European transport trends and environmental policy: doubts and possibile strategies

by Marco Ponti

(Professor of Transport Economics at the Politecnico University of Milan – marco.ponti@polimi.it)

and Francesco Ramella

(Researcher, Istituto Bruno Leoni – francesco.ramella@libero.it)

0. Structure of the paper

We will show that the present European policy of creating incentives for a modal shift (mainly for environmental objectives) from private to public transport presents high public and social costs, and very questionable results. This, for every component of the external costs: air pollution, CO_2 emissions, congestion, and accidents. Furthermore, even in the case that this policy would be successful (a highly unlikely result, after so many years of attempts), the environmental benefits will be limited. Finally, the main alternative policy, i.e. an effort to reduce external cost via technological improvements of road vehicles, even under the more prudent assumptions (i.e., relaying on already-existing technology, etc.), will present lower social costs.
In order to provide more conservative values (given the high uncertainties related to this issue), we will refer mainly on the U.K. figures, that present a situation of relatively weak support for public transport, and the lowest share of transport demand by public transport.
Finally, a simplified social surplus estimate of the considered alternative policies will corroborate the factual results shown by the main figures presented. Further research guidelines are eventually suggested on some of the issues presented in the paper.

1. Order of magnitude of total expenditures in public transport in Europe

The resources absorbed by railways and local public transport in the past decades seem to be extremely relevant. Beginning with the railways; public transfers take a large number of separate forms, such as investments, service-oriented subsidies (commuters etc.), operation of the infrastructure, rolling stock, are more standardised and common. But there are other less transparent methods of support;- the deficits generated on top of these subsidies are generally financed by debts, that the banks correctly treat as "sovereign credit", i.e. are not reluctant to serve. Other form of subsidies exists in terms of special grants for intermodal freight traffic, pension debts absorbed by the state, etc.
The order of magnitude of the total transfers is estimated in 47 billion Euro (2006) per year[1], of which 37 billion for operations and 10 billion for direct investments or debt service for investments financed by loans etc.
On the investment side, apart the new high-speed lines that represent a real increase of capacity, the largest share seems to be connected with periodic maintenance, i.e. operating expenses "disguised" as investments ("up-grading" for example is a rather ambiguous concept), in order to improve the image of the state budget.
Investments are seldom supposed to generate revenue and, even if they achieve some result of this type, the general financial structure of the railways companies is such that the total annual transfers from the state remain the only meaningful figure.
As far as local public transport is concerned, the total level of subsidy here is still more uncertain, given the fact that they are paid both at national and at local level, and in a vast range of forms (to the services, for the rolling stock, repaying debts, etc.). An "educated guess", based on rather old figures[2], is in the order of 20 billion Euro (2006) per year.

---

1 See NERA – "Study on the financing of and of public budget contribution to railways", Study for DG TREN, London 2004

2 See Ramella "Quale politica per il trasporto pubblico locale", p. 237. *Sources*: own calculation with data from DETR, 1999; Heike Höhnscheid (VDV), personal communication, August 2000; GART, 2000; Ministero dei Trasporti e della Navigazione, 1999.

This guess is based on available data for the main countries of the E.U. (Italy, UK, France, Germany), that amount to €14.03 billion, assuming a similar level of per-capita subsidies in the rest of the euro-zone (the population of the four countries being 262 million from a total of 385, this implies a quota of 68%). This rough estimate is not considering the investments in infrastructure (mainly metro lines).

The order of magnitude is therefore of 67 (2006) billion Euro per year. Part of this amount is certainly aimed at mobility goals, in order to support the users that have no access to private transport (but since a good share of local transport is used by students, or commuters in highly congested tertiary downtowns, that by definition have average incomes, but difficult access to private transport, the distributive content of this policy is far from straightforward). Another component of the subsidy can be aimed at changing the modal split. A first observation is necessary: subsidizing one mode in order to reduce the total cost of the externalities (congestion, environmental costs) in transport, is by definition inefficient. This, in fact, implies that neither mode will pay its total social costs (externalities, and production costs), generating, in the medium-long run, "overconsumption" of transport (and land). In the questionable case that the present level of taxation of passenger road transport is not entirely internalizing its social costs, the problem of urban sprawl can be seen as the evident consequence of this policy.

But how effective are the subsidies to public transport, and the taxation of private car use, in changing the modal split (setting aside the efficiency issue)? It depends on the cross elasticity of the demand. While the elasticity to travel time difference (and "reliability difference" for freight) is high, the elasticity to monetary cost is very limited[3]. Therefore the effectiveness of this policy seems also limited, as the actual modal split and its evolution in time demonstrates. After more than thirty years of high taxation of road transport and high subsidies of rail and local public transport, some doubts.

2. Modal split of land transport in Europe

A comparison among the main countries of the EU, France, Germany, Italy and EU shows that the present modal split between private car and public transport is quite homogeneous. Passenger cars share is on average about 85%: the lowest figure is for Italy (83%) and the highest for the UK (87%). In Switzerland, the European country with probably the best local and long distance public transport system[4], passenger car share is about 81% (Figure 1 and Table 1).

---

[3] See Lewis, 1978; Hensher, 1989; the general estimates put it at values in the order of 0,1.

Two recent cases clearly confirm this figure. The first one is the construction of a tramway system in Sheffield (UK). This system, built in the first half of the nineties, is made up of three sections which join up in the city centre. The overall extension of the system is 30 km. The project cost was about 450 million Euros.

According to the analysis carried out by Sheffield City Council (2000), since 1994, when the tramway began running, there has been no decrease of the number of people crossing the central area cordon by car, while there has been an increase of people entering and exiting the city centre.

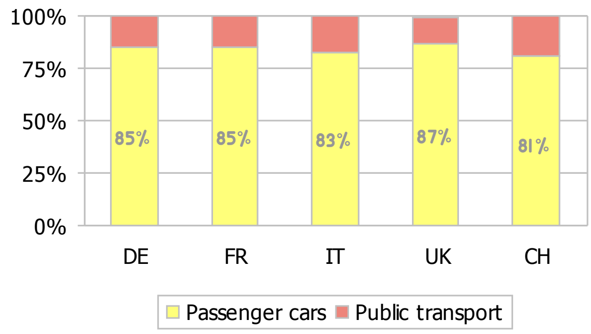
Gerondeau (1997) shows similar data with reference to the subway built in Toulouse (France) which started operating in 1993 and whose cost was about 500 million Euros.

Due to the new infrastructure, patronage of public transport has increased by 30 per cent. But the number of journeys by private cars has not changed by as much. Before the building of the subway, public transport had a share of 20 per cent of motorised journeys. So the increase of public transport has been equal to 6% of the journeys within the metropolitan area. Only a quarter of the additional passengers of public transport has been attracted away from private cars, the other ones being "new" journeys due to the increase of supply. Therefore road traffic decreased by a minuscule 1 per cent.

Baanders (1991) showed that in the Netherlands, even if in all the cities there would be a railway station and a high quality public transport, the number of vehicle-km by car would be lowered by only 5%.

[4] Rail network density in Switzerland is equal to 122 km per square km, 72% higher than the average of the four main European countries (the ratio rail length / population is 83% higher than the average); all the network is electrified (52% on average in Italy, France, Germany and UK).

Figure 1 and Table 1- Modal Split of Land Passenger Transport in Germany, France, Italy, UK and Switzerland – year 2003



	Passenger cars	Buses and coaches	Railways	Tram & Metro	Public transport
DE	85%	7%	7%	2%	15%
FR	85%	5%	8%	1%	15%
IT	83%	11%	5%	1%	17%
UK	87%	6%	5%	1%	13%
CH	81%	3%	16%		19%

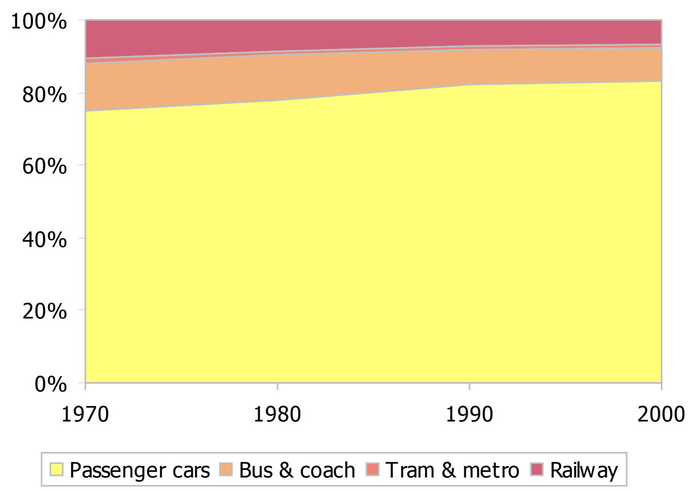
Source: Author's own calculation with data from European Commission, 2005 and LITRA, 2006a

In Italy there seems to be a much higher share of people using buses and coaches: the difference within the other countries is probably due to a stronger competition between the long distance services by coaches and railways (French law forbids coach lines parallel to railways). France, Germany and UK have a "bus and coach" share of around 6% while in the two continental countries railway share is about 2 percent stronger than in the UK.

Passengers car share in Europe (EU15) has increased in the last thirty-five years at a rate of about 0,03% per year: it was equal to 75% in 1970 and to 83% in 2000.

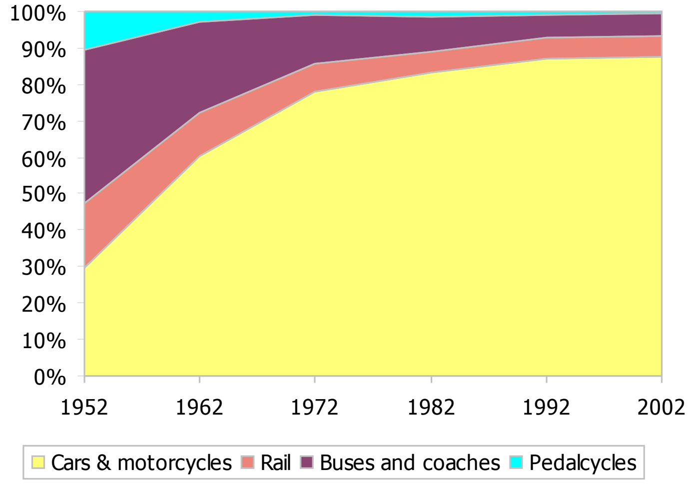
The big change of the split between public and private transport happened in the two decades after the second world war. In Great Britain, for example, passenger cars and motorcycles share was about 30% in 1952 and above 70% in 1972 (Figure 3).

Figure 2 - Modal Split of Land Passenger Transport (EU15) – year 1970-2000



Source: Author's own calculation with data from European Commission, 2004

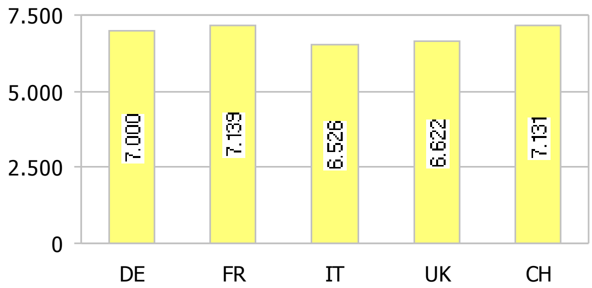
Figure 3 - Modal Split of Land Passenger Transport in Great Britain – year 1952-2002



Source: Author's own calculation with data from Department for Transport, 2006a

Road traffic per head is the lowest in Italy (6.526 vehicle-km per head per year) and the highest in France (7.139), just a bit higher than in Switzerland (7.131).

Figure 4 – Passenger road traffic on national territory [vehicle-km per head] – year 2003



Source: Own calculation with data from Department for Transport, 2004, Department for Transport, 2006a

There is a great variation in car ownership among the main European countries: in Italy the number of cars per head is equal to 0,59, 35% higher than in the UK. But in Italy there seems to be a much lower use of each car and a higher occupancy rate: so, notwhistanding the maximum level of mobility by cars measured as passengers*km, road traffic level in Italy is about 10% lower than in France and Germany and about the same that in the UK.

Traffic intensity, measured as a ratio between road traffic and GDP, is about 10% lower in the UK (and Switzerland) than in the main countries of continental Europe (Table 2).

Table 2- Main parameters of passenger road traffic in Germany, France, Italy, UK and Switzerland – year 2003

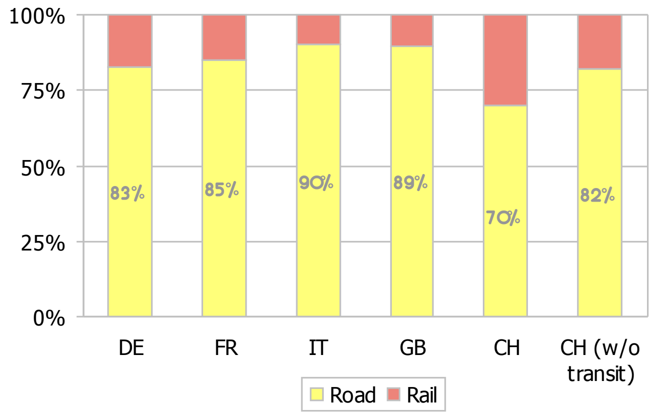
	Passenger cars [billion passenger-km] **(A)**	Road traffic [billion vehicle-km] **(B)**	Cars [thousands] **(C)**	Population [million] **(D)**	GDP per head [n.i.] (EU=100) **(E)**	Passenger-km per head **(A/D)**	Vehicle-km per head **(B/D)**	Average number of passengers per car **(A/B)**	Average number of km per car **(B/C)**	Cars per head **(C/D)**	Road traffic intensity **(B/D*E)**
DE	854	578	44.660	82,54	110	10.348	7.000	1,48	12.938	0,54	63,75
FR	739	425	29.160	59,53	109	12.407	7.139	1,74	14.575	0,49	65,44
IT[1]	711	374	33.706	57,32	103	12.404	6.526	1,90	11.099	0,59	63,12
UK	677	393	25.782	59,33	117	11.411	6.622	1,72	15.239	0,43	56,70
CH	90	52	3.701	7,32	130	12.295	7.131	1,72	14.104	0,51	54,90

[1] Road traffic in 2003 = road traffic in 1999 * passenger cars in 2003 / passenger cars in 1999

Source: Author's own calculation with data from, Department for Transport, 2004, Department for Transport, 2006a, European Commission, 2005 and LITRA 2006a

The modal split for land based freight is quite similar to that of passengers: in the main European countries the minimum share for road is lowest in Germany (83%) and the highest in Italy (90%). In Switzerland railway share is significantly higher, around 30%. This level is strongly influenced by traffic in transit from Italy and to the other European countries: if we take into account only import, export and internal traffic, road share is just below the European average (Figure 5).
Since 1970 railway freight has decreased in Germany, France and Great Britain on average by 25% while it has increased by 26% in Italy and Switzerland (+56% taking into account transit traffic) (Table 3).

Figure 5 - Modal Split of Land Goods Transport in Germany, France, Italy, Great Britain and Switzerland – year 2002



Source: Own calculation with data from, European Commission, 2005 and LITRA 2006b

Table 3 – Railway freight transport in Germany, France, Italy, Great Britain and Switzerland [billion tonne-km] – year 1970-2000

	1970	1980	1990	2000	Δ('70 - '00)
DE	113,00	121,30	101,70	76,82	-32%
FR	67,59	68,82	50,67	55,35	-18%
IT	18,07	18,38	19,36	22,82	26%
GB	24,55	17,82	16,00	18,10	-26%
CH	6,98	7,80	8,86	10,86	56%
CH (w/o transit)	3,74	4,10	4,28	4,70	26%

Source: Own calculation with data from European Commission, 2005 and LITRA 2006b

Contrary to passenger transport, there are important differences of freight road transport among the main European countries. Germany, whose economy is about 35% larger, has a road traffic, in terms of vehicle-km, lower than Italy and about half that of France. In terms of freight moved, levels of traffic are nearly proportional to the national GDP. The main factor explaining the difference between freight road traffic in Germany and in the other countries seems to be the kind of fleet of vehicles. Particularly, in Germany there is a much lower share of light commercial vehicles (68% against 91% in France) probably due to a major role played by big industries and great distribution chains. There seems to be a good correlation between the percentage of light commercial vehicles and the average load per vehicles which shows a minimum in France (2,28 ton per vehicle) and a maximum in Germany (6,05).

Table 4 - Main parameters of road freight traffic in Germany, France, Italy, Great Britain and Switzerland – year 2003

	Freight moved by road on national territory [billion tonne-km] **(A)**[1,2]	Road traffic [billion vehicle-km] **(B)**	Light commercial vehicles (< 3,5 ton) **(C)**	Light and medium trucks (> 3,5 and < 16 ton) **(D)**	Heavy trucks (> 16 ton) **(E)**	% of Light commercial vehicles **[C/(C+D+E)]**	Population [million] **(F)**	GDP per head [n.i.] (EU=100) **(G)**	Average load per vehicle **(A/B)**	Average number of km per vehicle **(B/C)**	Road traffic intensity **[B/(F*G)]**
DE	349	57,7	2.348.399	677.203	447.313	68%	82,54	110	6,05	16.614	6,37
FR	277	122	5.488.000	170.000	398.000	91%	59,53	109	2,28	20.063	18,71
IT	236	69	3.145.283	510.049	418.000	77%	57,32	103	3,44	16.866	11,59
GB	*157*	86,4	2.918.713	267.584	284.959	84%	59,33	117		24.890	12,47
CH	24	6,6	241.956	41.122	24.891	79%	7,32	130	3,61	21.431	6,94

1 2002 data (Italy: 2001 data)

2 UK: only freight moved by vehicles registered in the country

Source: Author's own calculation with data from Department for Transport, 2004, Department for Transport, 2006a, European Commission, 2005, LITRA, 2006b, ANFAC, 2005 and Swiss Federal Statistical Office, 2006

Assuming that the average distance per vehicle is the same for light, medium and heavy trucks, the share of road traffic due to heavy trucks is lower than 2% (4% if we apply a correction factor of 2). This share of traffic may be approximately considered as the potential market for railway: so, if all the freight traffic by heavy truck would be acquired by rail, road traffic would be lowered by just a few percent and that would mean an increase of freight by railways of between 100% in Germany and 379% in Great Britain (57% in Switzerland).

Table 5 - Road freight by heavy truck vs. railways traffic in Germany, France, Italy, Great Britain and Switzerland – year 2003

	Passenger road traffic [billion vehicle-km] **(A)**	Freight road traffic [billion vehicle-km] **(B)**	Total road traffic [billion vehicle-km] **(A+B)**	% of Heavy trucks **(C)**	% of Heavy trucks road traffic [billion vehicle-km] **(B*C)/(A+B)**	Freight moved by heavy truck [billion tonne-km] (estimate)[1] **(D = A*B*10)**	Freight moved by railways [billion tonne-km] **(E)**	Freight by heavy truck as percentage of freight by railways **(D/E)**
DE	577,8	57,7	635,5	13%	1,2%	74,3	74,0	100%
FR	425,0	121,5	546,5	7%	1,5%	79,8	46,8	170%
IT	374,1	68,7	442,8	10%	1,6%	70,5	20,3	347%
GB	392,9	86,4	479,3	8%	1,5%	70,9	18,7	379%
CH	52,2	6,6	58,8	8%	0,9%	5,3	9,3	57%

[1] Assuming an average load per vehicle of 10 tonnes

Source: Own calculation with data from European Commission, 2005 and Table 2

Moreover it should be added that the main share of road freight is made up by short distance journeys, i.e. the market segment where the gap of competitiveness between road and rail is the highest: in Italy, for example, 78% of freight traffic along the tollways is within the same Region: trucks whose movement are longer than 500 km represent only 0,2% of the vehicles on the tollways.
In economics terms, the share of railway transport is even lower than that in physical measures: in Italy the expenses for road freight transport are about 98% of the expenses for all land freight transport (Confetra, 2002).

2. Air pollution, CO_2 emissions, congestion and accidents

In the past there have been a number of arguments put forward in favour of public transport subsidization: to lower congestion, road accidents, air pollution and carbon-dioxide emissions. We will try to assess which role public transport may play in order to achieve these latter aims focusing our attention mainly on Great Britain where local public transport and railway share is the lowest in Europe and with some references to the other countries.

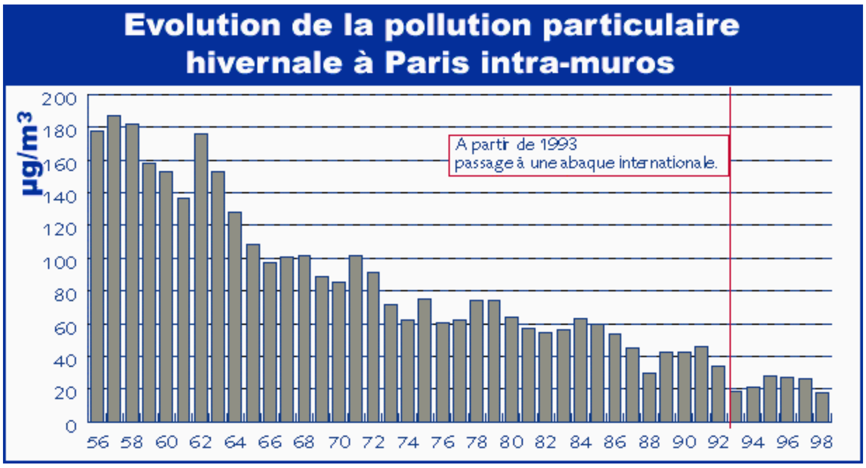
1.1 Air pollution

Subsidization of public transport is usually deemed desirable as a measure to improve the air quality through a reduction of private car travel.
According to the WHO (1999), "PM_{10} is an excellent indicator of the health-relevant air pollution mixture".
"In several recent European studies black smoke[5] was found to be "at least as predictive of negative health outcomes as PM_{10} and $PM_{2.5}$" (WHO, 2003, p.12).
Long term evolution of black smoke in European urban areas shows a large improvement:

- In Paris the winter mean concentration of black smoke between 1956 and 1992 decreased from 180 g/m^3 to 35 g/m^3 (AIRPARIF, 1999)

[5] "Black smoke" refers to a measurement method that uses the light reflectance of particles collected in filters to assess the "blackness" of the collected material

Figure 6 – Winter mean concentration of black smoke from 1956 to 1998

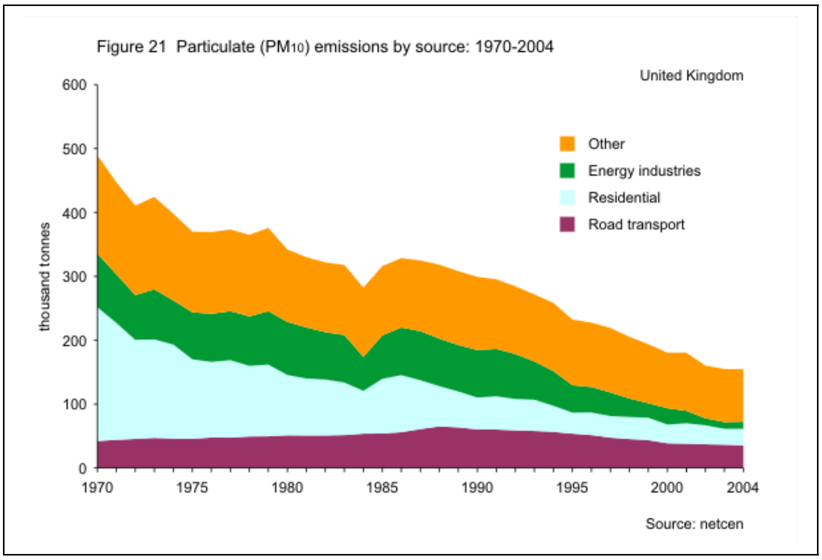


Source: AIRPARIF, 1999

- In London the annual mean concentration of black smoke between 1958 and 1971 decreased from 536 µg/m³ to 59 µg/m³ (Academie des Sciences, 1999).

In Great Britain, total emissions of PM_{10} fell by 69% from 1970 to 2004: emissions from road transport increased by 50% from 1970 to 1990 and then has fallen to 17% below the 1970 level; the present share of road transport emissions is about 20% (since 1970 passenger cars traffic has increased by 156% whilst bus and coach plus rail share of passenger transport fell from 24 to 12%).

Figure 7 – Total emissions of PM_{10} in the UK from 1970 to 2004

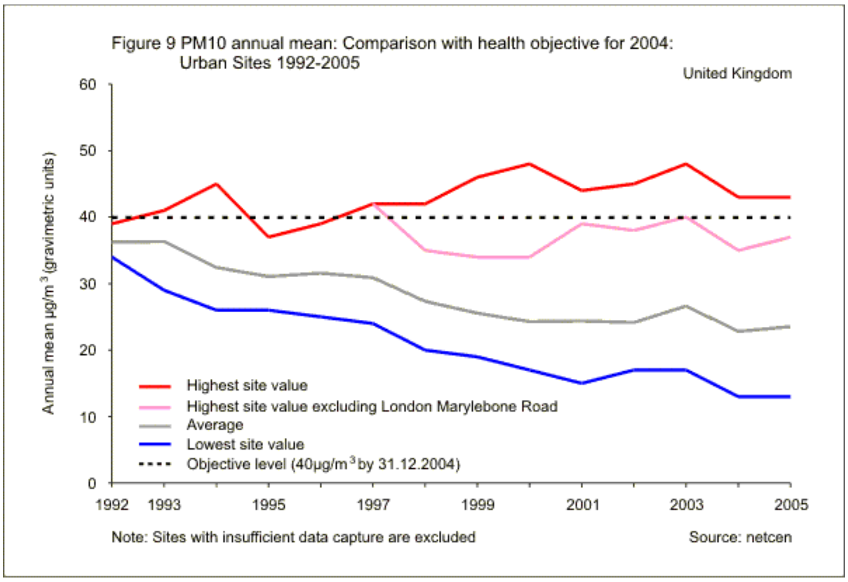


Source: DEFRA, 2006a

In British urban areas, since 1992 (start of monitoring) PM_{10} annual mean concentration decreased by about 40% from 38 to 24 µg/m³ largely below the objective level (Figure 8)[6]

[6] In the US total emissions of PM_{10} fell from 12,2 million of tons in 1970 to 2 million tons in 2005 (U.S. EPA, 2007a). Nationally, average PM_{10} concentrations have decreased by 25% from 1990 to 2005 (U.S. EPA, 2007b)

Figure 8 - PM_{10} annual mean concentration in British urban sites from 1992 to 2005



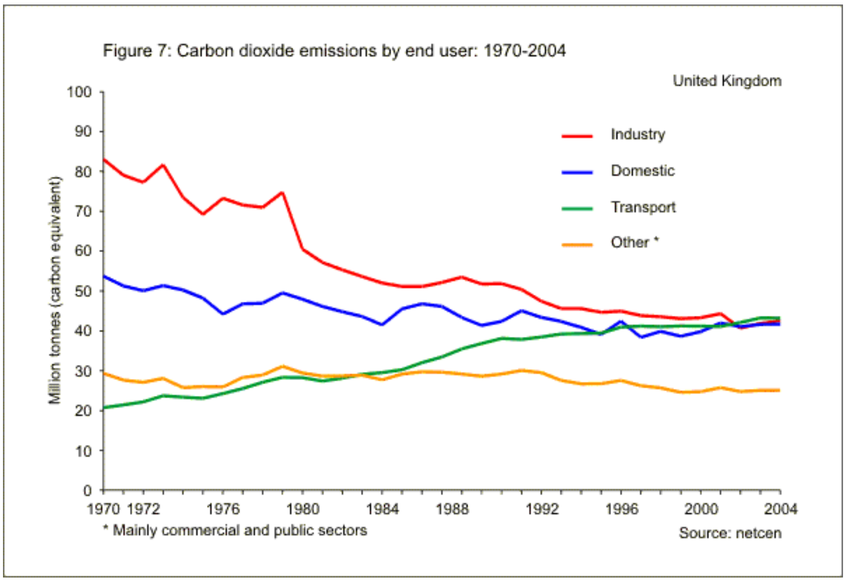
Source: DEFRA, 2006b

Previous data show that the leading factor in shaping the air quality has been and will be (Prud'Homme, 1999) technological improvement of vehicles whilst even a large change of the modal split between car and public transport may have only a minimal impact[7].

2.1 CO_2 emissions

CO_2 total emissions in the UK fell from 187 million tons (carbon) in 1970 to 157 tons in 2004[8]. Transport emissions rose from 21 to 43 million tons. As for land transport, road transport emissions rose by 117% and rail emissions by 16%. In 2004 road emissions share was about 95% of land transport.

Figure 9 – Total emissions of CO_2 in the UK - year 1970-2004



---

[7] It seems reasonable to draw a similar conclusion with reference to noise pollution. "Truck industry efforts in Europe have led to reducstions of exterior noise from 91 to 84 dB(A) between 1974 and 1984, which means that 1984 trucks were 84% less noisy than their counterpart 10 years before. This level has been further reduced to 80 dB(A) by 1996, thus cutting noise levels by another 50% at least" (Prud'Homme, 1999, p. 54)

[8] In the US CO_2 total emissions rose from 1.149 million tons (carbon) in 1970 to 1.615 in 2004 (EIA, 2007)

Source: DEFRA, 2006c

Table 6 – Emission of CO_2 per vehicle-km and per passenger-km in the UK – year 1970 - 2004

	CO_2 emissions per vehicle-km [g]				CO_2 emissions per passenger-km [g]				
	Cars and taxis	Buses and coaches	Light vans	Goods vehicles	Cars and taxis	Buses and coaches	Light vans	Goods vehicles	Rail[1]
1970	280	925	257	699	146	56	(n.a. data of traffic in tonne-km)		128
1975	274	952	264	749	150	51			113
1980	292	980	288	794	162	66			128
1985	265	1094	291	960	151	83			105
1990	240	1165	327	1008	137	117			126
1995	229	1057	330	1094	130	120			141
2000	222	777	302	1051	131	86			113
2004	211	803	310	1114	124	87			105
Δ('70-'04)	-24%	-13%	21%	59%	-15%	57%			-18%
Δ(year "max"-'04)	-28%	-31%	-6%	0%	-24%	-28%			-26%

[1] Emissions of rail passenger transport estimated equal to 80% of rail emissions

Source: own calculation with data from DEFRA, 2006d, DFT, 2006a and DFT, 2006b

Emissions per vehicle-km of cars rose from 280 g in 1970 to 292 in 1980 and then progressively fell to 211 g in 2004. Bus and coach unit emissions reached a maximum in 1990; since then there has been a decrease of 31%. Light van and goods vehicle emissions have increased since 1970 by 21% and 59%.

In terms of emissions per passenger-km there has been a decrease for cars of about 24% since 1980 (0,9% per year). Unit emission of bus and coaches double from 1970 to 1995 because of the large decrease of the average patronage per vehicle; afterwards there has been a strong improvement (-28%) due to technological improvement and, probably, to a shift toward smaller vehicle. Rail emissions per passenger-km do not show a clear trend. In 2004 average emission of cars were about 42% higher than for bus and 18% higher than for railway. The (relative) decrease of total emissions of cars achieved to the technological improvement since 1980 is in absolute terms equal to 26 million tons. If all the new demand satisfied by cars since 1980 would have been absorbed by public transport (bus, coaches and trains), that is if its patronage could have increased by more than 300%, there would have been a further reduction of emissions of about 8 million tons[9]. Even assuming a much higher efficiency of public transport, these figures show that future evolution of CO_2 emissions will be largely related to technological improvement of cars and only marginally to a different modal split: a 1% decrease of car unit emissions is equivalent to an increase of public transport patronage of about 6% (assuming that total emissions of public transport would remain the same).

For freight, the situation of CO_2 emissions seems less clearly defined. Actually, the (non independent) two main researches on the issue show contradicting results, depending on a series of assumptions made by the authors.[10] For this specific issue, a change in modal split may well show more positive results, but the opportunity cost of achieving this goal can be anyway very high, given the rigidity of road freight demand, barely influenced by taxes and subsidies on the rail mode.

2.2 Congestion

Since 1975 to 2005 road traffic in UK has more than doubled. The average distance travelled by car "as driver" per person per year rose from 1.849 to 3.685 miles and the number of trips from 262 to 345. As for public transport, there has been a large increase of distance travelled in London by underground (+87%) and by bus (+18% since 1975 and + 72% since 1985); the average distance travelled by surface rail also increased by 60%, mainly in the last ten years, while there has been a large decrease of the distance travelled

[9] Present unit emissions of public transport (bus, coaches and railways) have been calculated as weighted average of each mode and are equal to 96 g/km.

[10] See PACT (Pilot Action for Combined Transport) "CO2 Reduction through combined transport", July 2003, and IRU-BGL "Comparative analysis of energy consumption and CO2 emissions of road transport and combined transport road-rail".

by local bus outside London (-43%). There has also been a decrease of travel by bicycle and of walking (Table 7).
While, taking into account all the main land mode of transport, the average distance travelled per person per year has increased by 59%, total time spent travelling increased just by 17%: this is due to the modal shift from slower to faster modes of transport. The average speed of each mode has not changed much except for cars whose speed shows an increase of 21% (Figure 10). In 2005 the average speed of cars was about three times higher than that of local bus (outside London). The average trip duration by car in 2005 was about 21 minutes as in 1975 against an average of 32 minutes for local bus trips which are about 50% shorter (Table 8).
These figures show that the change of the modal split during the last thirty years has brought about a large improvement of mobility and accessibility and that, considered the gap between present average speed of cars and local public transport, there does not seem much room for improvement from a reversal of the past evolution in favour of collective modes of transport.
In this regard, Gerondeau (2004) make an interesting comparison between a French and a Swiss city: in the metropolitan area of Zurich (935.000 inhabitants), the daily average time spent for travelling is equal to 91 minutes against 53 minutes in the area of Nantes (566.000 inhabitants) where the share of trips by public transport is much lower (on average 110 trips per head per year by public transport against 470 in Zurich, probably the highest figure in Europe)[11].

Table 7 – Total time and averaged distance travelled per person per year in the UK – year 1970 - 2004

	Total time spent travelling per person per year [hours]					Average distance travelled per person per year [miles]				
	1975	1985	1995	2005	Δ('75 - '05)	1975	1985	1995	2005	Δ('75 - '05)
Walk	83	84	73	67	-20%	255	244	200	197	-23%
Bicycle	7	6	6	5	-30%	51	44	43	36	-29%
Car/van driver	92	101	141	151	64%	1.849	2.271	3.623	3.685	99%
Car/van passenger	64	69	82	85	32%	1.350	1.525	2.082	2.061	53%
Bus in London	8	7	7	10	27%	57	39	43	67	18%
Other local bus	43	33	26	24	-43%	372	258	225	212	-43%
LT underground	3	5	6	6	113%	36	44	60	67	87%
Surface rail	14	14	15	21	50%	289	292	321	461	60%
Total	314	319	354	368	17%	4.259	4.717	6.596	6.787	59%

Source: own calculation with data from DETR, 1999 and DETR 2006c

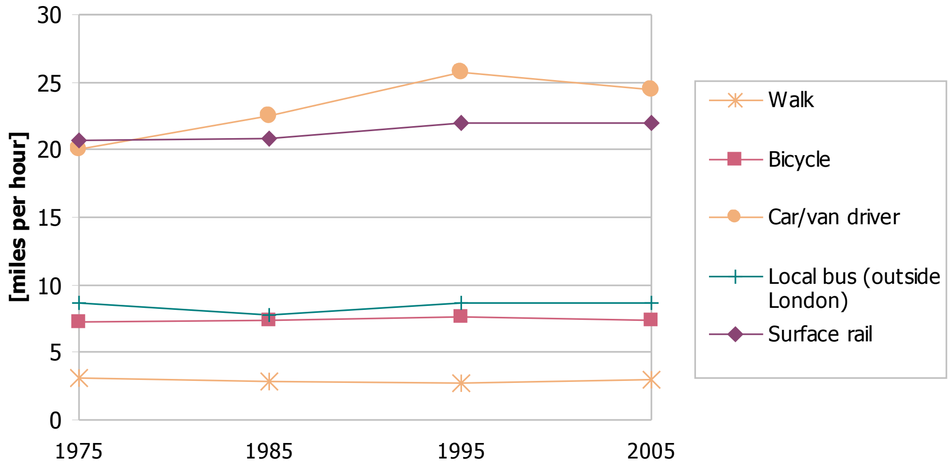
Table 8 – Average trip duration and distance of journeys in the UK – year 1970 - 2004

	Average trip duration [minutes]					Average trip distance [miles]				
	1975	1985	1995	2005	Δ('75 - '05)	1975	1985	1995	2005	Δ('75 - '05)
Walk	15	14	15	16	9%	0,8	0,7	0,7	0,8	3%
Bicycle	13	15	18	20	57%	1,7	1,8	2,3	2,5	48%
Car/van driver	21	19	20	21	-1%	7,1	7,2	8,5	8,5	20%
Car/van passenger	23	21	21	22	-6%	8,1	7,6	8,7	8,7	8%
Motorcycle	16	18	22	23	47%	5,2	3,6	8,8	9,9	89%
Bus in London	35	36	35	37	6%	4,1	3,5	3,3	4,1	1%
Other local bus	29	28	29	32	9%	4,0	3,6	4,2	4,6	14%
Non-local bus	86	160	125	190	120%	54,0	54,5	57,9	90,8	68%
LT underground	51	48	47	52	1%	9,0	7,3	8,4	9,0	0%
Surface rail	76	73	76	80	5%	26,3	24,3	27,8	29,3	12%
Taxi/minicab	20	16	15	18	-9%	4,3	3,9	4,1	5,1	18%
Total	21	19	20	22	5%	4,8	4,8	6,3	6,7	42%

Source: own calculation with data from DETR, 1999 and DETR 2006c

[11] In the US Metropolitan Areas with Largest Central Business Districts the average travel time in 2001 was equal to 23,2 minutes for single occupant vehicle and to 38,5 for public transport (Cox, 2001)

Figure 10 – Average speed of the main mode of transport in the UK – year 1975 - 2005 [miles per hour]

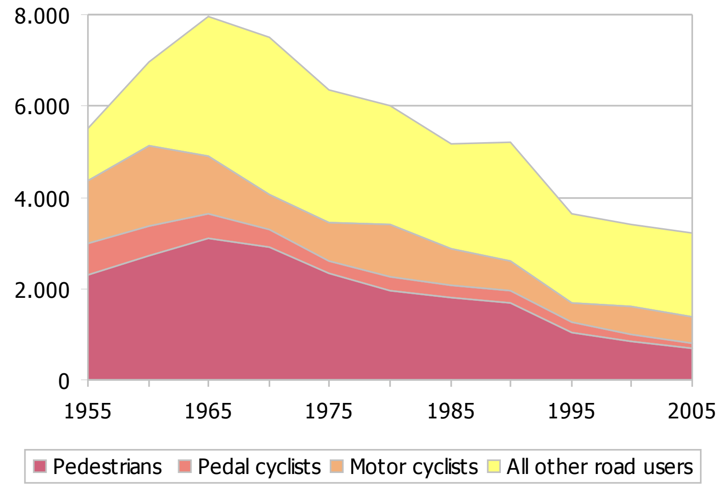


Source: own calculation with data from Table 8.

2.2 Road accidents

The safety of road transport in the UK is characterized by an a impressive improvement during the last fifty years. There were 5.526 persons killed in 1955 and 7.952 in 1965 (Figure 11). Afterwards fatalities decreased by 60% at a rate of about 1,2% per year. Dangerousness of road transport, measured in terms of casualty rate (number of persons killed and severely injured per billion vehicle-km), has decreased by about 90% (Figure 12). There has been a large decrease of fatalities even in the other main European countries: since 1970 the number of persons killed fell by 49% in Italy, 66% in France and 73% in Germany (Table 9)[12] . The present fatality rate in the UK is about fifty percent lower than that in France, Germany and Italy.

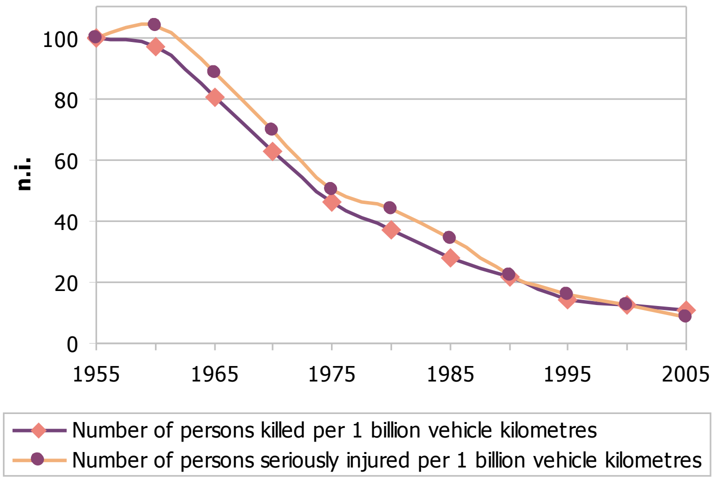
Figure 11 – Road fatalities in the UK – year 1955 - 2005



Source: own calculation with data from DETR 2006a

[12] In the US road fatalities were 36.399 in 1960, 52.627 in 1970 and 42.643 in 2003 (in 1992 there has been the minimum number of persons killed equal to 39.250) (U.S. DOT, 2006)

Figure 12 – Road casualties rates in the UK – year 1955 - 2005



Source: own calculation with data from DETR 2006a

Table 9 – Road fatalities in Germany, France, Italy and United Kingdom – year 1970 - 2004

	1970	1980	1990	2000	2004	Δ('70 - '04)
DE	21.332	15.050	11.046	7.503	5.842	-73%
FR	16.448	13.672	11.215	8.079	5.530	-66%
IT	11.004	9.220	7.151	6.649	5.625	-49%
UK	7.770	6.240	5.402	3.580	3.368	-57%

Source: Own calculation with data from European Commission, 2004 and European Commission, 2005

Table 10 –Fatality rate of road transport in Germany, France, Italy and United Kingdom – year 2003

	Passenger cars [billion passenger-km] **(A)**	Road fatalities **(B)**	Fatality rate **(A/B)**	Fatality rate [n.i]
UK	677	3368	4,97	100
DE	854,1	5842	6,84	137
FR	738,6	5530	7,49	150
IT	711	5625	7,91	159

Source: Own calculation with data from European Commission, 2004

As for the environmental impact of transport, these data seem to show that any reduction of road casualties achievable by a modal shift from private cars to public transport through subsidisation of the latter would be minuscule if compared to the results achieved as a result of technology (improvement of car safety) and an effective road safety policy like the British one.

5. The social cost of getting environmental goals through alternative strategies.

Given the weak empirical relations between modal change and external effects emerging from the previous analysis, it is useful to attempt some form of theoretical confirmation of the doubts on alternative policies that can be derived from the data considered. We try now to use a simplified microeconomic setting in order to show the possible policy implications of our analysis, even if limited to only one transport alternative (private cars and public passenger transport).
To stay on the safe side, we do not enter in the economic dimension of the climate-changing externalities of road transport. We assume just a political goal (similar to the Kyoto standard), of reducing the present level of emissions by 20% (this implies an infinite social cost above the set quantity, fully accepting the risk of catastrophic climate change, etc.).
The analysis will be limited to the emissions in the atmosphere, assuming these being the dominant environmental factor, and to private cars, since this type of vehicle is quantitatively dominant, and assuming that the basic rationale for other road vehicles will be basically similar.
We will compare two alternative strategies able to achieve the target: a change of the actual car with a less-polluting one (based on an existing model), and the transfer of the passengers of that car on public transport. We will consider only the economic costs involved in this transfer, assuming that the incentive-disincentive, or constraint-based policy set in place in order to obtain the environmental result to be relevant only for distribution issues. The tool used will be the variations of social surplus in the two cases, under conservative assumptions, i.e what is the least costly alternative to obtain the environmental goal defined above.
An European average car travels for about 10.000 km per year, and consumes about 1000 litres of fuel, with corresponding emissions, that we have to reduce by 20%.
We begin with the modal shift strategy: we reduce the number of trips by car of 20%, either by increased taxation or by constraints. We can now estimate, very roughly indeed, the net loss of social surplus implied by this approach.
We need to know the economic cost function of the use of an average European car, that we assume constant with the mileage (even this a conservative assumption, since the marginal cost is decreasing), and the taxation. By definition, the social surplus is the difference between the willingness to pay of the user, and the economic cost generated to the society by that use . The environmental cost are no more on the table, since they are treated in the form of an absolute constraint (i.e. in a very prudent way, without considering the high level of internalization already achieved trough gasoline taxation).
We do not know anything of the demand function, if not a single point A at the equilibrium consumption Q (Figure 13), and therefore we assume the more conservative shape possible for this demand function, i.e. the shape that minimize the surplus loss of this strategy (in order to stay on the safe side). We therefore assume a perfectly elastic demand up to the equilibrium consumption Q (even knowing that in reality the demand is quite rigid for car use, as demonstrated by all the existing literature; see note n.3).

Reducing the mileage and the corresponding consumption of fuel by 20% generates a social surplus loss that is, under these assumptions, equal to (€ 0,7 x 200 liters) = € 140, exactly corresponding to the loss of fiscal revenues.

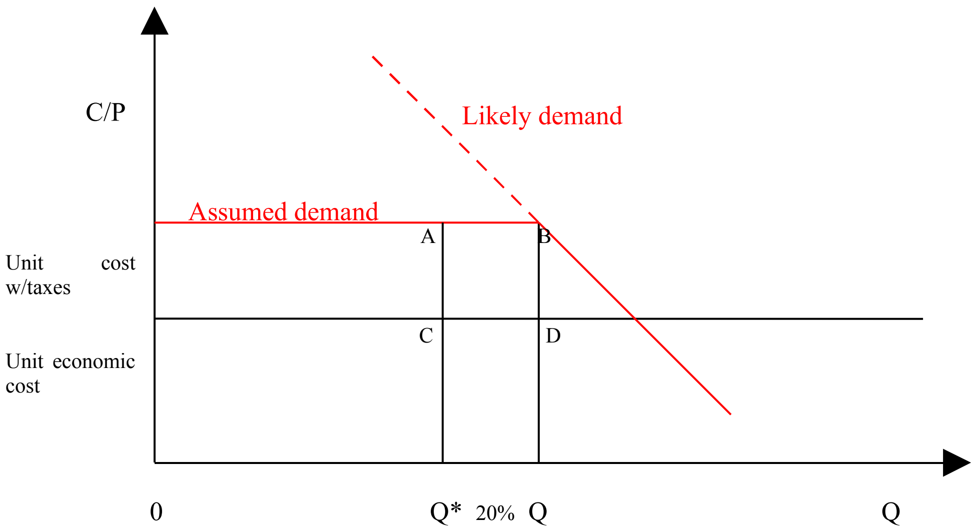
To these social cost, we must add the cost of providing public transport for the journeys no longer made by car. Also here we stay on the safe side, and we assume only 1.4 passenger per car, that generates (1.4 x 2.000) = 2.800 passengers x km of additional demand for public transport. Assuming a (conservative) economic cost of only € 0,2 per passenger-km[13], we must add € 560 to the above figure, reaching a social opportunity cost of € 700 per year (to stay on the safe side, we assume a public transport totally emission-free and accident-free).
Let us see now the opportunity cost of a change in technology.
A modern hybrid car gets the 20% reduction of fuel consumption, assumed as our target (we are not assuming the more optimistic figures provided by the producers), at the additional purchase cost of approximately € 2.500 (probably much less considering its economic cost, i.e. without taxation, and even less in case of larger quantities produced)[14].

[13] See Ramella, 2002. This is an average value. Assuming that there is spare capacity in public transport for large quantities of demand is unlikely. The contrary is probably true: the marginal costs will be much higher than the average ones. But since the cost assumed includes taxes, we have stayed with it, in order as usual, to remain on the safe side

[14] Source: price difference of a Toyota hybrid car (Prius) and a standard car of similar performances and dimensions, and informal information from technicians of FIAT.

The additional yearly social cost (assuming a ten-years lifecycle) is therefore € 250, against € 700 of the modal change, for meeting the set emission standards.
But a modal change generates also benefits in terms of reduction of air pollution (damaging health) and accidents and congestion[15]. The reduction of air polluting substances (damaging health) is the same is obtained reducing fuel consumption of road vehicles, and diverting traffic on non-polluting modes, therefore this issue is not at stake in the following comparison.
Let us add the social benefits of accident and congestion reduction to the modal change. As usual, we will take the maximum values available in literature[16]. For accidents[17], € 31 and for congestion € 50/1000 passengers-km. The total extra benefits will amount to (31+50=81; x 2.8 =) € 227. These benefits reduce the total social cost of modal change to (700 – 227 =) € 473, still higher than the cost of the alternative strategy . This, even staying on an "extreme" safe side.
And we remember that this scenario refuses any (highly uncertain) quantification of the social costs of climate change, in favour of a radical assumption that these costs, above the Kyoto threshold are to be considered as infinite.

Figure 13 – The social cost of modal change



Q = Present yearly fuel consumption

Q* = Target (Kyoto) fuel consumption (reduction of 20%)

ABCD = Total social surplus lost (minimum)

Furthermore, it has to be noted that adding the benefits of reduced congestion related to modal change is a questionable choice for two reasons: first, because these benefits are extremely variable in time and space, and therefore setting an average external cost has little meaning (at least at national levels, that are the ones considered here). But above all because these are mainly "club externalities", suffered by the same social

[15] Other external cost are less relevant, and for sure present also in public transport.
[16] All the following data are taken from INFRAS-IWW "External cost of transport- updated study", Zurich-Karlsruhe, 2004.
[17] There is for sure a relevant "club component" also in this externality, but we have kept the main stream of thinking on the issue.

actors that generate them (road users in the present case). Therefore for this specific externality any policy that is aimed at other social goals (i.e. the environment), if damages road users (constraints, tariffs), has to compensate them, for "horizontal" equity reasons, for the component related to congestion, in order that this social group at the end is not worse off (in terms of its total surplus)[18]. But obviously, in high-density contexts and in historical cities the social cost of congestion can be so high that a price-induced modal change can be a sensible policy ("Road Pricing").

But the main issue remains the assumption of demand elasticity for car use, that is for sure quite low, compared to the prudent assumption made here of infinite elasticity above the present level of perceived costs. A rigid demand at the end expresses the lowering density of land use, the increasing role of leisure activities, and the employment structure, more flexible in time and space. All these factors related to the demand of car use seem to be here to stay, and likely to further increase in time, being strongly linked with income levels.

Similar considerations are possible for freight transport. The road demand seems to be rigid, and this is also explained in Europe by technical reasons: high "value densities" of goods produced (light, high quality manufacturing), disperse location of factories, "just-in time" production that requires extreme flexibility in space and time, etc.. In fact, also for freight transport the European taxation is rather heavy, and, as we have seen, the subsidies for the alternative mode (rail) large, with very limited, or absent, practical effect on demand.

There are also important industrial, political, and fiscal aspects to be taken into account (that cannot be developed here in full). Improving the environment-related technology of road transport generates potential high-tech exports (far less so in the technologies related to public transport, that are basically "mature" ones). Diversifying the energy sources (for example, bio-fuels, electricity etc.) reduces the political pressure on security-sensitive oil supply. For the alternative strategy, i.e. modal change, the high marginal opportunity costs of public funds (related with the Maastricht constraints and the high level of public deficit and debt of many European states), makes the increase of public transport (heavily subsidized), a very unattractive perspective.

Moreover, subsidies to public transport generate further traffic; this is not a bad thing per se (it permits, for example, an "escape" from land rents), but for sure accelerate the drive for urban sprawl (the real transport costs involved by distant locations are not perceived); in turn, a lower-density territory become less functional to public transport itself.

6. Conclusions and further research

In the European context, any modal shift policy seems to generate extremely limited changes in external costs at national level, and very high costs in subsidies to public transport, both rail and local.
Shifting the focus of the political action for the environment to the technical improvement of road transport, seems to offer the potential for far larger social benefit, even assuming infinite costs for any emission above the Kyoto standards (or similar ones).
These benefits are in first place measurable, even in a very simplified form, in terms of net welfare gains (social surplus).
But other strategic benefits are the likely result of this change of attitude (that here are only hinted at): savings in scarce public resources, reduction in fossil fuels dependency (possibly far above the reduction of oil consumption, given the development of alternative energy sources), potential high-tech products for export.
Further research is needed on the total subsidies of public transport, especially local, and the results gained in terms of modal shift with these subsidies (adding their income-distribution goal, that is often assumed but rarely researched, and on which some doubts are emerging).
Another field of research is the social opportunity cost of reducing emissions in sectors different to transport, given the low elasticity of demand in transport (proven by the limited results of the present high level of taxation of gasoline in Europe. A simple calculation shows that for one ton of CO_2 emitted burning automotive fuel, the tax paid is in the order of €300, a level an order of magnitude above the environmental

[18] See again INFRAS-IWW, quoted.

taxation in other sectors). This in fact hints at a very high opportunity cost of public alternatives, while in other sectors the demand has proven far more elastic. Furthermore, a policy aimed at reducing directly road transport emissions acts on the largest share of the market: it follows than even limited unit results generate large overall benefits, while the magnitudes involved in modal split policies remain in any case limited.

BIBLIOGRAPHY

Académie des sciences - Cadas, (1999), *Pollution atmosphérique due aux transports et santé publique*, Editions Tec & Doc, Paris.

ANFAC (2005), *European Motor Vehicle Parc 2004*, http://www.acea.be/ASB20/axidownloads20s.nsf/Category2ACEA/45483306B8C171D9C125712600345336/$File/ANFAC-European%20Motor%20vehicle%20parc%202004.pdf

AIRPARIF (1999): *Les tendances de la pollution atmosphérique en Ile-de-France. Airparif actualité*, n° 7, Paris.
http://www.airparif.asso.fr/airparif/pdf/evolutions.PDF

Baanders, Bovy, Van der Hoorn, and van der Waard (1991), *Substitution of Travel Demand betweenCar and Public Transport*, Tijdschrift voor Vervoerswetenschap, Rotterdam

CONFETRA (2002), *La fattura Italia dei servizi logistici e del trasporto merci*, Quaderno n. 98/2 - Luglio

Cox (2001), *Travel Time by Mode: 32 Large US Central Business Districts & Other*, http://www.publicpurpose.com/ut-25cbd-sp.htm

DEFRA, (2006a), *Particulate (PM_{10}) emissions, by source: 1970-2004*, http://www.defra.gov.uk/environment/statistics/airqual/kf/aqkf21.htm

DEFRA (2006b), *PM_{10} annual mean: Comparison with health objective for 2004: Urban Sites 1992-2005*, http://www.defra.gov.uk/environment/statistics/airqual/aqparticulate.htm

DEFRA (2006c), *Carbon dioxide emissions by end user: 1970-2004*, http://www.defra.gov.uk/environment/statistics/globatmos/kf/gakf07.htm

DEFRA, (2006d), *Estimated emissions of carbon dioxide (CO_2) by IPCC source category, type of fuel and end user: 1970-2004*, http://www.defra.gov.uk/environment/statistics/globatmos/download/xls/gatb05.xls

DETR (1999), *Transport Statistics Bulletin. National Travel Survey 1996-98 Update.*

DFT (2004), *Transport statistics for Great Britain – International comparison*

DFT (2006a), *Transport statistics for Great Britain*, http://www.dft.gov.uk/stellent/groups/dft_transstats/documents/downloadable/dft_transstats_613483.pdf

DFT (2006b), *Transport statistics Bullettin. Road Traffic Statistics*, http://www.dft.gov.uk/stellent/groups/dft_transstats/documents/downloadable/dft_transstats_611960.pdf

DFT(2006c), National Travel Survey 2005 Data Tables, http://www.dft.gov.uk/stellent/groups/dft_transstats/documents/downloadable/dft_transstats_612473.xls

EIA (2007), *Total Energy-Related Carbon Dioxide Emissions by End-Use Sector, and the Electric Power Sector, by Fuel Type, 1949-2005*, http://www.eia.doe.gov/oiaf/1605/ggrpt/excel/historical_co2.xls

European Commission Transport Directorate General (2004), *EU Energy & Transport in figures 2004*

European Commission Transport Directorate General (2005), *EU Energy & Transport in figures 2005*

GART (2000), *Memento 1998 des transports publics*, Paris

Gerondeau (1997), *Transport in Europe*, Artech House, London

Gerondeau (2004), *SNCF, Transport publics et autres. Les danseuses de la République*, L'Harmattan, Paris

LITRA (2006a), *Estimation des quotes-parts des différents moyens de transports, volume total du trafic en Suisse*, http://www.litra.ch/dcs/users/2/M04f_voyageurskm.pdf?ExtranetFrontEnd=96709f07416546145922cf17e4fb8561

LITRA (2006b), *Trafic suisse et de transit - Estimation des quotes-parts des différents moyens de transport, volume total du trafic en Suisse*, http://www.litra.ch/dcs/users/2/M04f_tonneskm.pdf?ExtranetFrontEnd=96709f07416546145922cf17e4fb8561

Prud'Homme (1999), *Is our present transport system sustainable*, Presses de l'école national des ponts et chausses, Paris

Ramella (2002), *Quale politica per il trasporto pubblico locale?*, Rivista di diritto finanziario e scienza delle finanze, LXI, 2, I, p. 203-243.

Sheffield City Council's Planning, Transport and Highways Service (2000), *Vehicle & Passenger movements across Sheffield Central Area Cordon 1980-1998*, Sheffield, United Kingdom

Swiss Federal Statistical Office (2006), *Road Vehicles in Switzerland, stock as of 30 September - Distribution of road vehicles by vehicle group and vehicle type*, http://www.bfs.admin.ch/bfs/portal/en/index/themen/verkehr_und_nachrichtenwesen/verk_infra/blank/kennzahlen0/fahrzeuge_strasse/bestand.Document.52287.html

U.S. Environmental Protection Agency (2007a), *Air Emissions Trends - Continued Progress Through 2005*, http://www.epa.gov/airtrends/econ-emissions.html

U.S. Environmental Protection Agency (2007b), *National Trends in Particulate Matter Levels*, http://www.epa.gov/air/airtrends/pm.html#pmnat

U.S. Department of Transport (2006), *National Transportation Statistics*, http://www.bts.gov/publications/national_transportation_statistics/2006/pdf/entire.pdf

WHO - Regional Office for Europe (1999), *Health costs due to road traffic-related air pollution. An impact assessment project of Austria, France and Switzerland, Federal Department of Environment*, Transport, Energy and Communications, Bureau for Transport Studies, Bern, Switzerland.

WHO - Regional Office for Europe (2003), *Health Aspects of Air Pollution with Particulate Matter, Ozone and nitrogen*
Dioxide, p. 12, http://www.who.dk/document/e79097.pdf