ET   Faculteit der Economische Wetenschappen en Econometrie

Serie Research Memoranda

Transport Mobility, Spatial Accessibility and Environmental Sustainability

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1. Euro-mobility

In a recent publication (see Nijkamp et al., 1990) it has been conjectured that the spatial development of Europe (and of all developed and industrialized countries) can be characterized as the 'geography of movement'. There has been an unprecedented rise in both passenger and freight transport. This observation can be confirmed by a recent publication of the ECMT (1990), where it has been shown that from 1970 to 1986 passenger transport by both roads and railways increased by 59.2 per cent in OECD Europe countries (see for details also Figures 1 and 2). And it is foreseen that - in the absence of radical changes in social and economic conditions - current transport trends are likely to continue. Furthermore, it is shown that in OECD Europe and in the United States, annual investment in transport infrastructure is decreasing, an observation also made by Bruinsma et al. (1992).
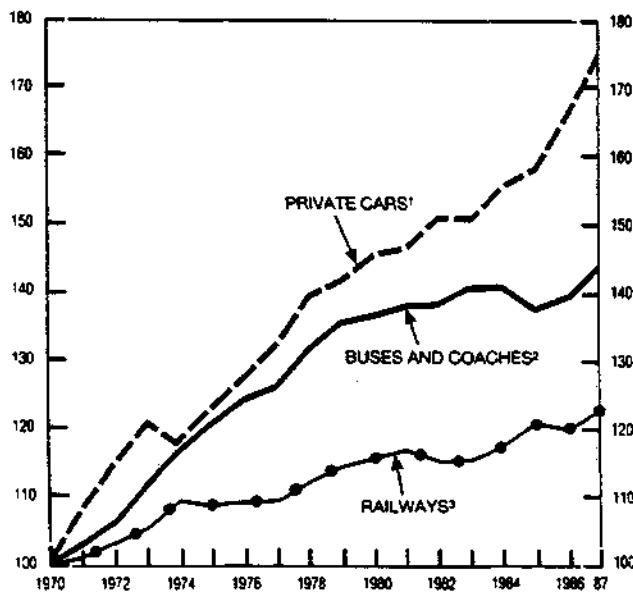
1 14 countries: A. B. DK, SF. F, D, I, NL. N. P. E. S. CH, UK.
2. 16 countries A. B. DK, SF. F. D. GR. I. NL. N. P. E. S. CH. UK. YU.
3. All ECMT countries.
Source: ECMT.

Figure 1. **Passenger Traffic Trends**
1970 = 100 (passengers-kilometres)
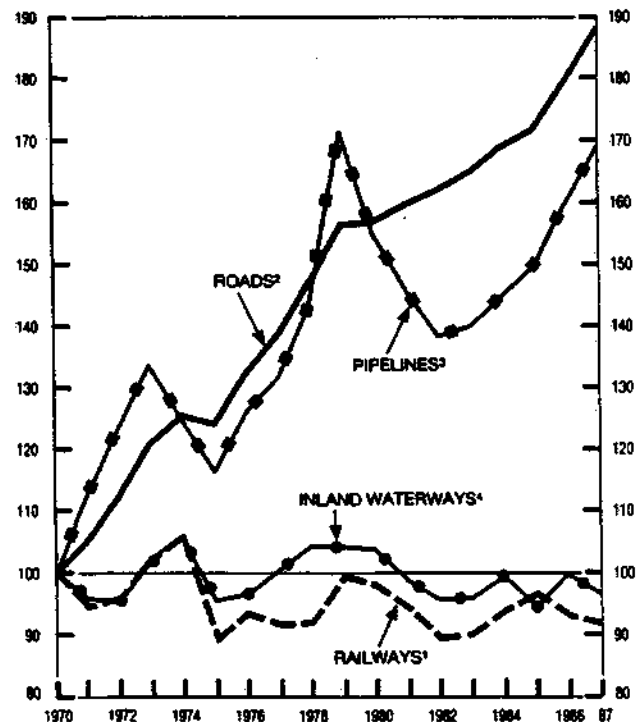
1. All ECMT countries.
2. 16 countries: A. B. DK, SF. F, D, I, L, NL. N, E, S, CH, TR, UK, YU.
3. 11 countries: A. B, F. D, I, NL, E, CH, TR, UK. YU.
4. 11 countries: A. B. SF. F, D. I, L, NL. CH. UK. YU.
Source: ECMT.

Figure 2. **Freight Traffic Trends**
1970 = 100 (tonne-kilometres)

The above figures on mobility are remarkable in that so far no saturation level has been reached. Apparently we are still observing the rising part of a logistic growth curve.

Traffic increase in Europe has mainly been caused by the rise in the number of cars, vans and lorries as well as by the rising number of air flights. The higher speeds obtained by new vehicles and new networks have been used for more traveling. Various recent forecasts still foresee a considerable increase in European traffic. However, the forecasts differ very much from each other. It should also be noted here that the forecasts are usually related to the economic development in the Western part of Europe; economic growth and its related traffic are still uncertain in many former socialist countries in the eastern part of Europe.

The International Road Federation (IRF) (1990) expects a 35 per cent increase in passenger-kilometres in Western Europe from 1988 to the year 2000. If this pace of increase would continue, car traffic would double early next century. This kind of development has been forcasted in the United Kingdom where 82 (low GDP growth) to 134 (high GDP growth) per cent increase (from 1988 up to the year 2025) is expected in car traffic (cf. Goodwin et al., 1991).

In other forecasts somewhat lower expectations are presented. For example, in Finland car traffic is expected to reach a maximum in 2010 and then to decline because of decreasing population (Tie- ja vesirakennushallitus & Taloudellinen suunnittelukeskus 1987). Before that period an increase of 50% from the end of the 1980's is forecasted. A similar increase, 54 per cent, has been foreseen for Sweden (Svidén, 1983), although another study (Jansson, 1989) gives somewhat lower estimates, viz. 23 per cent (1984-2010). Also in the Netherlands various forecasts have been made. According to De Jong (1988) a 70 per cent increase up to the year 2010 in car traffic is possible, compared to a 40 per cent rise indicated by Vleugel et al. (1990). Also De Jong (1988) points out the possibility of a reduced increase in car traffic because of restrictive

governmental actions.

Theoretically, the upper limit of car ownership per capita might be reached when almost all adult persons would own a car. However, Californian figures showed that this 'natural' limit can easily be exceeded. Whether such a situation would ever become reality in Western European countries is still an open question. The total number of cars depends naturally on the number of people, but this is apparently not leading to a fixed saturation level. In any case, in countries with still an increasing population the increase of car traffic will undoubtedly still continue after the saturation of car ownership has been obtained.

If we assume a saturation level of one car per adult person, then in many European countries a saturation of car ownership has approximately already been obtained for males. For example, in the Oslo area during the years 1977-1990 the share of car owners has been fluctuating around 80 per cent for males between 25 - 54 years old (Vibe, 1991). This figure has been reached in 1990 also by older males (55 - 74 years old). If we would exclude the oldest generations, only a minor increase may be foreseen resulting in a situation where almost 85 per cent of adult males own a car. For females however, car ownership has been increasing very fast for all generations. However, still in 1990 the share of female car owners stayed just over 60 per cent for females of 25 - 54 years old. The same phenomenon can be observed in Swedish forecasts (Jansson 1989), where male car ownership is expected to grow only by 3 per cent at the same time when female car ownership will likely grow by 70 per cent.

Theoretically, the limits of car traffic might be calculated with the aid of behavioural data. The average daily travel time seems to be very stable over time (cf. Brög 1991, and Himanen et al., 1992)[1]. The average daily travel distance has increased with

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[1] Vilhelmson (1990) has presented a thorough discussion about the theory of the stable daily travel time. He also noticed that the average daily travel time is independent of household characteristics, except for old people. Prendergast and Williams (1980) have however, found that travel time is related to various socio-economic characteristics.

higher average journey speeds obtained by cars (Himanen et al., 1992). However, the average daily journey distance for car users has been 51 km and for non-car users 27 km (age groups 13 - 64) in Finland from 1974 to 1986. These figures are very close to Swedish figures, viz. 53 and 25 km for 1984/1985 (Vilhelmson 1990)[2]. When we would know demographic features and suppose that female car ownership will probably remain somewhat below male ownership, the maximum traffic might in principle be calculated. It has to be added that the number of average kilometers can be made with different cars (e.g., one for long distances and one for intra-urban traffic), so that the saturation level for car ownership is still difficult to identify.

The development of freight traffic is influenced amongst others by the number of people and the level of consumption. IRF (1990) expects a 30 per cent increase in freight ton-kilometres in Western Europe in the year 2000, compared to the 1988 level. If this increase would continue, the freight traffic would also double early next century. ECMT (see ERTI, 1990, p. 31) forecasts a somewhat lower increase, by which European freight transport would obtain the same 30 per cent increase ten years later.

It is evident that the share of road transport is all the time increasing. ECMT (1985) supposes that freight transport on rails and inland waterways would not increase at all; the prodominant expansion would take place on roads with a 70 per cent increase in ton-kilometres between 1988 and 2010. A similar development has been forecasted in the United Kingdom (1988-2025); heavy lorry traffic will go up by 67 - 141 per cent and light goods traffic by 101 - 215 per cent (cf. Goodwin et al., 1991). In Finland a more moderate increase is expected, viz. 23 per cent for lorry traffic and 70 per cent for van traffic (Tie-ja vesirakennushallitus & Taloudellinen suunnittelukeskus 1987).

Demand for air travel and air freight transport will likely continue to expand well into the next century. This growth is expected to be supported by the coming liberalization of regular

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[2]   The journey distances given above were averages for the whole country. The journey kilometres inside an urban area are lower.

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air sevices and scheduled flight routes.

Clearly, much information is still needed to offer reliable and convincing traffic forecasts and mobility pattern estimates. Interesting information can be found in a recent study on mobility trends in (nine) EC countries by Van Maarseveen and Kraan (1991). Some general data on population density, car density and infrastructure (viz. motorway and rail) density can be found in Table 1. Especially the difference in car density (with a maximum for Germany and a minimum for Ireland) is noteworthy.

country	Popu-lation density inh./km²	Cars per 1000 inhab.	Motor-way-density m. per km²	Rail-density m. per km²
France	101.6	402.7	10.9	63
Italy	199.6	434.7	19.9	54
Fed. Rep. Germany	248.1	472.2	33.8	110
United Kingdom	233.1	348.7	12.7	74
Denmark	118.3	321.6	13.9	58
Netherlands	355.8	355.7	50.5	68
Belgium	324.6	363.9	48.7	120
Luxembourg	153.8	454.1	38.5	100
Ireland	49.4	211.6	-	27

Table 1. General density data on 9 EC countries
Source: Van Maarseveen and Kraan (1991)

The same authors have also collected data on annual mobility rates for car and train (1971-1986) for these nine EC countries (see Tables 2 and 3).

country	Passenger-kms(*10⁹) 1971	Passenger-kms(*10⁹) 1986	Annual Rate (% per year)
France	285.0	517.0	4.1
Italy	271.9	394.4	2.5
Fed. Rep. Germany	371.8	510.3	2.1
United Kingdom	330.0	428.0	1.7
Denmark	35.0	43.9	1.5
Netherlands	88.9	124.3	2.3
Belgium	36.8	56.4	4.4
Luxembourg	-	-	-
Ireland	-	-	-

Table 2. Annual mobility rates by case (1971-1986) on 9 EC countries
Source: Van Maarseveen and Kraan (1991)

country	Passenger-kms(*10⁹) 1970	Passenger-kms(*10⁹) 1985	Annual Rate (% per year)
France	40.98	61.89	2.8
Italy	32.46	37.40	0.9
Fed. Rep. Germany	37.46	42.71	0.9
United Kingdom	30.41	29.70	-0.2
Denmark	3.35	4.51	2.0
Netherlands	8.01	9.01	0.8
Belgium	7.57	6.57	-0.8
Luxembourg	0.21	0.23	0.7
Ireland	0.58	1.02	3.8

Table 3.   Annual mobility rates by train (1971-1986) on 9
EC countries
Source: Van Maarseveen and Kraan (1991)

The information from Table 2 shows a uniform rapid rise in car mobility (with a maximum for Belgium and France and a minimum for Denmark and the United Kingdom). Table 3 indicates a significant variation in train mobility (with a maximum for Ireland, France and Denmark, and a negative growth rate for Belgium and the United Kingdom). Clearly, car mobility rates are much higher than train mobility rates.

The authors have also analyzed the impact of car ownership on mobility, both by car and train, using a specific transportation model called the Mobility Scanner (see Table 4).

country	% growth car population 1970-1985	impact on passenger-kms by car (%)	impact on passenger-kms by train (%)
France	3.6	0.6	-0.3
Italy	5.4	1.2	-0.5
Fed. Rep. Germany	4.2	0.9	-0.5
United Kingdom	2.8	0.5	-0.3
Denmark	2.2	0.3	-0.1
Netherlands	4.4	0.7	-0.4
Belgium	3.3	0.6	-0.3
Luxembourg	3.4	0.8	-0.4
Ireland	4.0	0.4	-0.1

Table 4.   The impact of car ownership on mobility in 1985
(base year 1970) in annual rates for 9 EC
countries
Source: Van Maarseveen and Kraan (1991)

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It is clear that car mobility has risen drastically in all countries, and it has had a strong positive impact on car use and a small negative impact on train use.

Thus the overall conclusion is clear: there is an evident situation in Europe of a strong rise in car ownership and car use, and a modest rise in train use.

Given the above observations, it is plausible to state that 'Euro-mobility' has become a widespread phenomena in all European countries, not only for local traffic but also for international traffic. this mobility drift is clearly not exclusively technology-driven, but also a result of far reaching changes in our ways of living, thinking and working. Our welfare societies have apparently generated a complex array of contact patterns (material and immaterial) which require physical interaction at an unprecedented scale. Nevertheless, it is noteworthy that the daily travel time per person has hardly increased; this 'law of conservation of travel time' means essentially that the average travel speed – and hence distance – has increased (see also Section 3). Apparently there is an intrinsic human resistance against unlimited travel time, so that the need for efficiency rise of transportation networks (i.e., higher speeds) has become predominant.

Clearly, similar observations emerging from social science research can be made in the context of changes in labour force participation, life styles, demographic development etc. In this context, it is interesting that social science research provides convincing empirical evidence that changes in our societies are major driving forces for the intensification of spatial mobility (persons and goods) in our Western world.

In addition, the awareness of the limits to growth in mobility – as a result of high social costs involved – has also dramatically increased. Environmental and safety considerations have become major determinants in the declining social acceptance of our mobile society. Thus new transport solutions and technologies will have to be implemented within increasingly narrower limits imposed by our society and the environments (i.e., ecologically sustainable socio-economic development). The

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range of such solutions is further influenced by the simultaneous behaviour of all actors in a transport system generating congestion effects (including high accident rates) thus causing additional social costs.

The previous observations also provoke an intriguing policy dilemma in transport planning: transport is a necessity for economic and budgetary reasons, and at the same time it is a social evil for environmental and safety reasons (see Himanen et al., 1992). This dilemma evokes the important question: is there a case for co-evolutionary mobility policy that reconciles the positive and negative aspects of the Euro-mobility phenomena? This question will be addressed in the next sections. First, the nature of the above dilemma will be spelt out in greater detail in Section 2.

2.   The Triangular Relationship of Sustainable Spatial Development, Mobility and Accessibility

Conventional economic policy has to face in general a conflicting relationship between **allocative efficiency** and **distributional equity**. In recent years also a third element, i.e. **environmental sustainability,** has gradually been added, following the spirit of the WCED (1987) report on 'Our Common Future" (the so-called Brundtland report) (see also Nijkamp et al., 1991). Applying the previous concepts to transportation planning there is clearly an equivalence between the following concepts:

. Spatial mobility   -   allocative efficiency
. accessibility   -   distributional equity
. sustainable spatial   -   environmental sustainability
  development

Each of these three concepts will now successively be described (see for details also Van Gent and Vleugel, 1991).

(a) Spatial Mobility

Mobility concerns the Spatial Movement of people and goods. Efficient transport is a sine qua non for a balanced economic development: it ensures that production factors be brought together in the production factors and that final products be

distributed to the markets. Both passenger and goods mobility will concisely be discussed here.

(i) **Mobility of persons**

Mobility of persons has steadily increased in the past years (see Figur 1), with the private car as the most important vehicle. The following factors can be mentioned for this mobility growth:

- **demographic** factors: not only population rise in absolute sense, but also (and more importantly) the decline in family size, the rise inthe number of small households and the increased female labour force participation.
- **technological** factors: the emergence of increasingly more 'footloose' activities, accompanied by drastic improvements in infrastructure and car technology.
- **spatial** factors: suburbanisation and des-urbanisation trends accompanied by lagging investments in public transport, as well as separation of work and home locations.
- increase in **car ownership** and **drivers's licence ownership**: the trend towards one car per adult person.
- general **income rise** per capita: removal of financial barriers for purchasing a car.
- rise in **leisure** time: a trend toward recreational and social mobility.
- **stable costs** of the car: a tendency in the past 40 years to keep the real costs of a car at a modest level.

It is quite clear that, if all these explanatory factors will follow more or less the same trend in the next years, also passenger traffic will continue to rise.

(ii) **Mobility of goods**

Freight mobility has also dramatically risen in the past decades (see Figure 2), while a considerable share of freight transport is taken by trucks (approx. 80 percent in many EC countries).

The following factors may explain the freight traffic trends:

- **flexibility** in delivery: a trend towards new logistic concepts and just-in-time door-to-door transport systems (where the truck has an advantage compared to rail or inland waterways).

- competitive transport **costs**: trend towards high-value low-valume goods transportation.

- **speed** of transport: a tendency towards high accuracy and reliability of freight transport.

- **containerisation**: a trend to use for short- and medium-distances the truck rather than container-oriented modes which are more long-distance oriented.

- **government policy**: a tendency to favour truck transport (e.g., by low diesel tax) compared to other modes.

- **suburbanisation** and **spatial deconcentration** of firms: a new geographic pattern where - apart from trucks - other transport modes did not have much potential.

From the previous observations it seems plausible that commodity transport in Europe - in particular after the completion of the internal market - will significantly rise in the next year.

(b) **Accessibility**

Accessibility refers to the ease with which people can reach desirable facilities (e.g., schools, hospitals, work, recreation areas etc.), and has as such direct distributional aspects. Equal access for everyone to all facilities is however at odds with the necessary economic efficiency of a transport system. But this access to facilities is often regarded as a public good, governments have decided to develop and maintain transport systems for mobility-deprived groups (e.g., special population groups such as elderly, handicapped people or children) or isolated areas (thus subsidizing public transport), even though this is financial-economically not profitable.

Accessibility is often threatened by **congestion**, which is a social cost borne by the infrastructure user. In this context mobility rise - as a result of the drift toward higher economic

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performance and efficiency - is in contrast with the accessibility goal.

(c) Sustainable Spatial Development

Sustainable spatial development in relation to the transport sector concerns a variety of environmental aspects, ranging from the construction of new infrastructure to car production and car use. Besides, there are significant and dramatic impacts on human health, not only via noise annoyance and exhaust gases, but also - and mainly - as a result of accidents: in Europe approx. 50.000 people are killed annually because of traffic accidents! Furthermore, there is the change in climate caused by the greenhouse effect to which also exhaust gases from transport vehicles contribute significantly.

In view of the mobility drift, it seems plausible to expect that spatial sustainable development will be seriously threatened in the next decades. In order to provide a framework for a policy analysis of the above triangular relationship we will in the next section pay somewhat more attention to the environmental issue.

3. Environmental Sustainability

Transport is part of our necessary livelyhood system. In developed countries transport is also a part of mass consumption and at the same time transport if 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 onthe law of conservation of matter and energy; see for more details Nijkamp, 1981).

Human life is dependent on an uninterrupted and balanced 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 and Knoflacher and Himanen, 1991).

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 various impacts of the spatially dispersed transport system 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 in developed countries 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 facilitator of the mass consumption system, there is no doubt that transport is likely to change as well.

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, chlorofluorhydrocarbons, and tropospheric ozone); depletion of the ozone layer caused by greenhouse gases - mainly chlorofluorhydrocarbons but also nitrogen dioxide - pushing up to the stratosphere. Also various solid wastes from the transport sector form a part of general accumulation of toxic materials in soils. The above mentioned traffic accidents have to be added as well.

Thus in many respects the transport sector has a negative impact on environmental sustainability. 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).

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 and quality of fuel used (e.g., unleaded petrol, content of sulphur in diesel fuel etc.).

Clearly, the precise implications of measures stimulating or improving ecological sustainability are difficult to assess, especially because the effects of transport cannot easily be separated from effects emerging from our mass consumption society. In the so-called Brundland Report by the World Commission on Environment and Development (1987), where ecological sustainability was discussed, no clear goals for reducing the environmental effects of the transport system are given. King and Schneider (1991), in a report by the Council of the Club of Rome, propose for the industrialized countries a carbon dioxide reduction of 30 per cent by the year 2005. It should be noted here that atmospheric concentrations of greenhouse gases adjust only slowly to changes in emissions. The longer emissions continue at high rates, the larger the eventual reduction would have to be. According to Döös (1991) an immediate reduction of over 60 per cent of net emissions of long-lived gases (carbon dioxide, CFC, and notrogen oxides) from human activities would stabilize concentrations at today's levels.

Unfortunately, no international agreement for limiting the emissions of carbon dioxide has been approved, although some recommendations were made in Toronto in June 1988. The obvious problems with limiting carbon dioxide emissions are related to

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mass consumption in developed countries and rapid population increase in many developing countries. The mass consumption system is in many ways closely connected with the massive use of fossil fuels. The need for economic development in developing countries will call for even more consumption of fossil fuels.

Governmental actions regarding CFC have been much more stringent. According to the decision of 93 nations in June 1990, CFC will not be used after 2000 in industrial countries and after 2010 in developing countries.

European nations have agreed to lower emissions of sulfur and nitrogen oxides, but according to Döös (1991) these commitments are far from sufficient to stabilize the harmful effects of acid rain in Europe. The agreed reduction was 30 per cent. According to Kauppi et al. (1990), a 90 percent decrease of annual sulphur and nitrogen deposits would be needed (compared to the year 1987) in order to stop acidification of forest soil in southern Finland. In order to meet the less stringent requirement that forest land acidification would be allowed to the extent that forests are not in danger, a 75 percent decrease of deposits would be sufficient. Similar figures are also obtained in Sweden (Eriksson and Hesselborn, 1990). Other gases responsible for the acidification problem are mainly produced outside the transport sector; sulfur dioxide in energy production and ammonia in agriculture.

It should be noticed that the European transport sector is only a fraction of the global system responsible for worldwide environmental problems. Its share is however, not negligible. According to King and Schneider (1991) at present there are four predominant cases of macro pollution as a global scale:

(1) Diffusion of toxic substances in the environment.
(2) The acidification of lakes and the destruction of forests.
(3) Depletion of ozone layer.
(4) Greenhouse effect.

It is clear from the above observations that the road towards co-evolutionary mobility is not easy to find. A free movement of people and commodities is apparently hard to

integrate in a conventional price and market system, so that the existence of negative environmental externalities causes a major concern to governments. This is an issue to be discussed in the next section.

4.   Transport and Environment: Is Policy a Matter of Tast?

Transport has a wide variety of negative environmental consequences: noise, particulates, vibration, risk, accidents, fuel emissions, depletion of natural resources, urban sprawl, damage to built environment, communiting severance, congestion, visual intrusion, aesthetics etc. Formally speaking, transport causes a qualitative and quantitative reduction in scarce commodities (or aspects thereof) thus affecting negatively individual and social well-being . Under normal conditions, where all sacrifices and benefits would be incorporated in the price of a good, the allocation of scarce resources would - in 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 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 calculated in from the source, an over-consumption of the activity will take place. This shortcoming in the price system is often called marked 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. Biased behaviour of economic actors 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

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signals of a market system. Such measures may be financed in money terms (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 with all 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 **response** failures may emerge, as public decision-makers are often unable to collect reliable information on the behaviour of actors in case of externalities (or of measures coping with externalities). Thus often they are not in a position to interpret the behaviour in case of biased signals. And indeed in many countries we have witnessed the existence of response failures of government (see Barde and Button, 1991).

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., 1991). 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 kilimeters in order to reach the circular ring around the city as close as possible (thus causing even more traffic annoyance) (see Damianides and Giaoutzi, 1991).

It is thus clear that public intervention is a risky matter, as most actors appeared 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.

The combination of signal and response failures may lead to high social costs of the transport sector. However, a precise

assessment of externality costs in the transport sector is fraught with many difficulties. Such an assessment has to take into consideration two types of costs, viz. **actual damage costs** (e.g., costs to human health, decline in market value of houses) and **prevention (or abatement) costs** (e.g., the construction of anti-noise screens, the design of new catalysators in cars). In most cases, it is possible to gauge the prevention costs, as these are based on expenses actually make. The quantification of damage costs is much more difficult, as this includes a mix of psychological elements, actual market repercussions, and multi-source effects. Various methods have been developed to assess the order of magnitude of such costs (e.g., multivariate regression analysis, hedonic price assessment, contingent valuation etc.), but a reliable outcome is still extremely difficult to obtain. In general, the damage costs show a spatial variation depending on the location of the amenity affected, the welfare level of people, the way of financing public goods etc. This estimation is once more complicated because of the above mentioned interference of signal and response failure.

Nevertheless, there is a growing awareness that the social costs of the transport sector have grown dramatically in the past years, so that there is an urgent need for a critical look at the applications of the transport sector in terms of environmental externalities. Despite the strong deregulation trend in the transport sector, governments begin to realize that these externalities have sometimes become unacceptable, so that there is a new trend starting with more public concern regarding social costs of the transport sector.

In general, the government tries to pursue mainly two objectives in the transport sector, viz. **economic** objectives (in view of the socio-economic importance of the transport sector, both as a source of economic growth and of fiscal revenues) and **social** objectives (in view of both environmental interests and the interests of the mobility-poor). In various situations these two objectives are conflicting, for instance, in the case of a joint application of two governmental fiscal instruments one favouring public transport through subsidies and another one

favouring truck traffic via a low diesel tax. Such conflicting objectives form also one of the backgrounds of the above mentioned public response failures.

It is often claimed that the best way to avoid such failures would be to introduce a system of user charges, so that all people using transport will have to pay the full price (including external costs) of their mobility. Various countries have indeed taken measures to charge external costs to the users of transport, but the degree of success so far has been fairly modest.

A main problem inherent in such road pricing schemes is the fact that the financial revenue accruing to the government tries to cover a set of mutually conflicting options:

- user charges can be used - in the form of tolls e.g. - to finance new expansion of infrastructure;

- user charges can be collected from car drivers in order to be used to cover expenses in new public transport;

- user charges can be used as an economic instrument in order to reduce congestion and to ensure that traffic will remain within the capacity limits;

- user charges can be levied in order to compensate for external costs (environmental decay, lack of safety etc.), both from signal and response failures.

It is clear that the use of a single instrument for so many purposes is almost bound to fail, in particular as these objectives are mutually conflicting.

The previous discussion has clearly indicated that there is a need for a balanced representation of all (social and private) costs and benefits of a transport system in all its modalities. the costs are already hard to assess, but the benefits are even extremely difficult to estimate, as this includes also access to all public and private facilities, social contact patterns, competitive production and distribution etc.

In order to create some structure in the assessment of social costs and benefits of transport modes from a public policy viewpoint, it makes sense to make a distinction into four categories of social costs (see Grupp, 1986):

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- infrastructure costs
- environmental costs
- accident costs
- government subsidies

A careful screening of all items and (public and private) expenses would then lead to a more ambiguous conclusion on the environmental sustainability costs and benefits of various transport modes. Dickmann (1991) concludes in this context that a user charge principle would make the viability of public transport dubious, but this statement would require more rigorous empirical research. In any case, it is clear that governments cannot play a passive role in the environment-transport sector. This will be further discussed in section 5.

5. A Confluence of Mobility, Accessibility and Sustainability?

It has become clear from the above considerations that the mutual relationships between economic interests, social equity and environmental sustainability are by no means a priori mutually compatible. In this context it is somewhat surprising that the modern transport problem – notably accidents and pollution – is essentially the result of solving an old historical problem: how to get from one place to another. The solution found by modern societies includes an enormous use of materials and energy. At the end transport policy is hampered between the demand for more mobility and worries about negative side-effects of traffic. It is also frustrating that after the modern transport problem we have also got a postmodern transport problem. Traffic volumes in bigger cities and on main roads of the European core area have reached the available road capacity resulting in severe congestion. It is obvious that it is hardly any more possible to expand road infrastructure or urban parking space to meet forecasted demand (cf. Button and Gillingwater, 1986, Plowden, 1983, and Goodwin et al., 1991). Congestion has reached such dimensions that many are waiting for the final gridlock (Banister, 1989). Although evidently, in many European countries physical limits for transport have been reached, there are still many other countries where people enjoy an ever

increasing mobility. The question confronting us is now whether we are able to cope with such seemingly irresistable processes.

According to Goodwin (1990) one may distinguish six different approaches to solve traffic congestion:

1. Classical road-building; more roads for more traffic.
2. Neo-classical traffic engineering; optimal use of existing capacity of the road system.
3. Public transport; increased use of public transport.
4. Traffic calming; reduced mobility.
5. Laisser-faire; transport corrects itself.
6. Road pricing; with right prices the system organizes itself efficiently.

Although even nowadays all such policy measures do exist, it is remarkable that transport policy has never resolved the conflict it has provoked. And actually the problem can hardly be solved inside the transport sector. The obvious failure of transport policy can be interpreted as a symptom of the above mentioned failing governments. This kind of problematic can be found in many areas. Capra (1983) noticed as a striking sign of our time that people who are supposed to be experts in various fields can no longer deal with the urgent problems that have arisen in their area of expertise.

The research into complex systems has produced results, which at least partly brought to light why transport policy has been unable to solve transport problems. According to Forrester's first law (King and Schneider, 1991) we may take for granted that: "In any complex system, attack - however apparently intelligent - on a single element or symptom generally leads to a deterioration of the system as a whole."

This can be illustrated on the basis of urban transport policy (cf. also Henson, 1986). When regarding urban transport policy we can see that at least four main items ought to be handled in a consistent and co-ordinated way:

1. Public transport
2. Road network
3. Parking in city centres
4. Pedestrian zones in city centres

These transport items are closely correlated to land use planning, which also must be included in a comprehensive policy strategy.

Wärnhjelm (1990) has investigated transport problems, measures, and results in 25 European cities. According to his material it is obvious that the cities which have had a broad approach have been able to avoid congestion and environmental problems much better than other cities. However, no city can be claimed to have found a permanent solution. Hannover can be taken here as an example. In Hannover a new transport policy was established already in 1967. Its main objectives were: improvement of public transport (especially light rail) and removing of through traffic from the city centre. These objectives were mainly obtained already in 1976. Also in the city centre a large pedestrian zone was established and car parking was concentrated outside the city centre in connection with public transport terminals. The results from Hannover compared to Essen, which represents a more common development, are striking (see Table 5).

	Modal split (%) in 1976/1990	
Mode	Hannover	Essen
Foot	36/23	39/27
Bicycle	9/13	3/5
Mot.two-wheeler	1/10	1/10
Car driver	26/30	27/42
Car passenger	12/9	13/11
Public transport	16/22	17/15

Table 5.   Model split in Hannover and Essen in 1976 and 1990.
         (Brög, 1991)

The modal split in 1976 was very similar in bot cities. In 1990 Essen is much more car oriented than Hannover. However, also in Hannover car traffic is increasing and resulting negative effects are felt. The same phenomenon can be found in Helsinki. Strict parking policy and rather well developed public transport have kept the share of public transport high. However, a small

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increase in car traffic to the city centre can be observed, viz.
on average 0.8 percent per year, which is very similar to the
situation Hannover has observed.

According to a recent study (Himanen et al., 1992) it seems
possible, with rigorous traffic restrictions, to prevent people
from undertaking certain trips. These restrictions are obviously
directed to urban areas and especially to city centres. Outside
city centres some restrictions might also be imposed, so that the
total effect might be a maximum of a 10 per cent decrease of
total national car traffic. It must be remembered however, that
the impacts of actually implemented restraint measures have been
much more modest (see also Webster and Bly, 1980).

There are also many technical possibilities (see Alppivuori
and Himanen, 1990) to decrease fuel consumption, e.g. smaller
cars, smaller engines, new diesel engines, electric engines, etc.
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
weighting 600 kg, the average reduction in raw material for the
whole car stock would be about 20 per cent.

When combining the above mentioned impacts of various
measures with a moderate 40 per cent increase (compared to the
late 1980's) in car ownership and car traffic in western parts
of Europe, the following assessments are plausible for the next
twenty to thirty years:

(i)   Car production, ownership, and mileage will still
        increase with 20 to 30 per cent;

(ii)   Raw materials needed for car production may
        remain at its current level;

(iii)   Fuel consumption by cars would decrease with at
        least 10 per cent;

(iv)   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 traffic, the corresponding impacts would be as follows:

(i)   Car production, ownership, and mileage would increase with more than 50 per cent;

(ii)   Raw materials needed for car production would increase with 20 per cent;

(iii)   Fuel consumption by cars would increase with almost 10 per cent;

(iv)   Exhaust emissions from car traffic could be reduced by 30 per cent (CO), 40 per cent (HC), and 80 per cent (NO_x).

When comparing the above mentioned objectives with the results of various measures, it may be noticed that the reduction in nitrogen oxides is near the target. The major effect has been obtained here by obligatory catalytic convertors. According to a recent review (Mäkelä et al., 1990), exhaust emissions per kilometer from new private cars using gasoline in 2010 will be 30 per cent carbon monoxide (CO), 10 per cent (HC), and 18 per cent (NO_x) of the emissions of the year 1989 in city streets. On highways the corresponding figures will be approximately 25, 50 and 6 per cent.

Production of carbon dioxide is directly correlated to fuel consumption. The impact of the measures in carbon dioxide fall short of the possible targets, even in case of a scenario with a moderate increase in car traffic.

Similar conclusions have been obtained by Eriksson and Hesselborn (1990) in a Swedish study. They noticed that regarding nitrogen oxides, hydrocarbons, and carbon monoxide it is possible to reduce the emissions according to very far reaching targets with the aid of emission limits and technological development. However, regarding carbon dioxide, the difficulties in obtaining targets ar much more severe.

It should be added that these estimates are made for private car traffic. The increase in freight traffic is also considerable, but its share in total traffic will also in the future be minor compared to that of cars. However, the possible reductions in exhaust emissions per kilometer for diesel engines

will be considerably less than those obtained by cars (cf. Mäkelä et al., 1990)

Possibilities to shift freight transport by means of various transport policy measures from road to rail have been studied by PROGNOS (see ERTI, 1990). However, very strong efforts in the field of the organization and realization of cross-frontier railway transport are then needed.

The future position of the railways in European cross-frontier transport is fairly debatable. On the one hand, the railways have suffered from the highly unsatisfactory functioning of European co-operation, technological stagnation, relatively low technical and commercial speed, strong centralization and bureaucracy, and insufficiently effective government policy. On the other hand, the rising problems of transport capacity and environmental restrictions may give a relative advantage to railways for long-distance consignments of goods which could partly influence transfer from lorries to rail haulage (Kristiansen, 1990).

The situation in former socialist countries in the eastern parts of Europe is different. The vehicle stock is old, unleaded gasoline is not or hardly used, emission reduction standards include only a small proportion of vehicle use, governments have insufficient means to check and enforce maintenance of emission standards, etc. For example, according to Mäkelä (1991) 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.

The above discussed measures are only examples of the possible actions. Even though some of the actions far exceed current policy actions, they are quite well possible to obtain and are including well-known technology. In fact, there is a variety of possibilities open. Himanen (1991) has calculated that the transport sector has 4800 possible futures. This figure is obtained by observing that we have six different ways to solve traffic congestion (see above) and five system keeping principles

found in the ecosphere (cf. Knoflacher and Himanen 1990) which can be assimilated also to transport systems. These must be combined with four main groups of objectives (socio-economic efficiency, equity, aesthetic and cultural values, and ecological sustainability), each one with at least four different aspects, and ten different transport modes.

Despite the above expositions, given the high socio-economic value attached to mobility, transport policy has in reality only a limited range of possibilities. In the **short and medium term**, it can only to some extent influence the volume of traffic, the use of transport modes, the way cars and modes are used, and the direct impacts on the environment. Examples of policy measures are road pricing (including urban cordon road pricing), emissions pricing (e.g., via fuel tax), technical emission standards for vehicles, zoning (e.g., pedestrian shopping zones), intermodal transport, public transport enhancement. There is nowadays a general tendency not to look for single measures, but for policy packages in order to offer a more comprehensive transport policy.

In the **long** run transport policy would have to take resort to new car technologies, road transport informatics and telematics, more environment-oriented physical planning and urban design, new ways of transport (e.g., subterranean transport, perhaps in vacuum tubes).

It is clear that in all cases there is a need for both transport users and supplies to pay the full external costs of their activities, including appropriate costs for environmental damage, resource depletion, human health and congestion. The extent to which such measures will be accepted depends also by individuals and group choices made in a democratic society. In line with the triangular relationship discussed above three 'ideal types' of scenario's can be imagined; viz. an environmental scenario, a car mobility scenario and an accessibility scenario (see also Vleugel and Van Gent, 1991).

(a) **Environmental scenario**

This scenario aims at strictly reducing transport mobility, especially car mobility (by both pricing regimes and regulations based on polluter pays principles), the design and introduction

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new 'best technical' vehicle technologies, a strict shift towards environment-friendly transport modes, a ban on expansion of road infrastructure, new urban design and physical planning etc.

(b) **Car mobility scenario**

The car mobility scenario takes for granted sufficient investments in new road infrastructure, a moderate pricing policy for transport, no strict traffic-ban regulations, limited substitution towards other transport modes, and development of car technologies that ensure enduring car mobility.

(c) **Accessibility scenario**

This scenario is based on sufficient investments in all infrastructure types, intra-urban access roads, separation of passenger and commodity transport, a moderate transport pricing regime, sufficient infrastructure for isolated areas, adequate and reasonably priced public transport, and use of 'best available' car technologies.

All these scenario's play implicitly or explicitly a role in each transport policy and hence the search for a co-evolutionary mobility policy ensuring a confluence of interest is fraught with many and diverse difficulties. From an analytical a research perspective it would make sense to investigate policy measures that would be in agreement or at odds with each of these scenario's. This would require a more systematic typology of policy options. A useful typology seems to be according to demand-side transport policy, supply-side transport policy, and coordinated demand/supply-side policy (see also Louw et al., 1991). A systematic screening of various policy options against the attributes of the above scenario's brings to light main items on a research agenda for co-evolutionary mobility policy:

. identification of all relevant (micro and macro, individual and social) costs and benefits of transport

. analysis of effectiveness of policy measures in terms of mobility, accessibility and sustainability

. design of new packages of policy instruments with a particular view on attaining co-evolutionary mobility patterns (e.g., location policy, marketing, price differentiation)

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- development of new technologies favouring a more efficient and environment-friendly transport system (not only vehicle technology but also telematics and road informatics technology)

- societal acceptance of policies aiming at behavioural change of transport users (using bot social and economic stimuli)

- institutional reorganisation of the transport system in which more market-oriented stimuli (ranging from local to international transport movements and for all modes and all users) are given.

6. Concluding Remarks

Transport policy has never escaped from the conflict between the historical and modern transport problem. Now, faced with the emerging postmodern transport problem (heavy congestion without any space to enlarge the capacity) in major European cities and motorways of the European core area, the identification and acceptance of a solid and fruitful transport policy is still more difficult.

The design and implementation of transport policy is embedded in general policy making with - from the environmental viewpoint - two unresolved long-term problems: the future of mass consumption in developed countries and dramatic population explosion in developing countries. In fact Europe has just now a special public planning problem in view of the great many development needs in former socialist countries in the eastern part of Europe.

Clearly, there are many possibilities to obtain environmentally more friendly transport systems when combining governmental actions and technological development. However, some questions are still left unresolved, e.g. how to decrease carbon dioxide emissions. Also the necessary effective governmental actions are mainly still on the waiting list. Decision-makers cannot only be blamed here, because there is even no general agreement among transport professionals regarding solutions to urgent transport problems.

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