that the main obstacles to introduction are of a socio-political nature: privacy aspects, worries about revenue use and a general uneasiness about the introduction of a completely new instrument dominate the debate (Goodwin 1990; Hansson 1992). In view of the major benefits associated with efficient pricing and the impossibility of achieving similar impacts on congestion when applying alternative instruments it appears that governments have a strong incentive to move in this direction.

### 5.2 Air pollution

The problems discussed in Chapter 2 apply to internalising air pollution externalities much more than to congestion. The exact physical impacts are not known but seem to vary greatly according to the specific type and the exact place/time of emission. Intergenerational aspects further blur the picture. Monetary valuation is thus particularly difficult and finding an appropriate tax base is not straightforward.

generally, observers arrive at relatively modest estimates for conventional (HC, NOx, CO) emissions; in the range of 0.2 -0.4% of GDP. However, some researchers have pointed out that these estimates might significantly understate total costs as they are not based on willingness to pay considerations (Hanson and Markham 1992). In addition, it should be stated that for CO2 emissions no reliable cost estimates exist. With

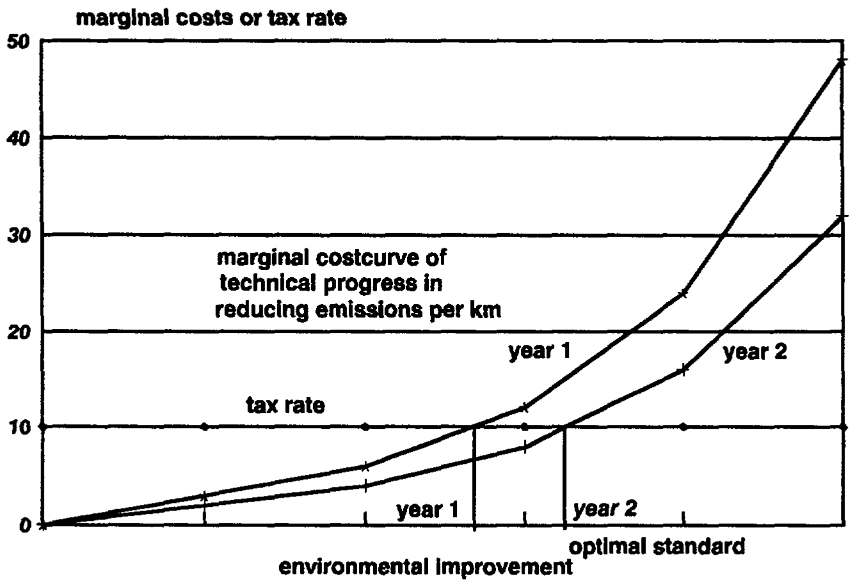


**Figure 2.** ***Devising standards to mimic the effects of a tax***

respect to the emissions, proxies such as avoidance costs or proposed incentive tax levels (e.g. the EC's proposed carbon/energy tax of 10 $ per barrel of oil equivalent) have to be found. For cost-effectiveness reasons these should be applied economy-wide.

If accurate cost estimates were readily available, the optimal policy would imply taxing emissions directly which would give an efficient incentive. Such a policy would, however, require monitoring of emissions. In addition, adjusting the tax rate to the actual damage caused which depends on many additional factors such as geography and temperature should be introduced. Even if this were technically possible, monitoring would probably imply major operating costs, whereas continuous adjustments of rates probably requires more information than is currently available. Thus, in general, the introduction of the theoretical first best instrument, i.e. a direct emission charge, is not - yet - feasible.

In designing a second best instrument one should, as much as possible, aim to maintain the incentive effect of the hypothetical direct emission charge. As emissions per kilometre depend to a large extent on the technical characteristics of the vehicle and the fuel, an important element in such a strategy consists in the setting of tailormade technical standards - such as tailpipe standards to (partly) internalise external effects. The aim would be to determine vehicle emission standards per kilometre in a "quasi-efficient" way in which marginal costs of emission abatement would be equated with the marginal benefits (reduced air pollution). This procedure could be carried out on the basis of the damage value of emissions, emission abatement cost curves in transport and lifetime vehicle kilometres travelled.[8] Basically, this approach implies calculating the present value of future direct emission charges and determining the technology that would have been chosen by private actors if such a tax were applied to new cars. Figure 2 illustrates this procedure. An important characteristic of such an approach is that as technological progress occurs standards should be tightened.

Indeed, for conventional emissions, standard setting - although not necessarily with a view to the implied costs - is the approach that has been followed in all OECD countries.

An important difference between a policy based on setting emission standards and hypothetical emission charges is that in the former system the marginal costs of pollution are zero. For new cars, which are relatively clean, this is not likely to imply a significant difference in impact on conventional emissions. Differences in emissions between vehicles (of various generations) are very large indeed within relatively narrow cost ranges, implying that techno-adjustments (i.e. vehicle choice) are likely to be the preferred consumer response in a direct emission charge scheme. Impacts on vehicle use will probably be limited. However, new cars do emit pollutants which represent an externality. These should also be taxed as would be the case in a direct emission scheme. It is hard to introduce an incentive that imitates this aspect of direct emission charges, although a - vehicle type dependent (in view of significant differences in emissions across vehicles) - kilometre tax might contribute significantly. A restructuring of circulation taxes would be appropriate to take account of this aspect.

The main difference between the two systems, however, arises with respect to old cars. Emission charges would affect all drivers and all cars, whereas standards only impact upon new cars. This is by no means a trivial problem as some estimates indicate that as little as 20% of all cars - the old ones -cause as much as 80% of the conventional air pollution from transport. Furthermore, by raising the relative price of new cars, old cars might become more attractive, implying an ageing of the car fleet with undesirable effects on emissions (Crandell 1986). This effect has, in fact, occurred in the US (Atkinson et al. 1991).

In addition to focusing on new vehicles it is thus necessary to deal with the old car problem. Several partly overlapping options exist in this field. An obvious element would be to incorporate old cars in the new circulation tax scheme, which would be based on kilometres and a measure of the average emissions per kilometre. Ideally, the latter element would be vehicle type based, but various proxies (e.g. standards at the date of introduction) are possible. In view of the poor emission performance of old cars this would imply a significant financial charge and a strong incentive to reduce the use of old cars. In addition, the 80/20 problem might also be tackled by giving credits for taking very old cars out of the market. These credits could be used by stationary sources to contribute to their emission reduction obligation. Such a scheme is an interesting example of how cost-effectiveness might be promoted by exploiting cost differentials across sectors. The State of California, where a pilot project ran for some time, is studying how to set up such trading schemes; a development which could also be of great interest to European policy makers (CARB 1992).

Another important difference is that, as standards are often applied to large countries/free market areas and have a very important internal market aspect attached to they cannot efficiently take account of regional disparities with respect to impacts on environmental costs. In an optimal world these disparities would lead to different emission charges - hence, incentives - in different regions. Standards cannot mimic this aspect and will therefore lead to implicit under-taxation in some areas and over-taxation in others. Because of this averaging they are less efficient than emission charges. This implies that there are benefits to be reaped if certain regions are allowed to promote stricter emission profiles. This is why the US policy to grant California, which has some of the worst air in the US, the right to set its own standards and the new EC policies which enable Member States to a certain degree to promote stricter future EC standards make sense, both from an environmental and an economic point of view.

In the case of conventional air pollution, it appears that even in a second best scenario the role of a fuel tax would be limited. As it only gives an incentive to use less fuel and not to switch to an efficient technology it is a rather imprecise and hence inefficient instrument. A vehicle and kilometre based circulation tax is to be preferred as this instrument also gives an incentive to exploit the technical potential.[9]. A carbon-based (and economy-wide) energy tax would only be a first best instrument for limiting CO2 emissions. As long as low carbon fuels are not readily available the main impact of such a tax would come via fuel efficiency. In the longer run, however, such a tax would act as a powerful incentive to switch to clean fuels.

Finally, it is useful to underline that, in view of the advantages of direct emission charges, the availability of low cost emission metering equipment could imply significant welfare benefits. In the meanwhile, the introduction of fool-proof mileage metering devices is of great importance to facilitate the introduction of quasi-efficient circulation taxes. R&D activities in these fields are likely to have a high potential rate of returns.

### 5.3 Safety

Road accidents give rise to significant costs in the form of people killed or wounded (some 50 000 people were killed in road transport in the EC and the EFTA in 1989), the associated loss of production and material damage, plus various costs for public authorities. Several estimates for a number of European countries point to a social cost of road accidents of on average 2% of GDP (Hansson and Markham 1992). A crucial element in executing this estimate is the valuation of the loss of a life; which makes up roughly 50% of the total costs. This value is composed of the "pure" value of a life to its "owner", the pure value to relatives, plus the lost production, net of future consumption of the life's owner; which constitutes a loss to society as a whole. It turns out that the first two components are significantly larger - often more than twice as large - if measured by a "willingness to pay" technique in comparison with a production loss metric. On welfare-theoretical grounds, the former is to be preferred if the "pure" value of life is to be gauged (Jones-Lee et al. 1985). As many countries still use a production loss approach and the above-mentioned figure of 2% of GDP is an average of various country studies, it is quite possible that the true social costs are significantly larger.

Two main policy questions arise in the context of road safety. The first is how to take the value of life into account in designing infrastructure (which, being a quasi-public good, is of great importance to accident risks). The second is to determine which part of the social costs are externalities and to appropriately charge road users.

The answer to the first question relates to the theory of efficient infrastructure planning discussed above. To the extent that safety is a dimension of infrastructure - such as capacity and durability - safety should be produced in infrastructure until the marginal costs of doing so equate the marginal benefits (avoided costs of deaths and injuries). Monetising benefits by willingness to pay (WTP) measures instead of by production losses raises the marginal value of safety and would thus save lives if an efficient infrastructure policy were followed. Based on a "cost of safety" function Jones-Lee 1990, for example, estimates that such a switch in valuation might save 600 lives per annum in the U.K.

The externality issue depends crucially on the extent to which participation in traffic (a) endangers the surplus value of life to society and to relatives and (b) threatens the safety of other participants in traffic. Obviously material damage to one's possessions, the value of one's own life and safety (as long as traffic risks are known) and one's medical expenses (to the extent that one is insured) are internal effects. However, the surplus value of life to society and relatives clearly represents an external effect. Its value can be calculated by adding the net production value (surplus value to society) to the willingness to pay of relatives and friends to avoid death or serious injury to a third person.

With respect to the impact on the safety of other traffic participants, the scant empirical evidence available points to the rate of vehicle-vehicle accidents per kilometre being independent of total vehicle kilometres travelled (see references in Newbery 1988; Jones-Lee 1990). This might mean that drivers adjust their behaviour in order to respond to initially higher risks brought about by higher traffic densities (there are some indications of drivers having a "preferred risk level", which following policy changes is maintained by changing behaviour, see: Peltzman 1975). The evidence is rather sketchy here and more research is clearly needed as this point is of major importance in allocating social costs to internal and external effects. Even though car accident rates might be independent of traffic volumes, accident rates for pedestrians and cyclists seem to be related to car traffic. This is an externality which should be valued according to the WTP for one's own life plus the WTP of relatives, plus the net production value.

Various estimates indicate that if these elements are taken into account the total externality comprises roughly half of the total social costs (Newbery 1988, Jones-Lee 1990 and Hansson and Markham 1992). In order to efficiently internalise these externalities it is of importance to maximise the incentive effect. This means that the charge should differ across the various vehicle types used in view of the very large differences in accident rates between categories such as cars, motorcycles and busses. They should also vary in relation with the safety performance of the driver and his or her annual mileage. The first best instrument in this respect is likely to be an obligatory insurance directly related to kilometres driven and containing a no-claims bonus scheme to take account of the safety-performance of drivers and to act as an incentive to safe driving. In rewarding damages this insurance scheme should take account of the above-mentioned WTP estimates. Such a first best instrument comes reasonably close to the already existing third-party insurance schemes in some countries - save for the distance related aspect. Jones-Lee 1990 argues that in fact the externality to be internalised (equivalent to 0.75% of GDP in her calculations) is already for a large part covered by the third party liability in the UK (for approx. 70%). The reason is that this scheme awards damages to surviving dependants of persons killed in accident. Apparently, only a small extra charge is needed to achieve full internalisation. It certainly seems worthwhile to investigate to what extent insurance schemes in other EC countries already cover part of the externality.

## 4. A COMPARISON OF FIRST AND SECOND BEST POLICY OPTIONS

Thus, it appears that for the major externalities identified above a fuel tax is not the first best solution, and often not even the second best instrument. Only in the case of limiting CO2 emissions does a carbon content based energy tax seem to come first best. As many environmentalists and some policy makers consider an increase in fuel taxes to be an essential element in limiting externalities from transport it is worthwhile to compare the impact of the identified first-best instruments with that of a fuel tax in terms of limiting the externality, welfare, transport performance and energy consumption. As discussed in Chapter 2 such a comparison should ideally be made at a point where both instruments have the same impact on the externality. As for some externalities the fuel tax will not be able to reach the optimal reduction of the externality unless draconian levels are introduced, it is simply assumed in the qualitative analysis of Table 2 (see appendix at the rear of the paper) - which presents an overview - that a "significant" fuel tax is introduced.

The results generally show that the welfare effects of the fuel tax are significantly more negative than those of the first-best instrument. In some cases - wear and safety - it is not at all clear whether the welfare impact of the fuel tax would be positive.[10] Significant welfare losses of taxation -the well-known dead-weight losses - would have to be compared with probably minor benefits in terms of reduced externalities.[11] An interesting aspect is that an equivalent fuel tax is, a priori, likely to have somewhat stronger impacts on total mobility than an efficient instrument. In a sense this is not surprising: the reduction of mobility and energy use are the only "weapons" a fuel tax employs in reducing externalities. If the impact on the externality were to be similar to that of the efficient instrument all effects would have to come from these two sources which would imply significant welfare losses. Obviously, the impact of the fuel tax on energy use is relatively strong as this instrument is directly geared to this goal.

Only in the case of a CO2 tax are the impacts of a fuel tax and the first-best instrument comparable. Obviously, there need not exist any difference between the two if the fuel tax were carbon-based. In this case they would be identical. Research shows that these two instruments are much more efficient than alternatives such as energy efficiency standards. The latter increases vehicle kilometres travelled instead of reducing them because the marginal costs of driving are decreased. This brings about many adverse side-effects and means that the increase in vehicle energy efficiency has to be much larger than in the case of a $CO_2$ based fuel tax. Crandell (1992) presents evidence indicating that the cost differential between these two instruments is at least a factor of 8.5.

Massive expansion of public transport is often advocated as an effective instrument to reduce externalities from car use. Evidence from a scenario study presented in CPB (1992) and Koopman (1992), however, shows that substitution in the direction of public transport is unlikely to be a major factor in limiting car use. The main reason behind these findings is that the differences in trip speeds between car and public transport are so large that even major improvements in public transport have only limited effects on car traffic: average substitution elasticities are very small indeed (also see Button 1990). Furthermore, if car use externalities are internalised, the case for hefty subsidies to public transport (on average roughly 0.4% of GDP in the EC) is significantly weakened. In the first best policy case it is thus likely that all transport prices will rise: and the expansion in public transport is likely to be rather limited and focused on routes where the competitive advantage is strong (e.g. urban areas with high congestion charges).

If one inspects the current policy mix addressed at the various externalities and the first best policies it becomes clear that especially where congestion and infrastructure financing are concerned, the difference is very large, due to the complete absence of congestion pricing and efficient (i.e. damaging power related and kilometre based) wear charges in Europe. It is in this context that actual fuel taxes play an important role as revenue raising instruments. Even in the absence of strong $CO_2$ policies, they also contribute to $CO_2$ emission abatement, in the form of "implicit $CO_2$ taxes", which are already quite high in Europe - especially where motor fuels are concerned (Burniaux, et al. 1992). In the case of safety, the current policy stance already comprises elements of a first best approach in some countries, but - in the light of significant externalities - a careful examination of current insurance schemes is necessary. For conventional air pollution a more explicit cost-benefit oriented analysis of optimal standards - both for fuels and vehicles - would be desirable. Even more important is the current lack of policies in Europe to deal with conventional emissions from the existing vehicle fleet. Policy innovations in this area such as vehicle-type and kilometre based circulation taxes are likely to be particularly cost-effective. Furthermore, a certain regional differentiation of incentives for limiting emissions from vehicles might be achieved by means of fiscal incentives aimed at arriving at a cleaner vehicle fleet in regions which suffer from relatively bad air.

From a welfare point of view a switch from current policies to efficient policies would obviously be recommendable in the EC. An obvious question is how to get from here to there, in other words how the transition should look. This is not the place to present a full discussion on this important issue, but it is worthwhile to briefly look at two issues: the role of existing fuel taxes and the division of labour between the EC and its Member States. Where fuel taxes are concerned, it seems attractive to keep the current (minimum) *nominal* levels while introducing congestion pricing, efficient maintenance charges etc. As these should be phased in carefully in a learning-by-doing process fuel taxes should continue to play their role of rough incentives for some time to come. During this period they should be restructured to better take account of the carbon content of fuels in order to fulfil their function as efficient instruments to limit global warming. This could significantly aid the introduction of fuels with a low $CO_2$ content. The level of the tax would eventually depend on the appropriate economy-wide $CO_2$ tax.

As regards the respective roles of the EC and the Member States, several observations can be made. First, internal market consideration require (a certain degree of) EC harmonisation where fuel and vehicle standards, fuel taxes, maintenance taxes and congestion metering *apparatus* are concerned. Due to increased intra-EC traffic it will also be necessary to fully introduce the *territoriality principle* according to which each traffic participant pays for the costs he causes in various EC Member States, irrespective of his nationality. Furthermore, with a view to the large gains to be reaped and the requirements of the internal market, agreement should be introduced at the EC level on the broad *structure* of efficient transport policies. If road costs are largely to be financed out of congestion and efficient maintenance charges, this has implications for intra-EC traffic and the role of fuel taxes. Agreement on such issues should be reached at the EC level. However, given the large differences in population densities, traffic and infrastructure conditions, safety performance etc., it is evident that the Member States should have significant leeway in applying the common policy structure. This is not just for the sake of easing implementation, but also because such a decentralised approach is likely to lead to higher societal benefits. Examples of areas where flexibility at the Member State level is of importance are decisions with respect to the levels at which congestion charges are introduced, the execution of efficient infrastructure planning, programmes for limiting the contribution to air pollution from old-cars, additional fiscal instruments to achieve better emission profiles for new cars than EC wide standards require and a review and adjustment of current third party insurance schemes. Thus, within the framework of a common European approach *subsidiarity* has an important role to play.

## 7. CONCLUSIONS

The following points summarise the main conclusions of this paper:

1. The total welfare effects of transport policies are the appropriate criterion by which to judge their attractiveness. If the benefits of environmental improvements are hard to quantify then cost-effectiveness should be the relevant yardstick. In that case, the *total* welfare *costs* of introducing policies should be taken into account and the least cost instruments should be selected. This is quite different from looking only at the expenses policies induce because the latter do not comprise the welfare impact of behavioural changes. Cost-effective policies are likely to rely on market incentives (e.g. charges) as these allow individual agents to efficiently tap all sources of externality reduction.

2. Fuel taxes are unlikely to constitute first best policy instruments to tackle the main externalities of transport. Carbon-content based fuel taxes provide an efficient instrumen only for limiting global warming . In an efficient transport policy scenario the future of fuel taxes will thus heavily depend on the severity of the global warming problem. In view of the dominant role they currently play their relative role in the policy tool kit is likely to diminish if efficient policies are adopted..

3. Although fuel taxes might be lower in an efficient transport scenario, efficient congestion charges, insurance premiums, standards and fiscal charges will raise the cost of driving in order to internalise the main externalities. Significant welfare gains are to be expected when moving in this direction. Impacts on mobility and *total* energy use might, however, be more limited than doing the same with a fuel tax because efficient instruments rely on more adjustment mechanisms to reach the same goal.

4. For wear, air pollution and safety vehicle-type specific kilometre taxes/premiums are likely to constitute an important element in efficient policies. Kilometre metering will thus be necessary and existing devices should be upgraded.

5. Energy efficiency *per se* is unlikely to constitute a sound policy goal and this is reflected in an efficient transport policy scenario. The impacts on fuel efficiency in this scenario depend essentially on how *competitive* fuel efficiency is as a response strategy in reducing externalities compared with alternatives such as techno-adjustments (clean fuels, clean vehicles etc.), reduced private mobility etc. This is essentially an *empirical* question, the answer to which can only be formulated in a least cost fashion if efficient instruments are used allowing various options to compete. If alternative -low greenhouse gas - fuels become available at low cost then the powerful incentive from global warming will diminish and the main driving factor for efficiency would be the gradual rise in world market energy prices.

6. In switching to an efficient transportation scenario both the EC level and the Member States have an important role to play. The EC level should set a broad policy structure, deal with the harmonised fuel taxes, ensure harmonisation or at least compatibility of congestion metering apparatus, introduce the new cost-effective approach for standard setting and would have to give Member States significant legal leeway to introduce changes in their policies. Member States would introduce congestion pricing, efficient infrastructure planning, contemplate whether to introduce incentives that go further than EC emission norms, set up schemes to tackle the emission problem of the current car fleet and review insurance schemes;

7. A major research strategy is needed into various important areas in order to help define and maximise the benefits of moving to an efficient transport policy. Examples are: the evaluation of traffic flow-speed curves,

the estimation of accident avoidance cost curves, the impact of extra traffic on average accident risks, the determination of damage curves for conventional emissions, the elaboration of cost curves for emission standards for cars and fuels etc.

## ENDNOTES

1. The opinions and conclusions presented in this paper are solely those of the author and do not necessarily represent the views of the Commission of the European Communities.

2. An important assumption is the absence of market barriers. Limited information, principle agent problems and other barriers reduce the efficiency of policy instruments that rely on market mechanisms.

3. An alternative approach is to define "critical loads" or "sustainability targets" for various externalities (e.g. emissions). This approach assumes that there are certain levels above which externalities destabilise the ecological system: it is claimed that - irrespective of the costs - externalities are to be kept below these levels.

4. A complication arises in the case of multiple externalities affected by some of the instruments concerned. The side benefits of such instruments should also be taken into account and can only be made comparable to those related to the "target externality" by monetisation.

5. The consumer and the producer surplus are measures that indicate the aggregate willingness to pay more than the market price and supply goods at lower costs, respectively.

6. If positive externalities of transport infrastructure exist, then these should also be taken into account when constructing infrastructure. The issue is rather contentious as no general proof of the existence of such externalities has been given. For an overview of the literature and of factors which might lead to such positive externalities, see Peca (1993).

7. In Newbery's analysis for the UK's 1986 network the above mentioned correspondence was found. However, when updating the analysis for 1988, Newbery concluded that revenues from congestion charges would significantly outstrip infrastructure cost, thus possible indicating a shortage of roads.

8. Standards for fuels have also an important role to play. For example, the significant increase in the Reid vapour pressure (RVP) of US gasoline has led to an increase of VOC emissions from US automobiles by roughly 30%. Gradually bringing down the RVP to 1970 levels could be done at reasonable cost and would have a direct and thus major impact on VOC emissions (Atkinson, Cristofaro and Kolb(1991) and Waxman et al. (1990)).

9. Fuel taxation implies strongly differing emission taxes on cars introduced under different sets of standards. For example, cars meeting the 1991 EC standards have a 2.3 times higher implicit emission tax than cars that just meet the previous standards. Different tax rates per ton of emissions are a clear indicator of inefficiency and are also unjust because agents switching to cleaner technologies are not rewarded.

10. For example, in the case of road wear the optimal tax is related to the damaging power of vehicles and the kilometers travelled. Such taxes are found in several US States and in Sweden. Very significant reductions in the damaging power can be achieved by introducing more axles in vehicles of a given capacity. A fuel tax does not give any incentive to exploit this particularly attractive potential. On the contrary, increasing the amount of axles implies a fuel penalty and is thus discouraged by a fuel tax.

11. However, it should be noted that there are likely to be side-benefits. For example the reduction in energy use will reduce the $CO_2$ externality to a significant degree.

12. a) The low estimate refers to countries where a low externality is combined with already quite adequate third party insurance schemes; in the high estimate it is assumed that three-quarters of the total social costs are external and that at present no internalisation exists at all.
b) The non-internalised externality consists of the difference between marginal and average costs. In relatively congested areas this difference can be as high as 90% of the marginal costs (compare figure 2), whereas the percentage is small if congestion is relatively insignificant.
c)Global warming is not taken account of in these figures.
d) Most empirical estimates indicate that this is one of the smaller cost elements
e) There are significant differences between countries in the extent to which road users pay for infrastructure costs, police assistance etc.
f)Mackenzie et al. (1992) quote a cost estimate for the US of 2%.

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Table 2 First best policies to deal with various externalities compared with a fuel tax

| | congestion and infrastructure cost recovery | conventional air pollution | global warming | safety |
|---|---|---|---|---|
| optimal instrument | congestion pricing, efficient wear taxes plus efficient infrastructure investment | efficient vehicle and fuel standards; plus environmentally adjusted circulation tax | $CO_2$ tax | efficient insurance scheme |
| **Impact on:** | | | | |
| welfare | optimal | optimal | optimal | optimal |
| vehicle kilometres travelled | significant impact on peaks leading to moderate reduction in total traffic; | limited; mainly via costs of vehicles | significant, effect could be less if carbon free fuels are cheaply available | reasonably large |
| energy use | savings from less traffic and better driving conditions | probably minor | significant, effect could be less if carbon free fuels are cheaply available | savings from less kilometres travelled |
| **impact of fuel tax on:** | | | | |
| welfare | possibly positive: deadweight loss to be compared to revenue gain | possibly negative; significant deadweight losses and minor reduction of pollution | effect very close to $CO_2$ tax if no carbon free fuels are cheaply available | possibly negative; significant deadweight losses |
| vehicle kilometres travelled | roughly equivalent reduction in total and congested traffic. | significant reduction in total traffic | effect very close to $CO_2$ tax | reasonably large |
| energy use | savings from less traffic and higher fuel efficiency | savings from less traffic and higher fuel efficiency | effect very close to $CO_2$ tax | effects stronger than in efficient case |