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Environmental Quality and Transport Policy in Europe

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Abstract

This paper deals with the social costs of transport in Europe and with the problems associated with an improvement of environmental quality. It is - in view of the high social costs of the transport sector and its close link with our welfare society - necessary to identify and critically review strategic development scenarios for this sector. The paper gives an overview of related problems and issues and offers a sketch of alternative scenarios.

1. Prologue

In recent years the European transport scene has shown significant changes. Mobility has drastically increased and as a consequence congestion has also increased, in almost all transport modes (see EMCT, 1990, and Eurostat, 1978). At the same time the environmental burden of the transport sector far exceeds the carrying capacity of our environment and threatens ecological sustainability as advocated amongst others in the Brundtland Report (see WCED, 1987). Transport seems to have a double face nowadays. On the one hand, it is increasingly recognized that transport plays a vital role in building up an integrated European network economy and on the other hand there is a growing awareness of the high - sometimes unacceptable - social costs of transport (notably in the area of land use and the environment). Transport has become a focal point of research and policy interest because of the conflicting roles it plays in our modern society (see for an overview also Banister and Pickup, 1989, and Nijkamp et al, 1990a).

It is also noteworthy that in the past years most European countries appear to have developed a common trend towards **devolution** of transport policy (e.g., deregulation, decentralisation, privatisation); see for more details Button and Pitfield (1990). This communality in European transport policies is not an exception: in the past decades European transport planning - and notably infrastructure planning - has shown striking parallel developments: for instance, a period of expansion in the 1960's, a period of contraction in the 1970's, and a period of selective expansion in the 1980's, governed by (controlled) market forces or decentralisation principles. Countries with a more liberal policy model and/or with severe deficits in the public budget tended to become the first ones to advocate contestability in the transport market, not only in the airline sector and the freight sector, but sometimes (e.g., in the UK and Portugal) also in the public transport sector (see also Berechman 1990). Clearly, among all these countries significant differences do still exist, as the intensity of economic stagnation and of monetarist policies may significantly differ. Besides, in some countries local autonomy or decentralisation rather than privatisation can be observed as a political ideology.

In our era of devolution of transport it has to be recognized that despite new advances in transport technology (e.g., telematics), which will not be discussed here the transport sector is also facing severe problems, notably high external or social costs (see also Section 2). The actual practice of both commodity and passenger transport is disappointing and often frustrating. Severe traffic congestion phenomena at the urban or metropolitan level (e.g., Athens, Rome, Paris), unacceptable delays in medium and long distance transport during peak hours, unsatisfactory service levels of European railway systems (and public transport in general), unreliable airline connections due to poor management of European airspace; all these phenomena mirror the problematic position of the European transport sector (see for an overview Nijkamp and Vleugel, 1990a).

It goes without saying that the combination of devolution, mobility rise and congestion will cause in general severe environmental degradation (cf. Hanson, 1986). Furthermore, deregulation seems to be at odds with environmental protection: in contrast to the deregulation in a contestable transport market, environmental policy is critically dependent on a great deal of regulations (e.g., limited emission levels of vehicles or even a prohibition of the use of certain transport modes). The question has to be answered whether transport can be made compatible with the environment in the long run, so that the mobility rise does not compromise future generations in regard to their environmental quality.

As a result of many diverging movements, nowadays transport policy makers in most European countries find themselves in extremely complicated situations. A large number of interest groups, ranging from multi-national companies to local environmentalists, urges them to take action, though often in quite different directions. On the one hand it has become obvious that the environment poses its limits on the volume, the character and the pace of the extension of the transport infrastructure. On the other hand many firms in (Western) Europe are concerned about their competitiveness in a global context due to inadequate infrastructure, as a relatively slow growth in physical infrastructure in Europe may curtail the industries in their possibilities to offer new services, while the restricted capacity of inland transport networks may cause higher production cost levels in Europe (see Bruinsma et al., 1990).

It should be noted here that the high mobility (and its related external costs) does not necessarily mean that more hours are spent on travelling. Zahavi (1979) has stated that people, on average, use slightly more than one hour daily for travelling. This is confirmed by national traffic studies in Finland which give 71 minutes as the average daily travel time. The travel time has been fairly stable during the period 1974 - 1986. The daily travel lengths and speeds have, however, increased considerably (see Figure 1).

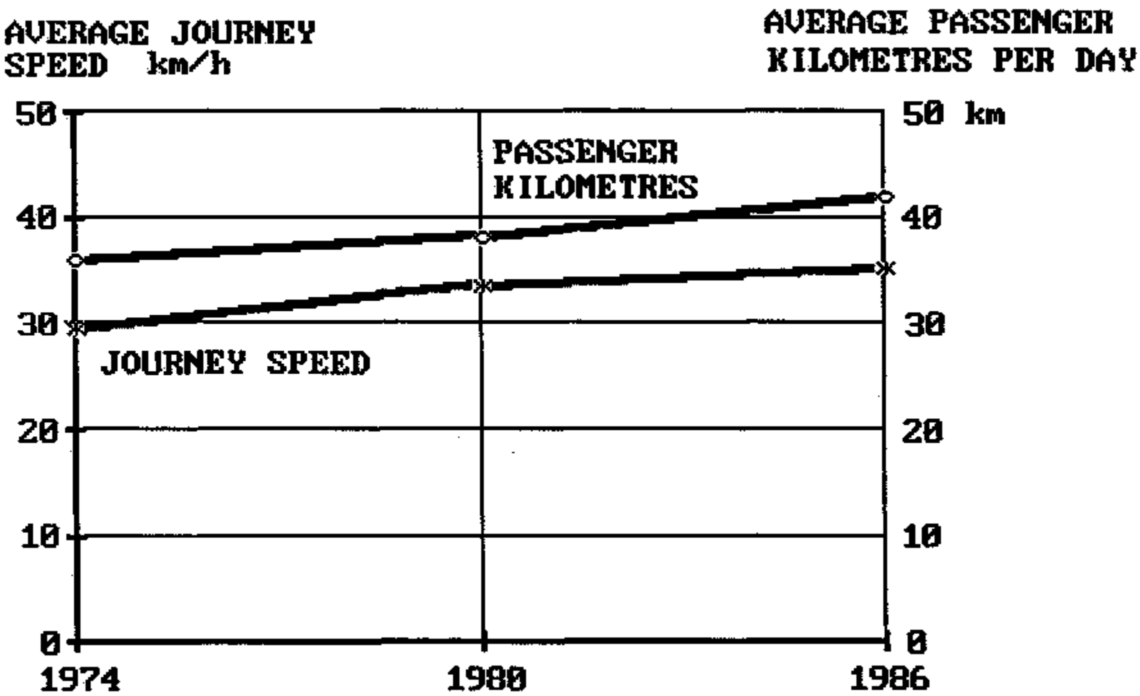

Figure 1. Average journey speeds and daily passenger kilometers in Finland during 1974 - 1986.

The higher travel speeds result mainly from improvements in infrastructure and car technology (cf. Flink, 1989). The results indicate that the higher travel speeds are utilized in order to increase trip lengths rather than to save time. For an individual non car-owner, the main possibility of increasing travel speeds is to purchase a car, as travel speeds of cars are on average for short and medium distance twice as high as for public transport.

The growth of the vehicle fleet and the resulting growth of car mileages seem to be a very stable phenomenon, which can be observed in all developed countries despite significant differences in national incomes or other characteristic features (see Horowitz, 1982, and Nijkamp et al, 1990a).

Such conflicting developments would require the design of strategic scenarios, focusing on environmental quality or even **ecological sustainability** in relation to the transport sector. The current emission levels of the transport sector (contributing inter alia to acidification and climate change) and the expected global increase in average mobility are by far not compatible with a long-run (environmentally and economically) sustainable development. Are there guiding principles for judging such strategic scenarios in terms of their overall political viability? The answer to this question requires first more empirical evidence on the social costs of the sector and the problems facing governments in reducing these costs. This will be discussed in Section 2. Section 3 will then be devoted to a further exploration of environmental sustainability issues in the transport sector.

2. Social Costs and Response Failures in Transport Policy

It turns out that in recent years environmental impediments have become critical in the evaluation of new transport systems and of current mobility patterns (cf. OECD, 1988). The main problem, however, is that external costs such as environmental pollution or lack of safety are not easy to capture in economic-financial measuring rods. Congestion costs are perhaps somewhat easier to assess, as here cost-benefit types of analyses (based on consumer surplus and willingness-to-pay) can in principle be applied. But other social costs are more hard to gauge (see also Jones-Lee et al., 1985). Nevertheless, in various countries several attempts have been made.

In a recent OECD report (1989a) various social costs of road traffic in several countries have been assessed:

- **noise annoyance**, including both damage costs (e.g. productivity losses, health care costs, decline in property values and loss of psychological well-being) and abatement costs (e.g., adjusted vehicle technology, anti-noise screens, double glazing etc.). Studies in various countries show a relatively high level of social costs of traffic noise and range from 0.06 to 0.12 percent of GDP.

- **air pollution**, including both damage costs (e.g., damage to health, buildings or forests) and environmental protection costs (e.g., air pollution control, new vehicle technology, catalytic converters etc). Numerical estimates of air pollution costs caused by transport show some variation, but point all in the same direction and amount to 0.2 to 0.4 percent of GDP.

- **lack of safety**, mainly resulting in accidents, leading to damage costs and recovery costs (including medical treatment, productivity losses, damage to vehicles, policy and emergency service expenditures etc.). Various cost estimates have been made which show high financial burdens ranging from 1.5 to 2.5 percent of GDP.

On average the estimated social costs of road transport in developed countries fall in the range of 2.5 - 3.2 percent of GDP. This is a conserative estimate: if congestion and consumption of land (e.g., roads, parking space etc.) would also be included, the non-internalized social costs of]nord transport might amount to approximately 5 percent of GDP in most countries (see also ECMT, 1990). It is evident that the above figures on the social costs of transport are by far not precise, but rather indicative. Some more recent estimates of social costs of traffic give considerably higher figures (see Himanen et al., 1989). In any case, should such cost estimates be appropriate, then they might be internalized in the price mechanism and hence lead to a Pareto - optimal situation. The background is that the allocation of scarce resources will - in the view of a conventional economist - lead to an equilibrium between wish and possibility (or between demand and supply) via the intermediate tool of the market mechanism. This mechanism is giving price signals as a way of generating adequate responses of economic actors. One of the critical assumptions in the economist's view of the world is that all costs and revenues are to be reflected in the price mechanism. Failure to do so leads to biased signals and hence to inappropriate behaviour. For instance, if certain social costs (e.g., noise annoyance of cars) are not adequately inputed to the source, an over-consumption of the activity will take place. This shortcoming in the price system is often called **market failure**, although a more appropriate term may perhaps be a **signal failure**.

There is, however, also a related problem which may intensify the impacts of signal failures. While there are many examples of the use of traffic management schemes leading to a significant improvement in traffic conditions (including environmental impacts), there are many more where little has been achieved (cf. Bayliss, 1990). This is related to the biased behaviour of economic actors which - as a result of signal failures - has in many countries led to government responses in order to cope with negative externalities of economic activities. Given the above mentioned exposition, it is clear that a government intervention will only restore the balance, if the measures imposed on actors ensure that all social costs are fully reflected in the price signals of a market system. Such measures may be financial in nature (e.g., charges, subsidies or taxes), but may also include non-financial instruments (e.g., regulations, standards or prohibitions). In all cases, the effects of such measures should be such that they charge economic actors against full marginal social costs (either directly or indirectly). Otherwise an efficient market equilibrium will not be reached, or in the worst case the government response may even lead to a further deviation from a social optimum. Such **responses failures** may result, when public decision-makers are unable to interpret signal failures or are facing biased signals. And indeed in many countries we have witnessed the existense of response failures of governments.

Two examples may clarify this case. Parking policy in the Dutch city of Utrecht has aimed at reducing car use by restricting the number of parking places, but as a result most car-drivers were driving more kilometers (and hence causing more air pollution) in order to find a parking place (see Vleugel et al., 1990). Traffic restraint policy in Athens has tried to reduce car use by introducing the system of even and odd number plates for entering the inner city circle on a given day, but as a result car-drivers were making many more kilometers in order to reach the circular ring around the city as close as possible (thus causing even more traffic annoyance) (see Damianides and Giaoutzi, 1990).

It is thus clear that public intervention is a risky mattter, as most actors in transport systems seem to have creative talents in circumnavigating intervention measures. Given the rigidity in government behaviour, in various countries severe response failures appeared to emerge. The transport sector is a glaring example of the existence of a great many of such response failures. Clearly, there are also examples of response successes. The introduction of rapid railway systems in Europe and the improvement of the level of service of public transport in many European countries or cities may be seen as signs of success, in which environment and transport are brought more in harmony with each other. This question of compatibility between environmental quality and the transport sector will be discussed in section 3.

3. Ecological Sustainability and the Transport Sector

In a recent study (see Nijkamp et al, 1990b) the critical success factors of transport systems were studied from the viewpoint of a five-dimensional critical success prism, called the pentagon model. In this model hard ware, soft ware, org ware, fin ware (e.g. funding) and ecoware (e.g. ecological sustainability) appeared to be the decisive factors for the acceptability and performance of (new) transport systems. Notably eco ware - in combination with org ware - appeared to be a crucial variable. Therefore in this section attention will be focussed on the issue of environmentally competible (or ecologically sustainable) efficient transport systems.

Transport is part of our necessary livelihood system. In developed countries transport is also a part of mass consumption and at the same time transport is necessary to facilitate mass consumption. Our economy uses energy and raw materials from our natural environment and - after its use in production or consumption processes - returns these as waste and heat back into the natural system (the so-called materials balance system, based on the law of conservation of matter and energy; see figure 2; see also for more details Nijkamp, 1981).

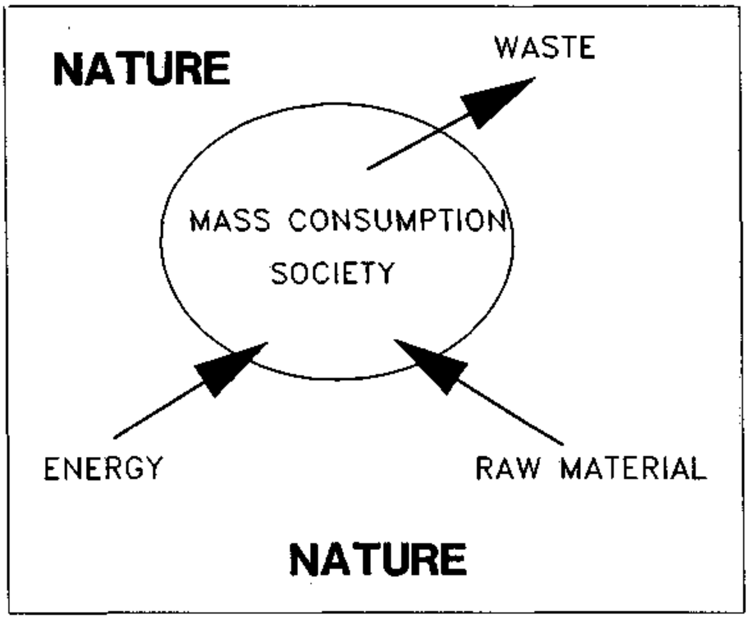

Figure 2. Interrelationship between mass consumption system and nature

Human life is dependent on an uninterrupted functioning of natural ecosystems. These systems do not always react immediately to distorting human activities, since they can - because of their resilience - continue to function for a long time by means of stabilizing feedbacks, but they cannot resist structural and intensive environmental disruption (see also Stutz, 1986).

Exhaust fumes form the most important part of the waste generated by a transport system, although also liquid and solid wastes are noteworthy. Both exhaust gases and other wastes have an impact on the quality of air, water and soil (and hence indirect implications for our well-being and health). The same holds for noise annoyance, although this may have lesser impacts on global ecological sustainability.

The various impacts lead to a complicated process together with waste impacts from sources outside the transport system.

It is evident that the future of the mass consumption system depends - besides the development of the system itself - also on the limits set by nature. In Europe, the environmental hazards caused by the mass consumption system are accumulating in such a manner that many changes in the production and consumption system are needed (Stigliani et al., 1989). Being a part and a facilitater of the mass consumption system, there is no doubt that transport is likely to change as well.

In addition to limits set by nature, in many European countries physical limits have been reached as well, especially in urban traffic in terms of both movement space and parking space; (cf. Button and Gillingwater, 1986, and Plowden, 1983).

Ecological sustainability and the carrying capacity of the environment are threatened by the transport sector in various forms and at different geographical levels. Examples are: local health risks in urban areas triggered by exhaust fumes on or nearby busy streets;regional health risks triggered by photochemical smog (a mixture of gases and particles oxidized by the sun); forest damage, damage to buildings and destruction of soil quality caused by acid rain (generated especially by sulphur dioxide, nitrogen oxides, and hydrocarbons); climatic changes activated by atmospheric concentrations of greenhouse gases (carbon dioxide, methane, nitrogen oxides, chlorofluorocarbons, and tropospheric ozone).

Thus in many respects the transport sector has a negative impact on environmental quality. The main question now is whether the transport sector - and other parts of a mass consumption economy as well - is able to minimize the use of non-renewable energy and raw materials and to keep the amount of hazardous waste and pollutants inside the compensation possibilities of the natural environment (thus ensuring an improvement of environmental quality and hence ecological sustainability).

In answering this question, it should be recognized that exhaust fumes have a time and areal coverage (see Figure 3). There is a time gap when the impacts move from one level to another. At higher levels, the original impacts are connected to many other effects and systems, which are not exclusively related to traffic.

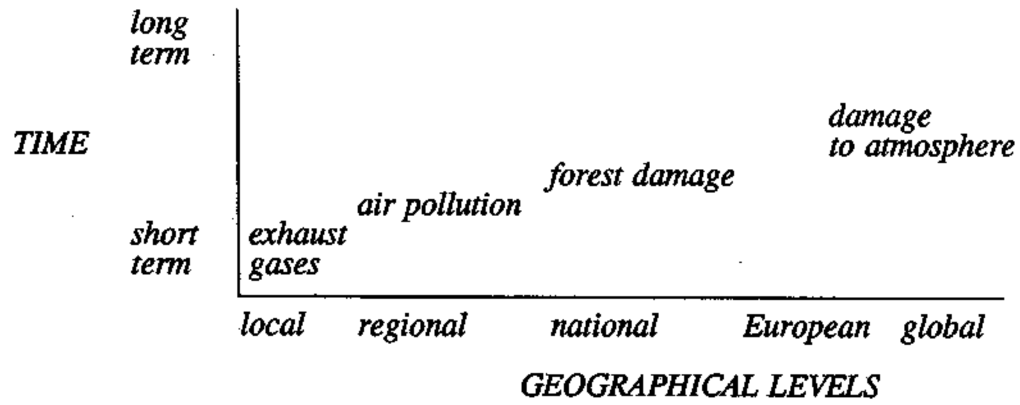

Figure 3. Time and areal coverage of exhaust gases

The increase in the amount of exhaust gases and other waste material is, of course, related to the increase in vehicle traffic. The amount of exhaust gases and other wastes as well as the use of fossil energy and raw materials depends primarily on the number of vehicle kilometers driven and the number of vehicles used. Fuel consumption depends also on various characteristics of vehicles and on cruising speeds. The amount of harmful components in exhaust gases is influenced by possible exhaust cleaning mechanisms, e.g. catalytic converters and by the type of fuel used (e.g., unleaded petrol).

It may plausibly be assumed that transport policy may improve environmental quality and hence ecological sustainability (leading to a natural recovery of both local and global ecosystems) if it:

- decreases vehicle mileage;
- decreases production and ownership of vehicles;
- decreases fuel consumption;
- increases the use of effective cleaning mechanisms for exhaust gases.

Clearly, the precise implications of such measures guaranteeing ecological sustainability are difficult to assess, especially because the effects of transport cannot easily be separated from effects emerging from our mass consumption society. However, some tentative estimates of the order of magnitude of various necessary changes can be found in a recent Finnish study (Kauppi et al., 1990). In order to stop acidification of forest soil in southern Finland, a 90 percent decrease of annual sulphur and nitrogen deposits would be needed (compared to the year 1987). In order to meet the less stringent requirement that forest land acidification is allowed to the extent that forests are not in danger, a 75 percent decrease of deposits would be sufficient.

Apart from various ad hoc measures and policies, one might also look into long-term and more effective strategies. In this framework, scenario analysis may be useful. This will be the subject of the next Section.

4. Strategic Scenarios

In order to explore possible future transport policy options from the viewpoint of strategic environmental policy, in this section various scenarios will be presented. Such strategic scenarios are proposed as a means of evaluating policies for the protection of the environment, taking into account the adverse effects of traffic (cf. Beaumont and Keys, 1982, and Rietveld and van Wissen, 1991). Each scenario assumes a certain course of events and does not claim realism nor quantitative precision, but is expected to provide a general picture of the range of future environmental consequences in relation to transport policy. The aim is thus to provide a future sketch of what might happen if a set of factors with a given intensity and range would influence environmental conditions. Such scenarios may then also serve as a basis for formulating an internally consistent set of measures for reaching a desired goal of environmental protection (cf. Plane, 1986). In this way it may be possible to foresee how these measures may have an impact on the indicators of ecological sustainability (an interesting contribution to the use of scenario analysis in transport policy can be found in Rothengatter, 1990).

The time horizon assumed here cannot be precisely defined, but ranges from approximately twenty to thirty years. It is difficult, if not at all possible, to foresee effects of technological change in the automobile industry regarding vehicle technology on the elimination or reduction of air pollution in such a long time. It is, however, safe to assume that new technological solutions will occur, although we do not exactly know when this will happen and what they will likely be. The scenarios discussed below are mainly policy strategies available to transport policy in most European countries, focussing attention on both the supply and demand side (see for a further underpinning of such scenario's also OECD, 1988, 1989b). Demand policies may refer to both redistribution (spatial or modal) and reduction of demand. In view of the interesting characteristics and impacts of these scenarios and of the possibility of forming combinations, we distinguish here - without claiming to be exhaustive - the following four 'ideal types' of scenarios.

(a) **Status quo scenario**

This scenario assumes that the prevailing transport policy (including its environmental implications) will be continued in the foreseeable future ('business as usual'). It includes amongst others traffic restraint measures and various types of traffic disincentives in particular areas (at certain times of the day for certain types of vehicles and types of traffic), as well as other similar standard measures, which are now in use in many European countries. This is a simple trend extrapolation of current events which neglects structural and dynamic features of past developments in the prognosis of future developments.

(b) **Rigorous traffic restraint**

The essence of this scenario is a more rigorous application of present protection measures and the application of a variety of restraint measures of different types. The extent to which these measures will be used will depend on target levels set by public policy-makers regarding the (percentage) reduction in total pollution caused by traffic.

The measures of this scenario may operate in three directions:

- a further extrapolation of current trends, such as an increase of the number, heterogeneity and intensity of traffic restrictions according to the volume of traffic in particular areas, use of certain types of vehicle, types of traffic, pollutant emissions from motor vehicle engines, route and time travelling choice, vehicle moving priorities, car ownership, driving licences etc.
- stimulation of automobile manufacturers to abandon the production of vehicles with harmful effects on the environments as soon as possible, and to encourage their buyers to abstain from purchasing and using such cars; a stimulation of the purchase of cars with catalytic converters and the use of unleaded fuel and the like also belong to this category of measures.
- extension of the spatial scope of traffic restraint measures; they should not only be oriented toward specific urban zones or cities, but be applied region-wide and nation-wide with a tendency of internationalization. For this purpose, an international agreement on technical standards and control devices is desirable, in the first place among regions and countries whose environmental conditions and level of economic development are largely similar. This kind of harmonization is already emerging in the Western part of Europe.

(c) **Redistribution of transport demand**

This scenario presupposes adequate measures to change modal split, i.e. to redistribute transport demand by mode, time and space (cf. Owens, 1985). These measures call for switching some kinds of trips, in particular the switch of commuter traffic by private cars to public transport (cf. White, 1982). The prerequisite for such measures is not only the price, but the quality of service too.

Comfort, convenience and reliability are likely to weigh more heavily in most people's judgement than the extra expenses of car driving. A subsidy to public transport to raise the quality of service is therefore likely to be a more effective means of attracting the motorists to public transport than a subsidy to reduce fares. The change in modal split is clearly easier to achieve in high density residential and business areas. Therefore, housing and employment should geographically be so arranged that journeys between these areas can be concentrated into a few corridors that are well served by public transport (see also Gakeheimer, 1978).

This scenario also presumes shifts in working hours, e.g. by stimulating people to travel in off-peak periods and on uncongested segments. It should also discourage people to buy and to use private motor vehicles. To some extent this could be achieved by fiscal measures discouraging car ownership (purchase tax, value added tax) and by more flexible charging mechanisms for the use of road infrastructure (e.g., road tax, parking tax, fuel tax). In addition, it would be desirable to increase effectiveness of private transport by expanding car rentals and car pool systems and by developing semi-public paratransit means (e.g., van pools, subscription buses) and public paratransit means (e.g., taxis, dial-a-ride services, jitneys).

(d) **Reduction of transport demand**

The most far reaching scenario is of course a reduction in mobility. Reduction of transport demand must be directed toward both the number and the length of motorized trips. This mean that physical integration and functional interrelationships of housing and employment on one hand, and community services and transport on the other hand is to be achieved, so that distances between homes, jobs, shops and other community facilities are small enough to be mainly covered by foot or bicycle. These are relatively long-term goals whose achievement will require careful planning, public consultations, and in many cases intervention in the private land market.

Clearly, many other scenarios may be imagined, but since the scenarios presented here are meant to be mainly learning experiments, it suffices to restrict an analysis to these four basic scenarios.

5. Impacts of Strategic Scenarios on Environmental Quality

The possible impacts of each of these four strategic scenarios on environmental quality depend on a number of exogenous factors and constraints (cf. Rothengatter), such as: (a) existing protection measures in each state, region or city, (b) the growth rate of urbanization and motorization, (c) the structure and quality of the transport system, (d) technological progress in air pollution and noise reduction, and (e) (inter)national views as to both the adverse effects of vehicle emissions and the need for strict protection measures. In this paper we have tried to provide a rational and plausible basis for assessing the impacts of these scenarios in general terms and under general assumptions. Interesting empirical faith regarding the environmental implications of different transport options can in particular be found in Barde and Button (1990). Despite many uncertainties the foreseeable impacts of different scenario's listed below seem to be plausible, given the methodology used. The basic idea is the assessment of the increase in car stock and of the consequences of emission control regulations in scenario (a). Next, the effects of various constraints on car travel and of new technologies are considered in scenario (b). The possibilities to influence travel behaviour by improved public transport in scenario (c) or by appropriate land use in scenario (d) are then estimated. Both theoretical arguments and empirical estimates are presented. Increase of car stock and car travel is gauged with the aid of various European forecasts (e.g. Eurostat, 1987). The effects of emission regulations are reasonably well documented in various countries (including various differences). The impact of constraints on car traffic as well as impacts in fuel consumption and raw materials use are estimated following common traffic engineering practice, supplemented with additional information from new surveys regarding the impact of technology on the reduction of external costs of traffic.

(a) Decreasing real prices of fuel and motorcars may in scenario (a) induce a further increase in car ownership, car mobility and volume of vehicle traffic (cf. Eurostat, 1987). According to a number of British studies, car ownership level for Great Britain in the next thirty years will probably amount to 40 or 50 million of motor vehicles (or nearly more than twice the current vehicle stock; see Adams, 1990). A two-year Swedish study predicts an increase of the automobile kms/year from 52 to some 80 billion in the next thirty years (and a rise of the auto passenger kms/year from 65 to some 110 billion) (see Svidén, 1983). A Dutch study estimates that for the period 1987-2010 the number of private cars will grow from 5,1 to 6,7-7,8 mln and the volume of passenger kilometers from 127 billion to at least 178,5 billion kilometers (see Vleugel et al, 1990). Similar forecasts have been made for various other OECD countries (see OECD, 1985).

Scenario (a) increases the gap between the existing and desirable environmental sustainability in spite of the fact that government policies in some countries have led to emission reduction. The main reason is the fact that protection measures are not comprehensive and not strict enough (Hills, 1988), although it has to be admitted that government policies in western European countries have had an impact on traffic emissions. For example, in the Netherlands out of six major pollutants emitted by road transport two have declined modestly (C_xH_y and S_2), and two have grown rapidly (NO_x and particulates) (see Vleugel et al., 1990).

According to a recent survey (Mäkelä, 1990a) exhaust emissions per kilometer from new private cars using gasoline in 2010 will be (in 30 per cent (CO), 10 per cent (HC), and 18 per cent (NO_x) of the emissions of the year 1989 in city streets. Analogous figures for cars, vans and trucks with diesel engines in 2010 amount to 85 percent for CO, 65 percent for HC and 35 percent for No_x, taking the 1989 emission levels as 100. On highways the corresponding figures will be approximately 25, 50, and 6 for cars using gasoline. Diesel-driven vehicles have the same figures for highways as for city streets.

This pollution reduction is due to already made governmental decisions concerning catalytic converters and probable emission limits imposed on diesel vehicles. Also the forecasted technological development was considered by the author. Because these standards are international, the Finnish forecast may hold true also for other western European countries, even though according to British sources, the government manifests much less concern about curbing emissions from cars than from power stations (see Adams, 1990).

The situation in eastern and perhaps in some southern European countries is much worse. Vehicle stock is old, unleaded gasoline is not or hardly used, emission reduction standards include only a small proportion of vehicle use, the governments have insufficient means to check and enforce maintenance of emission standards, etc. For example, according to Mäkelä (1990) old trucks using gasoline are the major pollution producers in road traffic in Estonia. Even though car traffic in Estonia is only 7 per cent of Finland's car traffic, emissions from road traffic in Estonia range from 20 per cent (particles) to 150 per cent (HC) of Finland's emissions.

Besides, surface ozone concentrations have been rising in Europe over the last two decades and are forecasted to increase considerably in the Northern hemisphere (Stigliani et al., 1989). Surface ozone is generated by the sun from air containing nitrogen oxides and hydrocarbons, emitted also by traffic.

According to Scenario (a), vehicle stock and vehicle mileage as well as fuel consumption in Europe will continue to increase, although at least in Western Europe catalytic converters and exhaust emission standards will decrease yearly emissions per car kilometer.

(b) More rigorous traffic restrictions, incorporated in scenario (b), will prevent people from undertaking certain trips. The restrictions are obviously directed to urban areas and especially to city centres. From total car kilometers driven in Western European countries, 30 to 50 per cent is driven in urban areas. In cities, on average 30 per cent of car traffic is related to the city centre. By eliminating half of this traffic, a reduction of 5 to 8 per cent of total national car traffic would be reached. To stop half of city centre car traffic would need - compared to current standards - very strong governmental actions. It should be added, however, that the impacts of actually implemented restraint measures have been much more modest (see Webster and Bly, 1980). Outside city centres some restrictions might also be imposed, so that the total effect might be a maximum of 10 per cent decrease of total national car traffic. Thus even drastic measures such as a 'car-less city' will have modest impacts.

There are also many technical possibilities to decrease fuel consumption, e.g. smaller cars, smaller engines, new diesel engines, electric engines, etc. (cf. Alppivuori and Himanen, 1990). Here the theoretical reduction in fuel consumption may be 30 per cent in passenger cars. To achieve this, strict national and international standards and pricing mechanisms must be established. Smaller cars will also need less raw material. Supposing that half of the car stock consists of small cars weighing 600 kg, the average reduction in raw material for the whole car stock would be about 20 per cent.

The previous observations mean that the application of this scenario may contribute to an abatement of negative outcomes of the current motorization level. Scenario (b) could reduce vehicle mileage with at most 10 per cent, fuel consumption with almost 40 per cent, and the use of raw material needed for car production with almost 20 per cent compared to the policy-off situation. However, it does not provide solutions for the reduction of the rise in future traffic volume which will likely result in additional negative externalities.

(c) Traffic redistribution between individual and public transport implied by scenario (c) may induce positive environmental outcomes supporting ecological sustainability, such as:

- a reduction in the number of vehicles produced and sold;
- a reduction in vehicle use and hence in the number of

kilometers travelled;

- a reduction in fuel consumption and in the volume of harmful pollutants.

This reduction may particularly be expected in urban areas with well organized public transport systems.

However, such a traffic redistribution is also restricted due to the following reasons:

- the high - and in some aspects unattainable - quality of individual transport service ('door-to-door'service, spatial and time transport flexibility);
- insufficient density of the public transport network;
- inert habits and prestige of individual car users;
- obvious advantages of individual transport for some trip purposes (e.g., shopping trips).

A decisive condition for the elimination of some of these weaknesses and for restraining obstacles to such traffic redistribution is a willingness of the government to interfere with the individual freedom to buy and use road vehicles. The rising tide of car ownership is certainly not an irresistable force of nature over which governments should have no control.

The improvement of public transport may increase patronage, but so far the decreasing effect in car traffic has been very modest (cf. Webster and Bly, 1980). Scenario (c) could be seen as complementary to scenario (b). To apply strict restrictions needed for overall reduction of car traffic by 10 per cent, there is a necessity to improve public transport. The increase of fuel consumption due to increased public transport services may be counterbalanced by new possibilities to improve fuel efficiency and to rationalize operations. These may lead to 20 per cent savings in fuel consumption according to Alppivuori and Himanen (1990).

(d) A suitably organized region or city - with an efficient spatial design and efficient transport corridors - may create a reduction of both the number and the length of necessary vehicle journeys. It may plausibly be assumed that

- some vehicle trips may be converted to walking and cycling,
- some vehicle trips may be shorter, and
- public transport instead of car is used for some trips.

This policy can be most efficient in urban areas. Considerably smaller effects are expected in rural areas or in long distance transport. Improvements are of course easier to obtain in new cities than in existing ones, where the land use arrangements have already established the patterns of movements (see Gakenheimer, 1978).

It is also noteworthy here that Webster and Bly (1980) - after having considered many transport studies - state that the mean daily number of trips, time and fraction of household budget spent on travelling are fairly constant over widely different types of areas with very different transport facilities. As stated before in Section 1, people use on average slightly more than one hour for travelling. The major possibility would then be changing of trips from car traffic to walking and cycling and also to public transport. This could have a similar effect as in scenario (b), e.g. a 10 per cent reduction in overall car traffic. In a way, we have here the same transport picture, which is obtained in scenario (b) by force and in scenario (d) by gradual development of land use patterns.

6. Further Evaluation of Scenarios

To get a general picture of future effects of the above described scenarios, some further assessments are presented. The quantified impacts of scenarios (b), (c) and (d) are compared to the status quo situation which is presented by scenario (a). A major unknown in scenario (a) is the economic development in Europe and especially in Eastern Europe. To illustrate possible developments, further assessments are made according to moderate and rapid increase in car traffic, which might manifest itself in the next twenty to thirty years as a 40 and 70 per cent increase in European car stock and car traffic. The slightly different rate of increase between car stock and car mileage is here disregarded. The reductions in fuel consumption and in the use of raw material are quantified according to the Finnish survey referred to above (Alppivuori and Himanen 1990). The original exhaust emission forecast, used here, was made for Finland (Mäkelä 1991b). Because of the large number of cold startups and cold driving in northern countries, the reductions in CO and to some extent also in HC are considerably less than the above mentioned capabilities of new cars. The original emission forecast was modified regarding cold startups and cold driving to reflect the average European situation, so that the following figures give a representative picture of the Central European situation. In northeren countries emissions are somewhat higher and in southern countries somewhat lower. However, the possible stricter enforement in northern countries may diminsh these differences.
Scenario (c) was determined as a necessary complement to scenario (b), while scenario (d) would reach more or less the same 10 per cent reduction of car traffic as scenario (b), the latter one by means of stringent restrictions and the first one by means of long-term land use developments. In the following paragraphs we will discuss impacts of scenario (a) and (b) to obtain a complete picture.

Starting with an average of 40 per cent increase (compared to the late 1980's) in car ownership and car traffic in Europe in scenario (a) and actions in scenario (b), the following assumptions are made:

- a reduction of 10 percent in car traffic obtained by restrictions in scenario (b),
- a reduction of 20 percent in raw material use obtained by the use of small cars in scenario (b),
- a reduction of 30 percent in fuel consumption obtained by new technolgy in scenario (b),
- a reduction of exhaust emissions in scenario (a) obtained by using by catalytic converters and by keeping emission limits as stated before.

When combining the above mentioned consequences, the following assessments are plausible for the next twenty to thirty years:

- car production, ownership and mileage will still increase with 20 to 30 per cent;
- raw material needed for car production may stay at its current level;
- fuel consumption by cars would decrease with at least 10 per cent;
- exhaust emissions from car traffic could be reduced with more than 40 per cent (CO), 50 per cent (HC), and 85 per cent (NO_x).

Next, assuming an average of 70 per cent increase (compared to late 1980's) in car ownership and car traffic in Europe, the impacts of scenarios (a) and (b) would be as follows:

- car production, ownership and mileage would increase with more than 50 per cent;
- raw material needed for car production would increase with 20 per cent;
- fuel consumption by cars would increase with almost 10 per cent;
- exhaust emissions from car traffic could be reduced by 30 per cent (CO), 40 percent (HC), and 80 per cent (NO_x).

It should be added that these estimates are made for private car traffic. The increase in freight traffic is largely unknown, although the possible reductions in exhaust emissions per kilometer for diesel engines will not be as large as for gasoline driven cars (as indicated before).

7. Concluding Remarks

The relatively high figures for social costs of road transport have serious implications for transport and infrastructure policy. In order to make transport part of an ecologically sustainable economy, intensified efforts have to be developed to make the need for transport compatible with the needs of the European economies. A decline in the social costs of transport requires a more efficient operation of current networks and a better, i.e. more coherent, design of new infrastructures. Also here cities may provide the working floor for a new infrastructure policy.

In this context, Cerwenka (1990) claims that "on the basis of foreseeable traffic trends, the general outlook for future environmental pollution caused by transport in the ECMT countries will be gloomy unless there is a switch to a resolutely and systematically environment oriented traffic management".

At present there is apparently a strong conflict between public and private interests in mobility patterns which will undoubtedly endanger ecological sustainability in the transport sector. The high social costs of the transport sector which are to a large extent a consequence of our welfare society can only effectively be coped with if drastic policy measures are taken, notably by internalizing the social costs of transport via user charge principles and by adopting strategic long-term physical planning principles in which such costs are minimized (e.g., by constructing new office buildings near major terminals of public transport). The governmental actions related to our scenarios (b), (c) and (d) far exceed current policy actions.

In the field of transport and the environment the role of governments is in the short run modest, although a joint rigorous European effort may lead to significant improvements in environmental conditions. Current piecemeal and ad hoc policies are not very promising and will probably only marginally eliminate some of the social costs of transport. Scenario analysis and policy analysis would have to be developed in a strategic forecasting experiment in order to trace the most plausible results of various public policy responses in combination with private behavioral responses.

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