„Changing Behaviour towards a more Sustainable Transport System“

COST Action 355

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Presentations and Resources

Working Group 1: Freight Transport and Energy Consumption

Working Group 2: The Automobile

Working Group 3: Overview of National Transport Surveys

Working Group 4: Integrative Synthesis

Introduction

Changing Behaviour towards a more Sustainable Transport System

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A powerful and efficient transportation system is a necessary prerequisite of both economic prosperity and for sustainable mobility of residents in a society. Transportation is necessary to ensure access of residents to their workplaces, to educational institutions or to meetings and customers. At the same time, an integrated economy that is based on specialization and division of labour needs a useful freight transport system to ensure provision of raw materials and manufactured goods. Increases in transport speed and extension of the network also sped up European integration and enabled business people and residents to meet their counterparts, relatives and friends all over the continent.

At the same time, there has been a growing awareness of problems and negative externalities that are related to traffic and mobility. Especially the issue of global warming has been thoroughly discussed recently, but also topics such as scarcity of fossil fuels, dependence on oil-exporting countries, accident injuries and fatalities, noise or particulate matters are issues of public interest. The question of how a transportation system has to be designed to meet the requirements of the residents and the economy on the one hand, and to be sustainable on the other hand is thus of eminent importance.

The concept of sustainability dates back to forestry in the 17th or 18th century: How can forests be managed that no more wood is chopped than can grow back at the same time? The idea that current behaviour shall be no burden for future generations was revisited by the Club of Rome in the 1970s, this time on a wider economic and environmental scale. Since the 1985, the concept of sustainability has also been cherished by the United Nations. As the transport sector is responsible for many long term impacts, such as CO2 emissions or .fossil fuel consumption, there is obviously a strong need to reconcile mobility and sustainability.

Within the EU, there is a strong variability concerning the transportation systems: On the one hand, there are countries that have experienced strong economic growth right after WW II, and that have also extended their networks, especially roads and motorways, in those years. Often a lifestyle evolved around the car that is characterized with sub-urbanization, households with cars for all adult members, while at the same time, people became more and more dependent on their vehicles, and public transport had difficulties competing with the ubiquitous car. Here, strategies are necessary how this dependence can be reduced, and how people can be encouraged towards an environmentally friendly mobility.

On the other hand, there are some new member states that have experienced strong growth rates particularly in the last few years, often combined with an increase in the car fleet and also an increase in automobile dependence. Often, these countries still have a good public transport system that is more and more marginalized by an increasing motorization. Here it seems to be important to decouple economic growth from fuel consumption and car dependency.

Other differences between the member states lie in the population densities: Countries like the Netherlands, but also Germany or Denmark, tend to have a high population density that make a tight network affordable, but that also implies that almost all areas are affected by negative externalities of road traffic. Countries like Finland or Sweden on the other hand have areas with low population densities that are difficult to access, but that are at the same time not much affected by car traffic.

With economic growth as well as with economic integration, there has been an increase in freight traffic as well. With the iron curtain in place, large areas in the Middle of Europe tended to be the end of one side of the world and thus also a barrier for most freight transports. With the fall of the Berlin Wall and the end of the Soviet Union, former border areas now lie in the middle of a reunified Europe. This has lead to freedom and economic growth, but also to a large increase in individual and freight traffic. Considering the long time that is needed to adapt a rail system to those big changes and the flexibility of the car and trucks, it is no surprise that the latter won a large share of the new pie of transportation demand.

The diversity of Europe offers the possibility that countries in similar circumstances or in comparable stages learn from each other. Furthermore, emissions or fuel scarcities are not stopped by national borders, thus the issues of transportation and sustainability have to be addressed internationally. This is particularly true for the still growing air traffic, with carriers competing worldwide, but also with an increasing share of low cost carriers. Passenger and freight traffic by road and rail, too, is not just a national issue in an integrated and growing European Union. Policy, planners and science therefore have to work together over the borders of their countries and their disciplines, to develop a sustainable transportation system that fulfils the economic and social needs all over Europe.

A prerequisite for an integrated and sustainable approach is reliable data and valid forecasts of future demand, to develop a transport system that fulfils future demand structures. Furthermore, to understand behaviour and to change people's attitude towards a more sustainable demand, it is important to move towards longitudinal data which enable us to better understand processes as described. Many data sources already exist all over Europe, but there is still a large necessity to harmonize these data sets, to make it known and accessible to other countries, and to learn from other experiences in the forefront of future surveys. These issues are addressed in Working Group 3: Overview of National Transport Surveys.

With reliable data sources, it is possible to analyze two important sectors of growth that both strongly affect the sustainability of the transport system: Freight traffic and the private use of the automobile. Working Group 1 "Freight Transport and Energy Consumption" addresses the issue in all major ways: Again, there is a sub-group that deals with data collection, which can be seen as the interface to Working Group 3. Then the occurrence of freight traffic is analyzed from the point of view of the whole supply chain as well as with respect to the last mile. Besides, air freight, national policies and the vehicle approach are discussed.

Working Group 2 "Automobile: Panel Data Analysis" mainly focuses on the private use of the car. Again, large growth rates can here be observed. This working group is also strongly connected to Working Group 3 and the data approach. Besides, travel behaviour, and increase in automobile dependence, car ownership and price elasticities are discussed in sub-groups. There are also important interfaces with Working Group 1 (Freight) regarding energy consumption, emissions and land use.

Regarding these important interrelations among all groups and to ensure an integrated approach towards a more sustainable transportation system, Working Group 4 "Integrative Synthesis" ensured joint discussion over the borders of all working groups. There were joint sessions between the working groups, and new research projects concerning data collection and data use in both the fields of freight and car use could be launched. Besides, the work of WG 4 ensured presentations and publications in renowned conferences such as the TRB, WCTR, ISCTSC or ETC.

The work of COST 355 was funded by the European Science Foundation (ESF). Sustainability is an issue that does not stop at national borders. Therefore, we are grateful for a large variety of participants from the European Union, from further European countries and from Canada. This variety can also be observed in the scientific backgrounds of the action members, that range from engineering, economics, planning and psychology to computer and natural sciences. We would like to thank the chairwoman and the chairmen of the working groups, the hosts of our meetings and all volunteers who helped with the organization and publication. Particularly, we would like to thank Christophe Rizet, who as chairman of the Management Committee has constantly contributed to all aspects of the action.

The work of COST 355 action addresses scientists, planners and politicians at the same time: It shall provide information on transportation and data collection in different European countries, and give recommendations to change towards a more sustainable transport system. The idea is to learn from one's neighbours experiences and to work together on important challenges: To ensure economic prosperity, mobility and quality of life for current generations as well as for our children and grandchildren.

WP 1 Freight and energy

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Analysing energy consumed in freight transport means observing and quantifying energy consumption, in relation with freight transport activities (vehKM, TKM). Different statistical units can be observed, each being a different approach to the freight and energy issues. Many of them have been presented during WG1 meetings but in this synthesis, we will focus on four of these approaches.

- The vehicle or a fleet approach, of which main objective is to quantify the vehicle consumption. Such a quantification is the basis for a detailed bottom-up approach and is already well established for trucks;
- in the Supply Chain approach, the objective is to quantify energy consumed in the transport of a product (a yogurt or a jeans for the particular case studies here taken into account) from raw material up to the consumer home, according to the logistical organisation of the supply chain;
- the modelling approach gives a more global view of energy consumed in freight transport, at the local, national or international level and should help the policy makers to assess measures;
- the 'last mile' or last link of the logistic chain differs from the upstream links, because of the urban constraints. This approach focuses on how improving these energy consuming deliveries on the last mile, in urban areas.

These different approaches lead to different conclusions, in terms of alleviation possibilities as well as in terms of data needs.

1) The vehicle approach

The vehicle approach aims to observe, quantify and understand energy consumption and CO_2 emissions at a disaggregate vehicle level, by relating the energy used by the vehicle to key transport indicators. This approach enables to investigate whether behavioural changes are leading to a straight decrease in final energy use or CO_2 emissions of the vehicle, and, if so, how this change can be supported by vehicle related measures taken by decision-makers from companies or from public sector.

Using existing data, fuel use and vehicle performance were compared in several countries, including Germany, Spain, France and the UK. The main used source was the national Continuing Survey of Road Goods Transport. These surveys have been harmonized since 1998 by EU rule on road freight surveys (CE n° 1172/98 of 25 May 1998). Their main objective is to give a picture of the use and efficiency of national road freight fleet and to quantify road freight transport and distance travelled. Data is collected from a random stratified sample of Heavy Duty vehicles (over 3.5 t.), each one being monitored during one week. The Continuing Survey of Road Goods Transport in UK (CSRGT, DfT 2006a) collects data from 12,000 vehicles per year, out of which 5000 are articulated trucks over 33 tonnes gross vehicle weight; in France, the yearly sample of TRM Survey (Transport Routier de Marchandises) is around 15,000 rigid trucks (out of a population 300,000) and 70,000 tractors (out of 290,000). For Spain, the "Encuesta Permanente Transporte de Mercancías por Carretera – EPTMC" has been presented by PJ. Pérez-Martínez (Arcueil, 2005). We also used available specific (non harmonized) surveys in UK (McKinnon, Berlin, 2005) and Germany (Léonardi, Arcueil, 2005).

The issue of comparability of available data, between countries and through the years, lead us to analyse in depth the way such data are collected and how data collection could be improved.

Road freight energy and CO_2 efficiency in UK

A transport energy efficiency programme has been set up in the UK since the beginning of the 1990s and is now leading to behavioural changes in the transport industry. This programme disseminates best practice resulting in efficiency improvements in companies (Roger Worth, Prague, 2006). To monitor these improvements, Key Performance Indicators have been defined, that enable benchmarking data on loading efficiency and logistic indicators related to energy consumption in companies (McKinnon, Berlin, 2005). A direct survey on companies includes questions on Key Performance Indicators: vehicle fill, empty running, time use, deviations from schedule and fuel consumption. These method and structure, repeatedly used in surveys since 1999, offer opportunities for linking transport indicators with fuel consumption indicators for each vehicle type and each company, allowing benchmarking and comparisons.

In table 1 several indicators calculated from the Continuing Survey of Road Goods Transport are compared with these Key Performance Indicators

	National statistics, computed from CSRGT				KPI Pallet Survey
Indicator	1995	2000	2005	changes 95-05	2004
Empty running kilometres (%)	28.6	27.5	26.8	- 6.3 %	12.8
Mean vehicle payload (t)	11.7	11.4	11.3	- 2.7 %	
Fuel consumption (l/100km)	39.8	37.6	35.3	- 11.3 %	
Fuel efficiency (millilitre/tkm)	34	33	31	- 7.9 %	
CO_2 emission efficiency (g CO_2/tkm)	89	87	82	- 7.9 %	92 to 155
Mean length of haul (km per trip)	142	135	124	- 12.7 %	156

Sources: Dft 2006a, Beaumont 2004

Table 1: Key performance indicator and efficiency in UK for articulated trucks >33t

The almost 8% CO_2 efficiency improvement between 1995 and 2005, of the UK truck fleet, is mainly the result of a decrease for vehicle consumption (-11.3%) and for empty running (-6.3%), despite an increase in total distance, a declining load factor, a slight reduction in mean vehicle payload and a strong decline in the mean length of haul (12.7%).

Road freight energy and CO2 efficiency in Germany

Energy and CO_2 impacts of efficiency measures, applied in German road haulage companies, have been surveyed in case studies between 2002 and 2005 (Léonardi, Namur, 2004 and Arcueil, 2005). To tackle the lack of national statistics on fuel use per vehicle type, the surveys also gathered information on vehicle characteristics, performance and fuel consumption on a sample of vehicles from 7.5t to maximum 40t total weight. A new indicator was developed in this survey: the mass-kilometre (mkm = [vehicle tare weight + payload]*vehicle kilometres). The ratio tkm/ mkm gives an indication of the 'efficiency of the vehicle use'; it allows performance measurement with regard to empty running operations, and to the matching of the vehicle size with its payload. A high correlation exists between this efficiency indicator and CO_2 efficiency.

Indicators	Sample n=153	trucks <40t n=44	40t trucks n=109
Mean load factor by weight in % (incl. empty runs)	44.2	43.0	44.7
Mean empty runs in % of the total distance	17.4	20.3	16.3
Mean vehicle payload (t)	10.16	6.06	11.01
Efficiency of vehicle use in tkm/mkm (means)	0.36	0.28	0.40
Mean fuel consumption in l/100 km	31.6	24.9	33.1
CO_2 efficiency in g CO_2 /tkm (means)	96	181	80

Source: NESTOR survey 2003, Léonardi & Baumgartner, 2004

Table 2: Key performance indicators in the German base survey 2003

Road freight energy and CO_2 efficiency in Spain

In Spain, road freight transport utilization, productivity and efficiency, are derived from a study conducted in 1997-2003 using data from the "Encuesta Permanente Transporte de Mercancías por Carretera – EPTMC", (PJ. Pérez-Martínez, *Arcueil, 2005).*

Indicator	*1997*	*2003*	*Annual changes in %*
Fuel efficiency (millilitre/tkm)	30	27	-1.4
Emission efficiency (g CO_2 /tkm)	79.4	73.0	-1.4
Transport content (km/ton)	9.6	8.8	-1.4
Mean transport distance (km)	113.2	104.1	-1.3
Transport efficiency (t/veh)	11.8	11	-1.1

Sources: Pérez-Martínez 2005, SGT 2005, McKinnon 2004

Table 3: Performance indicators and energy data for Spain, 1997 and 2003

The 2003 mean fuel and emission efficiency values are 27 millilitre /tkm and 73 g CO_2/tkm with very few variation from 1997 values: neither technological nor organizational improvement is identified. The different vehicle types show large differences with regard to their respective contributions to transport demand in terms of tonne-km and efficiencies.

Veh. Type and max. payload	Load	Total distance	Empty trips	Performance	Fuel use	Fuel Efficiency	CO_2 Efficiency
	10^3 t	10^6 km	%	10^6 tkm	10^9 litres	l/tkm	gCO_2/tkm
Rigid vehicles	742,206	5174	47	24860	15,523	0.062	165
3,6-7 t	52,816	1343	44	2729	3356	0.123	325
7,1-10 t	115,064	1558	44	5376	4317	0.080	212
10,1-14 t	327,009	1373	49	7444	3803	0.051	135
14,1-18 t	180,284	958	49	6238	2653	0.043	112
18,1-20 t	23,637	42	50	347	126	0.036	96
> 20 t	43,395	269	48	2725	860	0.032	83
Articulated	1,102,040	14,410	46	165,468	43,229	0.026	69
3,6-24 t	411,086	7121	45	76,373	21,363	0.028	74
24,1-26 t	492,578	6197	46	72,305	20,450	0.028	75
>26 t	198,376	1299	49	16,790	4468	0.027	70

Source: Pérez-Martínez 2005, SGT 2003

Table 4: Contribution of different vehicle types to Key Transport Performance Indicators in Spain 2003

Like in other countries, the contribution of articulated trucks is very high in tkm. Nevertheless the efficiency (70 g CO_2 /tkm) of heavy articulated vehicles (over 26 tonnes carrying capacity) appears better than in UK, France and Germany.

Road freight transport and fuel consumption in France

In France, the permanent Survey of Road Goods Transport (Transport Routier de Marchandises - TRM) gives a view into the use and efficiency of French road freight fleet. Its main objective is to quantify road freight traffic of French HDV. Here, the analysis is limited to the years with fuel records.

We first look at the importance of the different types of vehicles in transport activity and energy consumption (structure of fuel consumption in road freight transport). Then, a second step considers the evolution of fuel consumption for the articulated vehicles.

Veh. Type and max. payload	Load	Total distance	Empty trips	Performance	Fuel use	Fuel Efficiency	CO_2 Efficiency
	10^6 t.	10^6 km	%	10^6 tkm	10^9 liters	l/tkm	gCO_2/tkm
Rigid Trucks							
3,6 t - 10,9 t	19	709	25,50%	724	154	0.213	557

11,0 t - 19,0 t	217	4780	23,60%	16,355	1396	0.085	224
19,1 t - 26,0 t	304	1655	36,90%	9709	685	0.071	185
≥26,1 t	146	385	45,50%	2685	186	0.069	182
Total rigid	686	7530	27,80%	29,472	2421	0.082	215
articulated	1374	13,838	23,70%	175,807	5203	0.030	78

Source : MTETM/SESP 2007

Table 5: Performance and fuel consumption in French road freight transport in 2005

Rigid trucks performance indicators are weaker than those for articulated vehicles: 0.082 l/tkm against 0.030 for articulated vehicles and 215 gCO_2/tkm instead of 78. Of course this does not mean that one could substitute small rigid trucks with big tractors and trailers to get a better fuel efficiency. This result of 0.030 l/tkm for articulated vehicles (tractor and trailer) is very similar to the previous results for UK, Spain and Germany. But it is the result of a higher fuel consumption for articulated trucks in France (38.1 l/100km) than in other countries combined with a higher payload: 16.7 tonnes average payload in France, 11.3 in the UK, 11.01 in Germany, 11.0 in Spain (average payload for loaded trips, excluding the empty running). This high value for mean payload in France is difficult to explain.

Indicator	1994	2005	2005/94
Tonne kilometres (millions)	94,538	175,807	86.0%
Millions km	7942	13,838	74.2%
Empty running kilometres (%)	23	23.7	3.0%
Loaded km (millions)	6091	10,554	73.3%
Load (thousands tonnes)	778,937	1,373,916	76.4%
Mean load (t)	15.5	16.7	7.3%
Fuel consumption (l/100km)	38.4	37.6	-2.1%
Total consumption (millions l.)	3050	5203	70.6%
Fuel efficiency (millilitre/tkm)	32.3	29.6	-8.3%
CO_2 emission efficiency (g CO_2/tkm)	84.5	77.5	-8.3%

Sources: MTETM/SESP 2007, TRM survey

Table 6: Evolution of energy and CO_2 efficiency in France for articulated trucks

The large increase in energy consumed per articulated trucks from 1994 to 2005 (+71%) is the result of an increase in transport demand (transport activity: + 81% in tkm) slightly compensated by an improvement in fuel efficiency (l/tkm: -8%). The increase in activities mainly results in more tonnes lifted (+76%), while average distance per tonne only increased by 5%. The improvement in fuel efficiency is the result of average payload per loaded km (+7%) while empty running has increased slightly (+ 3%) compensating for the decrease in fuel consumption per vehicle (- 2%).

Comparison between countries

The comparison of the different road freight transport surveys shows similar results for energy efficiency in the four European countries studied: France, UK, Spain and Germany (around 0.030 l diesel fuel, or 80 grams CO_2 per tkm of road freight transport).

Country	CO_2 efficiency / energy intensity	Sources and comment
UK	82 g CO_2 /tonne-km	DfT2006, Articulated trucks >33t
Germany	80 kg CO_2 /tonne-km	Léonardi and Baumgartner 2004, 40t trucks
Spain	70 kg CO_2 /tonne-km	Pérez-Martínez 2005, SGT 2005 >38 t trucks
France	78 kg CO_2 /tonne-km	TRM, articulated trucks

Table 7 : Comparison of CO_2 efficiency / energy intensity from three European samples

The most efficient mean value is 70 g CO_2 /tkm for heavy articulated trucks in Spain and the least efficient average is 82g CO_2 /tkm in UK. Two groups of underlying causes can explain these differences:

- The survey sample structures might be different amongst countries (fleet characteristics, commodity types, distances, ...);
- The different design of the surveys could be another possible cause for different results, though they have been harmonised by EU.

These harmonised national surveys, when they also collect energy consumption, give a good picture of road freight performances as well as energy and CO2 efficiency. But the link with economic activity is rather weak and there is a need for further research on the design of surveys more related to economic activity and on the comparability of datasets obtained in different countries.

2) The Supply chain approach

Different supply chains, involving more or less transport activity and associated energy consumption, can be used to bring a product to the market. Differences amongst the supply chains can be the origin of their sourcing, the logistical organisation between production and retail and different types of retail outlet. Several products have been analysed to assess and compare the energy efficiency and GHG emissions of their supply chains. The yoghurt produced and sold in France, using nationally sourced milk and carried in refrigerated vehicles. By contrast, jeans are manufactured and sold in a global market where longer travel times are normal and where the main raw material is traded over long distances. The jeans case study investigates cotton sourced from three different locations abroad, used for the jeans sold in France and in UK. Two new products are currently analysed, for which only preliminary results are available: fruits & vegetables on one hand and furniture on the other hand.

The French yogurt supply chains

Yoghurt has a short shelf life and has to be kept chilled. Transport activity is required to move the product from dairy farms producing milk to factories producing yoghurt, then to distribution centres of the yoghurt producers, and further to distribution centres of the third party logistics provider responsible for supplying the yoghurt to retail outlets and finally to retail outlets selling the yoghurt to the final consumer. We also investigated a supply chain with e-commerce and home delivery. Between each location, transport of yoghurt takes place by road using refrigerated goods vehicles, except the last stage from retail outlet to home, which is carried out by the final consumer.

The nine stages in the considered yogurt supply chain are:

1. Collection of milk and other ingredients/raw materials (e.g. packaging)
2. Factory producing yoghurt
3. Transport by the producers to their distribution centres
4. Distribution centre of the producer
5. Transport by the third party logistics provider to its distribution centre
6. Distribution centre of the third party logistics provider
7. Transport to the retail outlet
8. Retail outlet
9. Consumer trip to the retail outlet to purchase yoghurt and carry it back home

Three different retail outlet supply chains have been analysed: hypermarket, supermarket and local shop. The only differences in these supply chains occur at stage 7 (transport to the retail outlet) in which various sizes and weights of goods vehicles are used, and distances to retail outlet differ, and at stage 9 (consumer shopping trip) where consumer trips vary in terms of mode and distance for different types of retail outlet. In the case of the e-commerce supply chain, the organisation is slightly different from that of retail outlets from stage 6 (distribution centre of the third party logistics provider) onwards. The subsequent "stage numbers" in the e-commerce supply chain are as follows:

10. Transport from the third party logistics provider's distribution centre to the e-commerce picking centre
11. E-commerce picking centre, where the customer's goods are picked according to the internet orders received
12. Transport to a local delivery point. The transport to the retail outlet in the 'traditional' retail chain (stage 7) should therefore be compared with the sum of transport stages 10 and 12 in the case of e-commerce
13. Local delivery point from where deliveries to home are achieved
14. Home delivery replacing the consumer shopping trip

The yoghurt factories are supplied with milk through milk collections from farms. If this local supply is insufficient, milk is bought and transported from more distant regions. As a result the average distance for the round trip supply of milk is 354 km. The factory is also supplied with packaging and other ingredients necessary for manufacturing yoghurt (fruit, containers, closures, sugar and cleaning materials). These products come from different regions of France and also from abroad. Delivery to the producer's distribution centre is undertaken with refrigerated articulated lorries each containing 33 euro-pallets. This transport is carried out by third party companies and the transport is assumed to be one way trip since the third party logistics provider will generally not return empty. In terms of the supply to shops, there are two categories of distribution centre – those that supply only hypermarkets and those with are used to supply supermarkets and local shops. Shipments to the hypermarkets are sent by (refrigerated)articulated lorries filled with standard pallets. Those to supermarkets and local stores are sent by smaller refrigerated vehicles filled with roll cages and some pallets.

Four types of chain have been compared; three relate to the various retail outlets (hypermarkets, supermarkets and local shops) and one is for the e–commerce supply chain with home delivery. Figure 1 here under synthesises the transport energy used in each of the legs from farm to retail outlet considered in the three retail outlet supply chains. The e-commerce home delivery chain has been excluded as it does not involve distribution to a retail outlet.

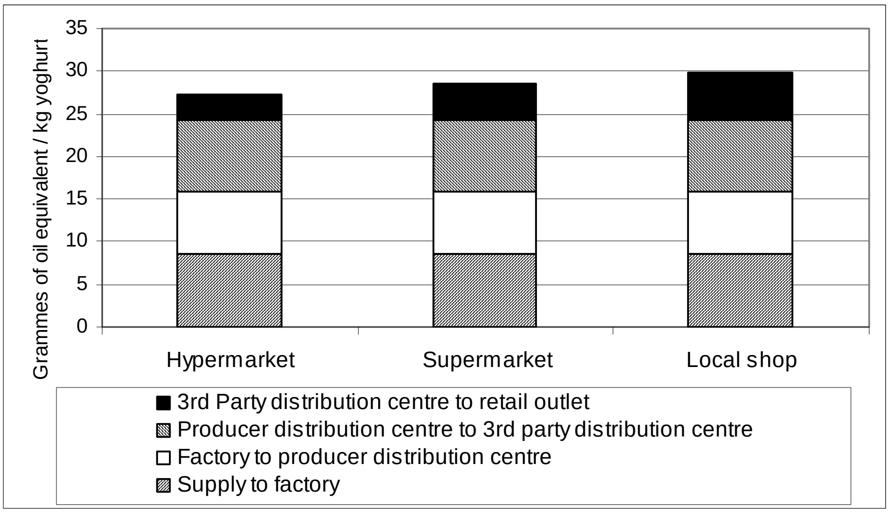


Figure 1: Transport energy consumed from farm to retail outlet in France for yoghurt

The three first transport stages (supply to factory, factory to producer distribution centre, and producer distribution centre to third party logistics provider's distribution centre) are the same for each type of retail outlet. These are responsible for approximately 80-90% of the total commercial transport energy consumed in the supply of yoghurt from farms to retail outlets. The transport leg from third party logistics provider's distribution centre to retail outlets does produce different results for the three types of retail outlet, because of the different sizes/weights of vehicle and total load weights of the deliveries. The consumer shopping trip consumption has been estimated using information from surveys and other published data and compared with the e-commerce and home delivery logistics chain.

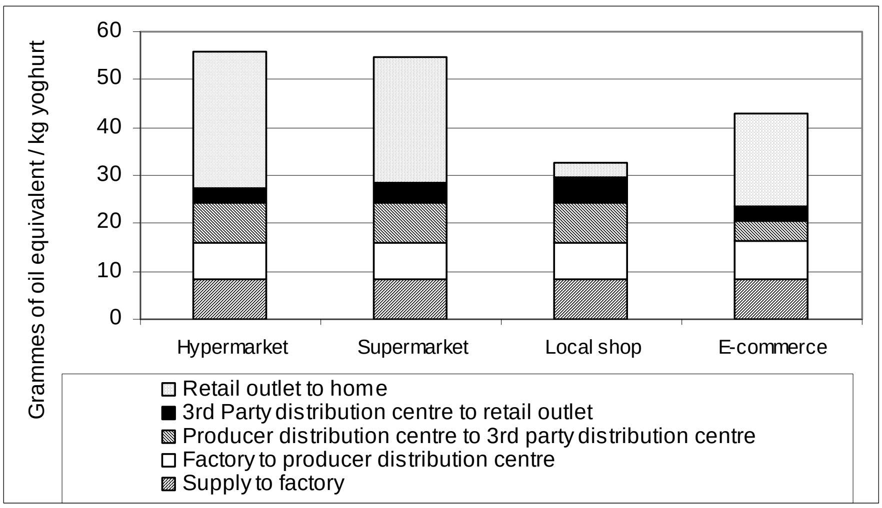


Figure 2: Transport energy consumed from farm to consumer's home for yoghurt in France

In the case of the hypermarket and the supermarket supply chains, the energy used in the consumer shopping trip is very significant and is approximately the same as the total commercial freight transport energy from farm to retail outlet. This is explained by the distance the consumer has to travel, the high level of car use by shoppers, the quantity of goods purchased and the hypothesis that the trip is solely (or mainly) undertaken for food purchasing purpose. By comparison, the energy used in the consumer trip when shopping at a local shop is far less, due to the lower distance from shop to home and a lesser use of cars. The results indicate that e-commerce and home delivery generate a lower total transport energy consumption from farm to home than a consumer shopping at a hypermarket or supermarket.

Clearly the evaluation of total transport energy used in the consumer trip from retail outlet to home (and the e-commerce home deliver) depends on a series of assumptions which will be discussed further.

The supply chains of jeans sold in UK or France

The production of jeans can be broken down into seven main operations: 1) cotton cultivation, 2) spinning and dyeing, 3) fabric manufacture, 4) garment manufacture, 5) importation of jeans to Europe, 6) domestic distribution, and 7) sale at the retail outlet. Transportation typically takes place between each of these operations.

For UK, the supply chain for a relatively basic jeans, sold by a major multiple clothing retailer was analysed. The supply chains analysed for France are for jeans sold in hypermarkets (large general retailers). The analysis includes all transportation stages from the cotton plantation through to the retail outlet, and transport to the consumer's home.

Cotton of jeans supply chains considered for UK is sourced from both the USA and Turkey and the processing factory is located in southeast Turkey, where the cotton is manufactured into denim fabric; spinning, dyeing, weaving and finishing are all carried out at the same site. The rolls of denim fabric are then transported in ISO containers to the garment manufacturing plant, located in Tangiers, Morocco, adjacent to the port. Finished jeans are packed as hanging garments into articulated good vehicles. The journey from Tangiers to the manufacturer's UK distribution centre takes place by road and ferry. It involves a ferry crossing from Tangier to Algeciras in Spain (35 km); a road journey to the Channel port of Cherbourg in France (2,000 km); another ferry crossing to Poole in England (120 km); and a road trip to Wales (280 km). At the manufacturer's distribution centre the garments are unloaded and stored for a short period and then distributed by lorry to the retailer's national distribution centre. From this depot the jeans are distributed to 10 regional distribution centres and sent out to the retail outlets by road.

For the jeans sold in France, two different cotton growing locations were considered: Cotton sourced in India is transported by road near Bombay where it is spun, weaved and dyed. The rolls of denim fabric are then transported by road in articulated good vehicles to a garment manufacturing plant located in Bangladesh, where the jeans are manufactured and washed. Cotton sourced in Uzbekistan is transported to Nagpur (India) for denim production. These rolls of denim are then transported to the same garment manufacturing plant in Dhaka, as described above for the cotton from India, where the jeans are manufactured and finished. From Dhaka, the jeans are packed and transported to a nearby warehouse where they are subject to custom authority checks. They are then packed into containers before being exported via Chittagong, Singapore and Le Havre. There, in a warehouse, where the retailer centralises all its garments, the jeans are unloaded and some are directly reloaded into other vehicles by cross-docking. But most of them are stored for a few days, before being dispatched by lorry to the retailer's hypermarkets all over France.

The total distances of the supply chains are as follows:

French chains with cotton from

India:	23400 km
Uzbekistan:	27200 km

UK chains with cotton from

USA:	18000 km
Turkey:	7600 km

The different types of energies employed along the supply chain are diesel for trucks and trains, bunker fuel oil and marine diesel oil for ships, electricity within shops and logistics platforms, etc. All have been converted in 'grammes of oil equivalent' using 'ad hoc' coefficients. Figure 3 here under compares the energy efficiency of the different supply chains, in goe/kg of jeans.

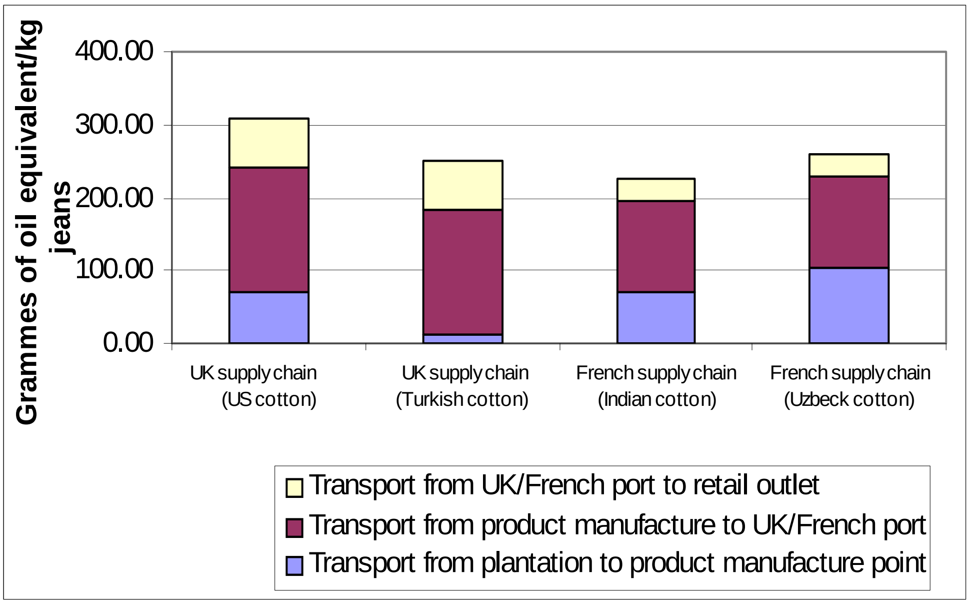


Figure 3: Transport energy consumed from cotton field to retail outlet for jeans

Energy use in consumer transport

The importance of the transport stage carried out by the final consumer in the supply chain, was also studied when it twas achieved by car; consumer trips by bus moped bicycle or walking were considered as negligible. In UK, the journey distance was assumed to be a round trip of 11 km from the consumer's home to the shop and back again. It was assumed that this trip is undertaken for two purposes (i.e. shopping and one other), so only half the total distance travelled is attributed to the shopping trip. The consumer is assumed to purchase 5 kg of goods during this shopping trip. In France the assumptions were drawn according to the type of retail outlet: hypermarket, supermarket, small shop. The distances were respectively 2, 8 and 12 km, the purchase loads 5, 15 and 30 kg. The results suggest that this consumer transport stage uses up to one third of the energy that is consumed in the total commercial transport stages from farm or field to shop. This is due to the very small quantity of goods carried by car compared with the goods carried by lorry and ship. Increasing the quantity of goods carried during the consumer transport stage results in a significant decrease in the energy consumed per kg of product.

Conclusions of the supply chain approach

In the case of the French yoghurt supply chains, the results indicate that each of the three transport stages from farm to third party distribution provider's distribution centre consumes approximately the same proportion of total freight transport energy. The transport stage from retail third party logistics provider's distribution centre to retail outlet uses less energy per kg of yoghurt than these three previous transport stages. However, this stage varies in the proportion of freight transport energy it accounts for, from approximately 10% in the case of the hypermarket to 20% in the case of a local shop. This reflects the importance of goods vehicle type on energy use. Despite the greater energy used to transport yoghurt from the farm to local shops compared with supermarkets and hypermarkets, the analysis shows that when consumer transport is taken in to account, local shops can result in the least transport energy use from farm to home of the three retail outlets studied. This is due to the shorter distances from home to shop and the greater use of non-car modes. Both the jeans and yoghurt case studies have shown the importance of the energy used by consumers transporting their products to their homes by car. Depending on the quantity of goods transported and the trip distance attributable to shopping, this can be equivalent to the total commercial transport energy used in the supply chain from farm/field to retail outlet (per kg of jeans transported).

The results of the jeans case study indicate that the transport stages from the product manufacture to European port are responsible for the greatest proportion in the supply chain.of transport energy use per kg of jeans Transport from the European port to the store accounts for between one-quarter and one-fifth of the total commercial transport energy used in the supply chain, depending on the location where cotton is growing. The results also show that far greater quantities of energy are used in transport from farm/field to retail outlet for jeans than for yoghurts. This is primarily explained by the distances involved in the respective supply chains.

In the future, an increasing number of producers, retailers and third party logistics providers are likely to need carrying out energy assessments like the ones presented here. This is due to the increasing sensitivity about climate change and carbon emissions. Some companies are beginning to adopt such approaches as part of their Corporate Social Responsibility agenda. The presented study has been helpful in illustrating that the assessment approach developed is useful in comparing the energy use implications of different supply chains and different strategies within any particular chain. It can readily be used to consider options such as sourcing and distribution centre locations, number of stockholding points in the chain, transport modes, road freight vehicle types and weights, vehicle load factors, empty running, and transport distance and load weight to the consumer's home.

3) The modelling approach

Freight transport modelling is a broad headline. Through various models presented in the COST 355 meetings, we tried to clarify this issue of energy consumed in freight transport.

A typology of freight models

A usual freight transport model consists of several steps or related sub-models, such as *Generation*, which deals with decisions about the location and quantities of the production per type of products, *Spatial distribution of trade* which analyses the relation between production and consumption locations, *Logistics at firm level*, which simulates the use and the location of inventories and supply chain management, *Mode and route choice*, *Transport logistics,* which undertakes the use of the vehicles (load factors, empty running), *Networks and assignment* which allocates the vehicles onto the physical networks, and finally, *Energy and environmental* consequences which matches the transport indicators with energy or environment factors. The focus of such models is at traffic level (vehicle km, tons, vehicles) and the related energy consumption is only directly included in a few cases. Not all models contain all the seven parts and there are many models which focus on a subset of the seven parts or even on a single part.

There are other approaches than the above described model-sketch, which can as well be of interest in relation to energy use. Two general modelling approaches are widely used to describe the first two layers of the conceptual model outlined above (generation & spatial distribution). One approach is to use the national accounting system in e.g. input-output based modelling. The national accounts contain information about the (transport) energy used by other industries and also in some cases by private households. They also have included specific transport industries components, which (in economic terms) describe the level of activity and demand by other industries. This information can be used in models predicting changes in energy use. Another approach is the *Spatial Computable General Equilibrium* models. These models are economic descriptions of trade between regions and among different industries. They further include demand for transport and/or transport energy often as a separate industry component. These models do not provide transport figures in the traditional sense (tons, tkm, vehicle km etc.), they do not calculate the physical energy consumed. Everything is measured in economic figures. However, the models can give insight in changes on freight transport and energy consumption in an economic consistent way, which is important when the wider effects of freight transport are assessed.

In this synthesis, we shall consider two types of models: Urban goods movement models presented mainly on French towns, and inter-urban models (regional, national & international), more developed than the previous one and mainly presented by our Danish members.

Freight transport and energy consumption are not always related to each other in the models. The models often calculate only the level of traffic, in vehicle km, and do not include a specific calculation of the related energy consumption. The development of freight transport is a good indicator for energy consumption, but the trends can obviously be decoupled by changes in vehicle choice, route choice or technical changes. A dedicated model for energy consumption should include such elements. WG1 mentioned the difficulties to have an accurate knowledge of the different types of used trucks (LGV, HGV), their age etc. For example, Freturb (French urban freight transport model) calculates the energy consumption for 6 types of vehicles (LGV, HGV) according to the breakdown of the vehicles gross weight.

Inter-urban freight models

A direct approach to investigate the drivers of freight flows or energy consumption is an aggregate version of the traditional freight transport models described above. This modelling approach has been used by O. Kveiborg (Arcueil, 2005) to analyse the decoupling of the historical growth in national Danish freight traffic (in vehicle kilometres) from economic growth (GDP or similar measures). This model estimates freight transport/freight traffic and energy use through industrial and commodity differentiation, value densities, handling factors, average weight and average trip length, using a decomposition method. The presentation demonstrated that overall freight traffic growth is a consequence of often opposite pointing growth effects in the underlying factors. The observed increasing decoupling of freight traffic growth from economic growth is mainly the result of using larger vehicles, increasing average loads, and less empty running. Growth in freight transport is primarily caused by growth in production. A decrease in the growth of tons lifted per ton produced (the handling factor) is offset by an increase in the ton kilometres per ton lifted. Kveiborg (Torino, 2007) addressed a specific issue influencing the decoupling problem – namely the empty trips and how these could be modelled.

The international freight flows have also been a particular model focus in WG1. Again focus was on the main driver for changes as exemplified in the presentation by Kveiborg and Vincent (DTF, DK) *The future flow of goods in the enlarged EU* (Berlin, 2005). In monetary terms the trade flows are well understood and related data are maintained in several different databases. The real problem is in the data concerning the transport performance and the modelling of transport. Many simplifying assumptions have to be made to link economic trade to movement of goods. One particular issue is the conversion of economic trade to physical amounts. This can be done through international trade statistics. However, there is often no link between the real origin of trade flows and transport. An example is Denmark importing most of its bananas from Germany and the Netherlands. This is because, in economic terms, the trade statistics is accounted for Germany, but obviously the international trade is with e.g. Brazil.

To analyse diesel oil price impact on freight transport, Hemery and Rizet (Torino, 2007) estimated the elasticity of road freight traffic to diesel price in France. Using log log models (constant elasticity over time), they found nearly the same elasticities for H&R, own account and total demand in vehicle km (-0.25, -0.26, -0.24) but rather high differences in TKM: when the diesel price increases; own account road freight demand, expressed in tkm decreases more than H&R, which means that H&R recovers a part of own account road freight share, mainly by increasing vehicle loads. The 'non logarithmic' models show an increase in vehicle km elasticities to diesel fuel price over time and this evolution is quite similar for OA and H&R.

A particular problem in freight transport is the utilisation of vehicles. This influences the link between transport (tkm) and traffic (vehicle km) since more vehicles are required if utilisation is lower. In relation to modelling, the load factor is widely used, but the topic of empty running has not been as much studied despite its evident relevance for energy consumption. O. Kveiborg, analysing the different methods for estimating empty running (Torino, 2007), showed that relatively simple methods give a rather good result compared to more complex models involving trip chains. The model test results also highlighted a need for further data analysis and modelling efforts in order to take appropriate concern of this subject in freight transport models.

A urban freight model: Freturb

In “An environmental balance from urban freight transport studies” JL Routhier (Arcueil, 2005), on the basis of thorough urban freight drivers surveys, computed the following indicators: number of deliveries and pick-ups generated by the different industries (economic sectors), number of veh.km generated by the different types of transport organisations (own account/ third party), size of vehicles, speed average, and, at a micro-level : engine specification, acceleration, slope of the roads, CO2 emission per day in a town, per inhabitant, per job. It was thus possible to measure the weight of each economic agent and the weight of each type of vehicle in the energy consumption for goods transport inside the city. A more recent approach was to build models in the same way as a data collection method. The French urban freight model FRETURB (Berlin, 2005) has been developed as a land use and tour-based model of urban goods transport. It consists of three modules which interact with each other: a "pick-up and delivery model" including commodity flows between all the economic activities of a town; a "town management module", consisting of transport of goods and raw material for public and building works, urban networks (sewers, water, phone), and removals; a "purchasing trips model", modelling shopping trips by car, which represents the consumer trips. The model is based on extensive data collecting and survey activities. The pick-up and delivery model is a regression-based model fed by thorough coupled 4,500 establishments and 2,200 drivers surveys carried out in three different sized towns. Those surveys brought to light relevant relationships between the behaviour of the shippers (spatial and economic data) and the behaviour of the hauliers (operations of transport). The modelled data is the movement (defined as a delivery or a pick-up associated to a given establishment, a given vehicle size, a mode of management and a logistic behaviour). It is derived from the empirical survey data after statistical validation. The Freturb model is widely using accurate rules and laws on logistical behaviour of the different stakeholders of urban goods movement proved by appropriate surveys. It works with numerous and homogeneous industry categories permitting a thorough description of the urban logistics in a French town. It requires a local establishments database but no large local surveys. The further improvements allow a distribution of the traffic from zone to zone through a probabilistic method. It is then possible to calculate the environmental (emission of greenhouse gas and pollution) impacts of the urban goods transport and its energy consumption at an urban level. Freturb model is also a simulation tool (Routhier, Berlin, 2005). On the example of the city of Lyon, some improvements of goods transportation in a metropolitan area were simulated through calculation of different scenarios for infrastructure investments and the model quantifies the consequences of these case studies on the traffic flows in 2020. It appears that energy savings and traffic optimisation are resulting from relocating activities to the city centre and moving the location of trade and distribution centres more closely to the customers, showing that it is possible to measure the impact of diverse land use policies at the urban level on freight transport and its energy consumption..

Main gaps in freight and energy modelling

The connection among the various scales of modelling is an important issue. In order to have a good assessment of energy consumption, it is necessary to take into account the whole transport activity. Different models are necessary, each focusing at a specific scale. There is a gap between the local policy objectives and the global policy concerns. The O/D matrix is difficult to calculate at a local scale: goods O/D differ from vehicles O/D and available data are often not modelling oriented. For example, commodity flow surveys are not well suited for the vehicle flows modelling. Therefore there is no doubt that freight data collection should be improved.

<u>On urban freight models</u>: In order to make possible a good appraisal of the impacts of policy measures on the urban logistics, the models should identify the "good" input variables (location of firms, warehouses and consumers, logistical choices (management, vehicles, packing, tracking …), consumer behaviours (home deliveries, e-commerce, …)), simulate the interactions between the needs for goods delivering from various industry (activity) sectors and transport operating, simulate the interaction of commercial transport system with land use system, and also with individual trips for purchase. The scenarios of delivering goods have to consider land use effects (location and dimension of establishments, urban density, urban sprawl, specialised or mixed areas), vehicles effects (clean urban vehicles, impacts according to their use), modal split effects, and regulation effects (harmonisation of rules, traffic calming, low emission zones, road pricing).

<u>On the harmonisation of models between countries</u>: Same indicators or parameters are differently defined and therefore cover different realities. Data sources are often very dissimilar from one country to another : the observation unit can be the vehicle, the good, the shipment or the operation (of delivery or pick-up). The time windows on which the indicators are calculated are often different (peak periods, day of activity, season, year). The disaggregation of the different types of vehicles is often different from one case to another.

<u>On the lack of data</u>: Freight transport modelling is achieved at a much simpler level than person transport models. Techniques are not as developed even though many of the approaches applied in passenger modelling can be converted to freight transport modelling. But often this transfer is not possible since freight related data are not as detailed and rich as data on passenger transport. The main challenge for modelling energy consumption from freight transport is the lack of data on actual transport performance (vehicle kilometres, ton kilometres) at appropriate detailed level. The problem is that the entity demanding transport and the one performing the transport are not directly linked. It is thus difficult to associate the reason for a trip to an actual trip. Logistic activities are the crucial central points in freight transport and resulting energy consumption. These are the links between transport demand (economic activities) and actually performed transport. Unfortunately, knowledge of this stage is limited and there are only few model approaches focusing on this leg of the supply cahin. Moreover existing models are not deeply detailed and miss the technical aspects of these logistic activities.

Hence WG1 recommends developing and harmonising data collection. Freight surveys should be developed simultaneously with models, for improving the integration of the various model scopes and for harmonising the space and time units. Such improvements would allow enlightening the different scenarios and solutions towards the sustainability. They would also allow listing and analysing the main exogenous and endogenous input variables in order to improve the models efficiency for predicting energy consumption (models policy oriented).

4) Last mile approach

In towns, the supplying of all households and premises concerning industrial, commercial and services activities can be considered as the last leg of logistic chains. The last leg of the logistic chains differs from the upstream legs because of the urban constraints: deliveries on the last mile, in urban area, are more expensive, because of waste of time in traffic jams and in parking, and they are also more energy consuming. This situation has undoubtedly an impact on road occupancy, CO_2 and pollutant emissions and security problems. Moreover the urban freight transport conflicts with individual cars and public transport, what makes it unpopular. Both public and private actors have been involved in various improvements; the common objective being the consolidation of goods flows in order to optimise the last miles and to decrease the impact of delivery vehicles in the city.

The last mile is a sector of high performance logistics with relevant contribution to the GDP. Particular problems of the last mile are its large contribution to the cost of the entire transport chain (B2B 35-50%, B2C 50-75% / 71-84%), the narrow time windows for deliveries, the varying structures of dispatchers and recipients (B2B, B2C, C2C) and the increasing requirements of customers (e.g. higher frequencies before 9 am and after 16 pm). The last mile is more costly because of numerous difficulties to deliver in urban area (restrictive regulation, requirement of different actors, congestion…). It causes 25 % of energy consumption and CO_2 emission of urban transport.

However, the last mile is quite difficult to manage since it results of different actors' behaviour. Last decade, many fast changes have been observed concerning:

- the industrial supply chain of which the last mile is the last leg;
- the households behaviour (purchasing);
- the development of e-commerce and more generally of new technologies of information and communication.

Large surveys carried out by LET in the framework of UGM national French programme reveal (Patier, Piraeus, 2006) the following interesting figures.

1. 39 % of urban freight transport are caused by exchanges between economical establishments, 51 % by particular for their purchasing and 10 % for urban managing (post, hospital, waste collection…).
2. Urban freight transport contributes to 9 to 15 % of vehicles movements, 13 to 20 % of vehicles*km. and 15 to 25 % of car unit vehicles*km.
3. There is a strong link between the density of activities and the amount of deliveries and pick ups, the same being true for densities of employment and amount of goods movements.
4. Hourly rhythms for deliveries/pick ups and individual trips as observed in Bordeaux area show that the peaks occur between 9 and 11 am for the goods with a "hyper peak" at 10 am (opening hour of the shops) and two peaks for the individual trips between 7 and 9 am and between 4 and 7 pm. The partial overlap between these different peaks causes the congestion.
5. Air photos realised from 9 to 11 am during an ordinary day in Bordeaux show moving or parked vehicles: 3/4 of the buses and 1/3 of the heavy trucks are moving whilst about 80% of individual cars are parked.
6. In the urban traffic of Bordeaux, private cars account for 75 % of the vehicle*km, 64 % of the ton equivalent oil consumed and the same part of ton CO_2 emitted. The part of the transit is low. But while the traffic of trucks is 4 % of the vehicle*km, it causes 10% of energy consumption and CO_2 emissions. The total urban freight transport is responsible of 14% of vehicles*km, 19 % of energy consumption and 21 % of CO_2 emissions.

For a better managing of the last miles, many solutions were experimented. Mostly, they concern the delivery places, the logistic organisation (urban logistic spaces), the type of used vehicles, the last platforms (i.e. the location from where the last miles is delivered), the deliveries scheduling, the possible regulations in cities. In some cases, new operators are involved or new technologies are used. Many European countries are involved in large programmes aiming at improving the urban logistics. Various experiments have been implemented, all experiments aiming at decreasing the impact of delivery vehicles in the city, leading to consolidate goods flows. Many of them tested UDC (Urban Distribution Centre) as the best practice. Recently many others experiments appear, more adapted to local needs.

The European project START(Hapgood, Prague, 2006) is such an experiment. Admitting that efficient goods distribution is crucial for the vitality of centres of European cities and that inefficient goods distribution causes emissions and pollution and is not cost effective, five cities (Göteborg, Bristol, Ravenna, Riga, Ljubljana) are involved together in the Intelligent Energy Europe Programme. The project "START" (Short Term Actions to Reorganize Transport of goods) wants to promote sustainable energy use in transport. The followed approach is based on close collaboration between public and private partners and on combining positive incentives, more coercive regulations and enhanced logistics. An initial six month trial in a test site in Bristol was free of charge for participating retailers. This trial phase has been assessed on the basis of consolidation benefits, stakeholder acceptance and retailer satisfaction. 53 retail outlets were receiving consolidated deliveries and 21 retailers were making contributions. Delivery vehicle movements have been reduced by over 70% for participating retailers. 96,681vehicle kilometres have been saved as well as 11.3 tonnes CO_2, 1.75 tonnes N_{ox} and 243 kg PM_{10} emissions. 5.7 tonnes of cardboard/plastic have been collected and recycled. The consolidation centre is located on western fringe of Bristol in an established business park and operates using 7.5 and 17 tonne vehicles. A satisfaction survey showed that 75% of all retailers interviewed chose the consolidation scheme because of the improved service and of the cost reduction opportunities. More than half of the retailers were saving over 20 minutes per delivery. 45% of the retailers said that their staffs were less stressed and 38% of them said they could spend more time with their customers.

A comparison between Paris and London strategies concerning decreasing of congestion, consumption energy and CO_2 emissions has also been presented (Mahmoud Atlassy, Piraeus, 2006). In London, the Mayor's Transport Strategy (2001): ensured efficiency and reliability of freight distribution, minimised the adverse environmental impact of freight transport and servicing as well as the impact of congestion and fostered the shift of freight from road to more sustainable modes. In Paris, the Master Plan (2002) optimised the distribution of goods, favoured modal shift from road towards rail and waterways and aim at controlling the harmful effects generated by urban freight. Different actions were undertaken by both cities to fill these objectives. In London, the Congestion Charge has been introduced in February 2003 (£8 daily charge). This toll is active between 7am and 6.30 pm, from Monday to Friday, excluding public holidays. The impacts of this measure have been assessed: reduction of the congestion inside the charging zone by 30%, 12 % reduction for the emissions of key traffic pollutants. Moreover impacts in the boundary area just outside of the charging zone are largely neutral. London lorry control scheme exists since 1986: Roads within 33 Boroughs of London are restricted for lorries over 18 tones maximum gross weight or on three axles or more, at night time and weekends. However road haulage companies with essential business in the controlled road network may obtain permits to operate heavy vehicles on these roads during controlled hours, provided that they are able to satisfy certain conditions. In Paris, the new regulation rules have as main objectives to harmonize already existing regulations and to elaborate a charter signed by all carriers' unions in order to agree on good practices for delivering in the city. Other experiments were (and still are) conducted in Paris for optimising the deliveries inside the city. We can mention consolidation centres like the ones exploited at Saint-Germain l'Auxerrois by "la petite Reine", private experiment for delivering the last mile by electric tricycles or the Consignity network (deliveries in lockers with real time follow up of deliveries for maintenance services , etc. Numerous other experiments have also been supported by Paris authorities for testing clean delivery vehicles. For example, new concepts as Compressed Natural Gas (CNG) vehicles or electric vehicles like electric handcarts or electric delivery tricycles.

Another approach was undertaken in a programme funded by French Ministry of Transport and ADEME (French Energy Institute) aiming at elaborating a typology of Logistic Urban Space (Patier, Prague, 2006). The main types of these spaces are defined as follows.

ZLU (Urban Logistics Zones) concern the whole city area. This space could be a railway station, a river port, or a specialised activity zone. A case study was presented. This example concerned one of the large French distribution groups. The objective was to deliver beverage and general products for house and individuals to 60 supermarkets in Paris. The former organisation scheme relied on 2 warehouses, located respectively about 30 and 40 km far from Paris. Upstream logistic chains involved waterway followed by trucks for the general products, railways followed by truck for beverage. According to the former logistic organisation, diesel trucks delivered the 60 supermarkets every day, with an empty return. These trucks used 210 000 litres of fuel per year. The new organisation implied that a new leg has to be inserted between the warehouse and a new urban platform located at a railways station in Paris. The upstream logistic chain and last miles delivery organisation did not change. The transport from the warehouse to the new urban platform was provided by freight train with 20 wagons per day on the RER subway line; during the off peak period. GNV (natural gas vehicle) trucks (29 m^2) will deliver the last km, from the urban platform to supermarkets. The achieved evaluation showed that ZLU using and railways transport would lead to save about 800 000 vehicles*km per year in Paris area, and about 235 tonnes of CO_2 (without taking into account the last mile transfer to planned GNV non-polluting vehicle) and 17 tonnes of NOx.

UDC (Urban Distribution Centres) are dedicated to urban area or part of cities (e.g. historical centres). The underlying goals are twofold: environmental and economical: decreasing the environmental damage caused by freight transport activities in cities and decreasing the amount of vehicles* km by consolidating freight. The Monaco UDC was set up in1989, with economical and organisational objectives, while La Rochelle UDC, set up in 2001, was mainly environmental. These two experiments have been evaluated and the results show a better performance in La Rochelle with regard to energy consumption and pollutant emission (61% saving), but a lower result with regard to urban congestion (33% increasing). This problem is related to the choice of electric vehicles: in France the 3.5 T. electric vehicles are not accredited, therefore, the size of the used electric vehicle was not very adapted for the rounds (parcels and palettes). That means a larger amount of rounds and thus a bigger urban congestion. Today the objective is to couple the environmental impacts of electric energy with the logistic efficiency of a larger commercial vehicle. In Monaco, the main aim was to optimise the rounds and decrease the number of vehicles. Hence the choice was using 3.5 and 7.5 T. heat engine vehicles It is worthwhile to observe that the logistic system exhibits a higher performance even if no improvement was achieved regarding the propulsion system of vehicles. Such a result proves that improvements regarding the organisational scheme are more powerful than ones related to technical issues.

VRP (Vehicle Reception Point) is an innovated facilitating system. It is intended to receive incoming goods before the last mile, in city centre. The first such space was initiated in Bordeaux in 2003. VRP is a dedicated parking place which is watched and where deliverymen find someone who will accompany them on foot, with handling equipment, to deliver the parcels on the last mile. A quantitative survey has been carried out in situations with or without VRP: A face to face survey with the deliverymen permitted to follows some indicators: number of stops, time saving, energy consumption, accessibility and congestion effects. During this interview, the drivers described the round they realised before the VRP setting (itinerary, number of stops, number of deliveries and parcels by stop…) and then how they behaved after the setting up of the VRP. A qualitative survey also revealed that shopkeepers, delivery-men, and carriers were very satisfied. For carriers such a experiment could impact the whole logistic organisation and not only what happens on the last mile, but this has not been yet evaluated. The environmental impacts have been measured as 1.44 vehicle*km saving per stop and a consumption reduction of 260 gep/stop.

ULB (Urban Logistic Boxes) enable deliveries in the absence of the receiver. Parcels are delivered in lockers, settled in secured premises. This concept is particularly adapted for the e-retailing and for the after-sales services. In Paris, the concept of ULB (the "Consignity") was settled for after-sales services, with three main aims: a share of the supplying flows in the rounds, a flows management with shifted schedules and the deposit of parcels in lockers, in secured premises. This innovation, sponsored by French authorities (ANVAR, PREDIT, ADEME) and European Social Fund, won the "sustainable development" innovation award in 2006. Such a concept is used for mail order sailing, for postal distribution etc. in Germany and other European countries. The success of this Consignity model is related to the amount of logistic boxes to be spread in the whole city. But the principal problem is to find a suitable location with cheap logistic costs so that a complete meshwork of the city could be achieved.

A last approach is to consider the shop as connection between upstream logistic chain and last miles to consumers (Cornelis, Arcueil, 2005 and Patier, Namur, 2004). The shop is the intermediate link between the production system and the consumer. It is strongly under pressure of the upstream (manufacturer, wholesaler, and logistician) and the downstream (purchaser) and must deals with urban logistics constraints, regulations, town planning environment… It is a breaking point in the logistics practice, the place where the control of this organisational system is lost.. In the upstream, we are faced with an integrated system but in the downstream we have to deal with a scattered system, often unknown. The supply chain management stops at the shop delivery. The last mile is left out. Therefore the shop is the crossing point of two logics, often dissimilar: the one from the production process and the one from households' behaviour.

Nevertheless the commercial supply and the households' behaviour can have impact on environment. The density, the type of shops, their accessibility, the public transport network are strong factors which have an influence on the consumer's behaviour. As example, the Beauvais consulting surveys show that the car traffic generated by a suburbs hypermarket is 4 times the one generated by a local supermarket (for the same shopping basket). The average distance for purchasing in an hypermarket rather than in a supermarket is 6 to 7 km longer according to the area density. In a low dense area, the rate of car use is very high (68% for the supermarket and 85% for the hypermarket). These analyses show that the type of retail outlet impacts the consumers' behaviour and the impact on environment is undoubtedly linked to the amount of vehicles-km they cause.

The last miles management is also confronted with the development of e-commerce and therefore needs new solutions for undertaking the related new forms of urban freight transport.. New organizations are necessary for improving planning conditions when the customer indicates a favorite delivery address and/or a favorite delivery time, offering [billable] delivery within narrow time windows, temporary special delivery services (e.g. bol & Boes Logistik for book deliveries during Christmas time) or delivery at 24/7 facilities. New delivery options are "shop-in-shop" systems, automated systems (Tower24) or boxes and lockers ("packstation" of DHL). Main aims of such new systems are reducing energy use by making freight vehicle movements in cities more energy efficient; But the question remains : is e-commerce good for the planet (Gascon, Turin, 2007) ? Many studies have been carried out about this new form of commerce. Only some of them deal with the environmental impacts. LET carried out a specific survey which revealed that, for consumers' goods, the organisation of large distribution rounds is more efficient than the individual trips for purchasing. The main reason for Internet shopping is time saving. Nevertheless, nobody is up to now able to know exactly if the households substitute this time with staying at home or going out for doing another activity implying car use. OECD announces that e-commerce globally increases the amount of trips. Whilst a Dutch newspaper reveals that e-commerce multiplies by 3 the amount of individual trips, Telemarket announces that e-commerce saves energy, time and reduces car congestion and CO_2 emissions (these would be divided by 8).

Conclusion on the last mile experiments

All these experiments contribute to improvement on urban traffic, congestion, energy consumption and emissions. Each experiment has to integrate a follow up with analysis of essential ratios. These assessments should deal with all the economic, social and environmental factors. And the units, ratios, and methodologies should be harmonised, to enable comparisons. It is important to know the part of the improvement due to the used techniques (electric vehicle, Chronocity) and the part due to the new organisation schemes. For example, in the Chronopost case, the evaluation showed that the new logistic management is more important that the type of used vehicle.

5) WG1 conclusions on freight and energy

Freight transport has been worldwide a key factor in economic prosperity and it is likely that it will continue growing to meet the growing transport needs. However, in most countries, the transport sector is a significant contributor to energy consumption and GHG emissions, representing 23% of CO_2 worldwide emissions from fossil fuel combustion in 2005. The sector as a whole is also exceedingly vulnerable to oil production: since it is 98% dependent on this energy. Therefore our countries will have to envisage a significant behavioural change in transport sector and especially in freight transport to account for shortage in oil and for climate change.

The benefits of freight transport to the society are not a direct function of energy consumed; in many instances it is possible to offer the same transport service with lower levels of traffic and energy consumption. There are significant reservoirs of energy efficiency that might allow economies to enjoy the same level of transport performance with lower overall levels of energy use or kilometres travelled. However, the difficulties in decoupling transport volume, energy use and emissions from GDP indicate that current approaches have not been sufficient to exploit these opportunities.

There is a clear need for better tracking and monitoring in freight transport-sector especially regarding energy performance across modes and across countries. Such measures are not only important for allowing countries which wish to adopt transport-specific GHG reduction tomonitor their performance, but also for a better assessment of impact and costs of measures. WG1 followed different approaches for this monitoring of freight transport-sector energy performance.

- The vehicle approach has been largely described in the literature, either to compare different modes or vehicles average consumption, or to analyse the changes in consumption according to the conditions of use of the vehicles. This approach leads either to develop technology options having the potential to improve the fuel efficiency and emissions characteristics of trucks or to intensify the use of vehicles. Its main limit is the difficulty to link vehicles activity to economy.

- Transport energy consumption does not only depend on the vehicle performance: the organization of the logistical chain (i.e. the succession of firms which supply raw materials, parts, assembly and distribution to the consumer) is also important. This supply chain approach is aimed at the manufacturing and distribution system and is intended to reveal the importance of energy intensity per product in the system of production, distribution and consumption. It may lead to measures on supply chain organisations but also to information provided to the consumers on the energy consumed for each product, so that the consumers who want to do something for the environment can account for energy intensity among their purchase choice criteria.
- The monitoring of the last mile of the supply chain is important and difficult because it results of different actors' behaviour (households, operators and public authorities). During the last decade, many organisational changes have been observed concerning the infrastructure and the vehicles which contributed to changing behaviours.
- The modelling approach gives a broader view of energy consumed within a town, a country or in international relations. It is necessary to asses (ex ante or ex post) the impact of different policy measures on energy consumption. These models, as well as the data needed to feed them, should be harmonised between European countries.

WP 2 The Automobile

Akli Berri, Bastian Chlond, Linda Christensen, Joyce Dargay, Jacek Malasek, Peter Ottmann

1 Introduction

Over the past 50 years, Western European countries have experienced a continuous growth in car ownership. While a car was a luxury good possible only for the privileged few following Word War II, it has since become a necessity, affordable to the majority of the population. In the many Western European countries, more than every second resident possesses a vehicle. In the EU15, there were on average 40 cars per 100 inhabitants 1994, while a decade later this had increased to 48, an increase or 20%. The picture is rather different in the newer member states. In 1994, there were on average 24 cars per 100 inhabitants; by 2004 this had increased 34, a growth rate of 41% (EUROSTAT). Although still lagging far behind, at current growth rates car ownership in these countries can be expected to reach Western European levels in the next decade.

The European Community Household Panel (ECHP), which covers 15 Western European countries and Greece, shows that car ownership levels are converging in these EU countries: in 1994 the percentage of households with access to a car varied from 49.9% in Portugal to 81.8% in Italy, a difference of 32 percentage points. By 2001, the difference was reduced to 23 percentage points: from 62.6% in Greece to 85.6% in France. In general, growth has been strongest in those counties with the lowest initial car ownership levels, with only marginal increases for countries with the high ownership levels, suggesting that the wealthier countries may be approaching saturation.

However, car availability in each country is often still very unequally distributed among households with different incomes. The difference amongst countries is most apparent in the lowest income quintile: in 1994 car availability ranged from 26% in Portugal to 72% in Luxembourg, while the range in the highest income quintile was from 81% in Greece to 96% in Luxembourg. By 2001 car availability had increased in most countries for both income groups. In the highest income group, over 90% of households had access to a car in the majority of countries, while in the lowest quintile, access to a car was still lowest in Portugal, but had increased to 32%.

The car has become the dominant mode of transport in most countries, and car ownership and use continues to increase. As a result, the problem of traffic congestion and local air and noise pollution has become widespread, particularly in the larger cities. The share of transport in total energy demand and in greenhouse gas emissions is growing, and the car is the major contributor. Because of this, any discussion of energy use, greenhouse gases emissions or sustainability must always address car use as well.

The European Union has experienced major changes within the last few years, particularly through the integration of less-wealthy new member states from central Europe. The high economic growth of these countries has increased their demand for transport and particularly for cars. In general, these countries are undergoing similar economic and social transformations as experienced in Western Europe some decades ago. The enlarged EU domestic market has led to new transport networks, and to an extended demand for both business and private trips. Although policy measures on the European, national and regional levels have been introduced to cope with the new situation, the economic and social changes of the early 21st century as well as a common market that unites several cultures and different economies are unprecedented challenges for transport planners and politicians.

Car ownership in Western Europe has closely followed the development in the U.S., albeit a few decades later. In Central and Eastern Europe, a similar process began in the 80s, with their transition to market economies. Today in the U.S. there are more cars than driving licence holders, and even in 1995, 14% of households had more cars than driving licences. This phenomenon can be explained by an increased specialisation in the use of each vehicle. Even those European countries with a high rate of motorization are still far from American figures, and households with more cars than adult members are still quite rare. However, in many Western European countries, two cars have become the norm for households with more than one member, and even three or four vehicles are no rare exception for larger families.

But at the same time, people are becoming increasingly aware of the negative externalities generated by the car. Recently, the issue of global warming has come to the fore, but other externalities are also of concern, for example the economic and time costs of congestion, traffic accidents, and problems of noise and particulate matter pollution. As a result, several questions have arisen. To what degree will the North-American situation be replicated in Europe, in spite of a notably different spatial structure, a better public transport system and a much higher over-all population density? Can increased demand for car travel be accommodated, and if not, what measures will be required to limit car use and car ownership? How will it be possible to reconcile the automobile and sustainable development? What measures have been proven successful in changing behaviour and attitudes towards more sustainable travel patterns? Can expected developments be changed? Are planners and politicians able to do so? What effects are to be expected when the framework conditions within the European Union converge? What can member states learn from the experiences of other member states? These questions are highly important for the future quality of life in a united Europe.

These issues were addressed within the framework of WG2. In presentations and discussions, the participants had the opportunity to exchange experience and to compare different policy frameworks and analytical approaches. Scientists from EU member states, as well as Switzerland, Norway and Canada contributed to discussions on the state of the art with respect to data collection, car ownership and use planning and forecasting and the ability to influence demand using various policy measures. The group was highly multidisciplinary, being composed of economists, sociologists, psychologists, engineers, urban planners, geographers and statisticians. The group members were also diverse professionally with representatives from academia, government agencies and private companies.

In the following sections, the issues mentioned above are discussed with reference to the presentations made in WG2. Section 2 addresses the role of the automobile, the utility of car travel and car dependency, and illustrates the usefulness of panel data in exploring changes in car ownership and use over time on the individual household level. Section 3 concerns the specific issue of the car and mobility in urban areas: the problems encountered and possible solutions. Directly linked to the issue of car dependency and urban mobility is the issue of land use planning, which is discussed in Section 4. The possibility of changing travel behaviour is addressed in Section 5, which reviews a number of studies analysing the effects of policy measures. The use of price related policy measures will, of course, not affect all individuals equally. The consequences for equity are discussed in Section 6. Finally, Section 7 addresses the question of whether car use is compatible be sustainable transport.

2 The role of the automobile

2.1 Utility of cars and car dependence

A central task of WG 2 was to give statistical descriptions of the motorisation processes in the different member states and to try to understand the factors explaining the differences amongst countries. In many European countries, both of these are very high, so the question of saturation is becoming more and more relevant. Data from some European countries (e.g. France, Germany) show that the share of car in household travel is stagnating or even shrinking. There are different factors or processes at play. For example, because of congestion, average car travel speeds are not increasing, and in many instances are even falling, while with other modes, travel has become quicker. Because of this the comparative utility of car travel is diminishing. It was shown by Chlond and Kuhnimhof (2006) that the level of car ownership in Germany is such that the utility of additional cars in the society is relatively small, so that although car ownership rates are still increasing the total mileage travelled by cars is not. From this one may conclude that saturation has been reached – not for cars, but for total mileage travelled by car.

The utility individuals gain from car travel will affect the possibility of replacing the car with other modes. If travel is purely a derived demand, the activities to be carried out at the destination are the prime motivation for travel, so that the mode, in itself, is not very important. Using a structural model estimated for the US, Diana (2004) shows that the demand for transport is not purely derived and that a non-negligible proportion is determined by the utility individuals gain from driving a car. If this also holds for Europe, it will not be very easy to attract individuals out of their cars and on to public transport.

The symbolic and emotional value individuals place on cars was addressed by Schmeidler and Hanzlikova (2006). The main emotional benefit is the feeling of independence and personal identity provided by the car. This can be actual or perceived. For example, the car can increase the subjectively perceived quality of life, so that being without a car is considered a lower life quality. This perception can be interpreted as an emotional dependence on the car.

In wealthier countries, the role of the car as a status symbol is not as important as it once was. This is not surprising, since as cars become more widely available, they loose their relevance as a status symbol. In addition, in many large cities, the car has become more of a burden than a benefit. In central European countries, however, car ownership is still limited to a smaller segment of the population, so that it maintains its value as a status symbol. Because the car is still viewed as a sign of prosperity in these countries, measures to stem its growth are not easy to legislate or to enforce.

Although psychological factors doubtlessly play a role in car ownership and travel, far more papers addressed the socio-economic and demographic determinants of car ownership and use. Below we discuss those that primarily consider the characteristics of individuals: their income, household composition, etc.

An overview of the development of car ownership in France, Germany, Italy, Netherlands, Poland, UK, Japan and USA is presented in Berri (2005). This was based on an Age-Cohort-Period model which differentiates between life-cycle effects (change in transport and car use needs as the individual ages, due to changing family composition, income etc), generation effects (more recent generations are more likely to own car because of social diffusion, driving licence holding, etc) and of the impact of the current economic context (incomes, prices, supply, etc). The results show that differences between countries and regions can be attributed to three main factors: the history of car ownership, the level of economic development, and population density. The USA is at one extreme: car diffusion started earlier than elsewhere so that differences between cohorts are narrower and the sensitivity to changes in income is weaker. At the other extreme, Poland, where wider diffusion began only since its transition to a free-market economy, still shows substantial gaps between successive generations.

A detailed overview of changes in the use of cars in Germany over time by different groups of individuals was given by Kalinowska and Kuhfeld (2007). They show how there has been a convergence between age groups, genders and over the life cycle. This analysis was based on the German NTS of 2002. The importance of life cycle on car purchases was also stressed by de Haan and Müller (2005). They outlined the use of a Swiss survey including retrospective biographies of mobility decisions and life events for analysing the relationship between changes in household circumstances and car ownership.

The effect on car ownership and use of various lifecycle events was also addressed by Ottmann (2006). Using the German Mobility Panel, he showed how changes over the life cycle in car use and mobility are affected by some biographic events. It was shown that mobility and car use are influenced by changes in the employment situation and, to a smaller degree, by family events. The acquisition of a driving license results in increases in total mobility and in losses for modes other than the car. After retirement, total mobility remains stable, but car use declines. It is also shown that retirement has a lagged effect on travel demand, so that although overall mobility does not decline immediately after retirement, it does so slowly over time. Knowledge of how individuals' travel behaviour changes after retirement will become increasingly important for projections of travel demand as the average age of the population increases, as is the case in many European countries.

The influence of income on car ownership is well-explored and it is clear that income has been a driving force in increasing car ownership and use in Europe, and throughout the world. The importance of "wealth" is less well understood. Nielsen (2006) shows that the massive increases in property values in Denmark over recent years have lead to a substantial increase in car ownership. This is also likely to have played a role in other countries where property values have increased. However, the effect is likely to have been greater in Denmark, where car prices are exceedingly high owing to taxation policy and car ownership comparatively low as a result. Nielsen also shows that low interest rates have also played a role, and have lead to increased car ownership amongst both home-owners and tenants.

2.2 Changes in car ownership on a household level - the role of Panel Surveys

Although car ownership is increasing on aggregate in all countries, the net changes conceal a substantial variability on the individual household level. By exploiting observations of individual households over time, it is possible to explore this volatility and to analyse the factors behind it. Considering an individual household over a number of years, or all households between any two points in time, car ownership and car use will decline as well as increase. Changes in car ownership are determined by economic factors, e.g. income and costs, and also by various changes in household circumstances. The latter can be considered as transitions: changes of residential location or place of work, entry into and exit from the labour force; changes in the structure of the household (arrival or departure of a member, reaching driving age).

In addition to these changing individual and household characteristics, there are other factors relevant in to the decision of owning and operating a private car. In Europe there is still considerable heterogeneity in terms of car taxation, but with respect to purchasing a car and to its operation. With the process of harmonisation of taxes being considered, it is important to understand how households make decisions regarding car purchase and use.

Given the wide spectrum of taxation policies in the countries involved in COST 355, much can be learned through the experiences of the different countries. In addition, an exchange of methodology and expertise has proven invaluable.

In terms of methodology, the contribution of panel data to the understanding of households' car purchase decisions has been stressed in a number of papers. Panel approaches are also relevant in cases where effects of certain measures are to be evaluated: since the same individuals are observed both before and after introduction / implementation of a measure the relevant effects can be isolated – something which is not possible with independent samples.

A major aim of WG 2 was to demonstrate how panel data could be used to better our understanding of the factors influencing individual travel behaviour and so improve the possibilities of changing this behaviour towards a more sustainable mobility. The task of WG2 in this respect was twofold: the exchange of methodology suitable for analysing panel data, and the exchange and comparison of findings related to the determinants of car ownership and use. The latter are relevant for policy formulation and evaluation.

Zumkeller, Chlond and Ottmann (2005) use the German Mobility Panel to investigate how car dependence can be quantified and how it is likely to develop in the future. The study includes detailed analyses on the use of car for different purposes; the year-by-year changes in car ownership on a household level and the impact of various life-cycle transitions on mobility. They conclude that it is difficult to define car dependence because it could be subjective or objective. However, they show that high mileage and service trips are often indicators of car dependency. Regarding the future, it is likely that demographic changes could increase future car dependency.

Using the European Community Household Panel (ECHP), Dargay (2005) investigates changes in car ownership on the household level. The overwhelming majority of households did not change their status as either car households or non-car households during the survey period. A significant proportion, however, do give up their car, and this proportion differs amongst countries. Greece and Spain have the largest proportions (3.8% and 3.4%), while Luxembourg, Germany, France and Belgium have smallest (1.1% to 1.9). For all other countries, the proportion is between 2 and 3%. Over the longer term (7 years) the proportion increases to from 2.5% and nearly 6%. Many households, between 8% and 17%, go from having a car to not having one or vice-versa many times over the years observed. Generally, it seems that households in lower income countries with lower car ownership show the most volatility with respect to car ownership.

Both Dargay (2005) and Dargay, Hivert and Legros (2006) estimate choice models based on the ECHP to determine the factors influencing car ownership, the latter study using a dynamic model. Income is shown to play a major role, as expected, although demographic and locational factors are also important. An interesting finding is that car ownership increases with population density in Denmark, Belgium, France and Ireland, while the opposite is the case in the Greece, Portugal and Austria.

Panel data are also shown to be useful in analyzing other aspects of behaviour. Based on the PARC-AUTO in France Papon and Hivert (2005) give an overview of which households are more likely to share or rent a car instead of buying one. They show that renting is an occasional practice, and that the majority of renters own relatively new, high quality cars. Households with more license holders than cars are most likely to share, with men more likely to the main driver than women.

3 The car and mobility in urban areas – problem awareness & solutions

This summary was prepared on the basis of 13 papers, presented during WG2 workshops. The analyzed papers described the transportation problems and suggested solutions in 12 European cities: Brno (Gelova, 2005), Hauts-de-Seine (Boucq, 2007), Karlsruhe (Chlond and Kuhnimhof, 2007) London (Rocci, 2006), Madrid (de la Hoz, 2006), Paris (Rocci, 2006), Prague (Kohlová, 2006), Riga (Yatskiv and Yurshevich, (2007), Skopje (Krakutovski, 2007), Sofia (Spassov and Krastanov, 2005), Vienna (Klementschitz and Stark, 2007), Warsaw (Malasek, 2004, 2007) and in Nagoya, Japan (Rocci, 2006).

3.1 Problem awareness

All cities could be divided into 3 categories (according to their population and area, which influence travel time and distances):

I category: Mega-cities will include London, Paris and Nagoya

II category: Agglomerations are Madrid, Prague, Sofia , Vienna and Warsaw

III category: Big cities include Brno, Hauts-de-Seine, Karlsruhe, Riga and Skopje.

The centres of mega-cities can not exist without a well developed, underground and overground rail network used every working day by ca. 60% of commuters; despite this streets are still full of cars all day round. Probably the only viable solution in this case is that implemented in London, which is very high cost of car use (Congestion Charge, parking costs, fines and insurance). Money paid by car owners can be used for improving other transport modes: development of underground network, bicycle routes and pedestrian facilities.

In London, road pricing policy and a relatively good public transport system results in a 44% share of PT in modal split, compared with only 32% in Paris and Nagoya. Also the percentage of households without cars in London is very high – 40%, when in the Paris agglomeration it is only 29% and in Nagoya 15%. Only 19% of London's households have 2 or more cars, comparing with 24% in Paris and 46% in Nagoya.

Agglomerations are facing similar problems (usually on a smaller scale) as mega cities and similar measures should be appropriate. The most information on mobility issues and implemented solutions are found in the Madrid and Warsaw presentations; however Madrid has a more sophisticated research analysis and better achievements in transport policy implementation.

In both cities the share of PT in modal split is high: 70.1% Warsaw and 69.2% in Madrid Central Area. Car ownership in Warsaw is slightly lower: 51.5% of households have no car and 7.2% have 2 or more cars. High PT usage is possible because in both cities public transport is well developed and priority for public transport traffic is extensive. In Madrid: 5 lines underground network, exclusive bus and HOV traffic lanes and a Park and Ride system; in Warsaw: one metro line, very well developed tramway system with separated right-of-way and some exclusive bus lanes. Under development are bicycle route networks – in Warsaw at present 140 km, with a programme for 300 km more. In both cities parking charging is used on a wide scale and - what should be important for decision makers – in Warsaw nearly 80% of car users accept further implementation of priorities for PT modes in most important transport corridors.

In Prague the PT share (57%) in modal split is lower than in Madrid and Warsaw and car ownership is 560 per 1000 inhabitants. To improve PT patronage transport policy is oriented to ecological transport modes: railway, metro, tramways and bicycles. The paper on Sofia concentrates on a programme for construction of several automated parking garages served by the stacker cranes. Results of the study on mobility characteristics of car park users in Vienna show a high share of trips where car owners see no mandatory need to use car (17% for shopping trips and 42% in case of leisure trips). Evidently, there is a high potential for influencing mode choice by introducing obligatory parking fees on private car parks.

In big cities (a quarter to 1 million population) the most suitable policies are:

- not to over-invest in road infrastructure;
- to develop well organized PT at ground level with traffic priority;
- to use railway lines for commuter traffic; and
- to implement parking charging in the city centre.

In Brno, the PT share in modal split is 55% and to keep it at this level the city wants to develop and promote environmentally-friendly mass transit modes: railway, trams and trolleybuses. The paper on Riga (car ownership 304 per 1000 inhabitants) concentrates on development of the road network (by-passing highway, urban roads) and the implementation of a Park and Ride system. Unfortunately, it appears that upgrading the PT system doesn't have a high priority in local transport policy. In Skopje car ownership is only 206 per 1000 inhabitants, but because of relatively large family sizes, only 36% of households are without car while 12.5% have 2 or more cars. The low quality of public transport contributes to the intense usage of private cars in the central area in the town, reducing traffic flow considerably. The effects of accessibility gains created by T2 tramway line construction on residential property values in urban areas were studied in Hauts-de-Seine department in France. The results show that the tramway accessibility improvements are capitalized into housing prices. Land taxation for the landowners can allow recovering the added value due to improvements in accessibility thanks to attractive PT modes.

Karlsruhe is the most interesting example of sound transport policy and planning results. This city of 275 000 inhabitants proves that a big challenge - implementation of sustainable transport ideas - is possible. Modal split for journeys to the city centre is really impressive, even compared with much bigger cities. Only 27% of inhabitants use the car, 47% chose public transport modes, 18% bicycle and 8% go on foot. This is not because of poor road infrastructure (it is really good) but thanks to well organized public transport (mostly a combination of railway and tramway operation) and mixed land use. The extension of the suburban railway system attracted about 40% of people who earlier were commuting by car. The ubiquitous availability of high quality public transport smoothens the real estate price differentials not only within the city but also in the whole region.

An excellent PT system is the main reason (the other reason is parking restrictions and charging) for stagnation of motorization in Karlsruhe since the year 2000 at the level of 480 cars per 1000 inhabitants. Car ownership differs from 330 per 1000 inhabitants in the city centre to 600 in city districts where PT travel time to the city core exceeds 40 minutes. Very interesting is also the implementation of car-pooling, popular in USA 30-40 years ago. Car sharing in Karlsruhe since 1999 reached nearly 3500 customers in 2005.

3.1 Policy solutions

In general, sustainable transport means less energy and land consuming investments and transport operations. As mobility is one of the important aspects of living standards and a big achievement of our civilization, we have to be sure that any restrictions on car use will not reduce indispensable mobility. The biggest challenge of sustainable transport policy in urban areas is to decrease car use in densely populated areas where the highest traffic flows are observed.

Concentrating only on indispensable mobility (most important and obligatory: to work, school, etc.) means that policy measures should try to reduce the need for car use by:

- Better communication;
- Attractive public transport;
- Modern land use;
- Clever and sound transportation policy.

Use of better communication can be a substitute for many trips. For example, the internet and other telecommunication services can be a substitute for:

- personal meetings (phone, fax or e-mail)
- everyday work trips by tele-work (working at home)
- business trips (visiting bank, city administration, etc.)
- shopping (tele- or internet shopping).

Attractive public transport means:

- quick travel by preferences in traffic (separated right-of-way for trams, bus lanes, priority at junctions, etc.)
- cheap (subsidized) tickets
- short, convenient and safe walking distance to mass transit stops
- short waiting time with short headways (smaller vehicles) or reliable time tables and well organized interchanges
- call-and ride services, mostly for handicapped.

Land-use planning in urban areas should follow such rules as:

- workplaces closer to home (advances in clean industry, so that there is no longer need to separate workplaces according to the Athens Charter)
- shops close home (out-of-town hypermarkets generate high volumes of car traffic)
- main trip generators (high-rise office buildings, shopping malls, sport arenas, etc.) close public transport interchanges
- in general: multifunctional and intensive land use should be promoted
- limiting urban sprawl (low density generates additional car traffic) using financial and administrative measures.

Coordination of spatial & transport planning policy means:

- balance in the CBD of three capacities: internal road network = external access roads = internal parking lots
- parking zones – standards for maximum parking spaces per 1000 sq. m. of offices in CBD and for minimum in the outskirts with low density
- Park and Ride systems close to mass transit terminals outside downtown area
- bicycle route network development
- well facilitated pedestrian areas.

3.3 Conclusions

1. Transportation problems in most cities are in general very similar:

- No possibility for unlimited car use in the city centre for everyone;
- Public transport modes not attractive enough;
- Priority of road investment over public transport development;
- Decision makers and politicians do not promote mass transit because:
  - they like to use their cars
  - they are afraid of a strong automobile lobby
  - they are afraid of losing votes, although is not always the case that people are against traffic priority for public transport modes.

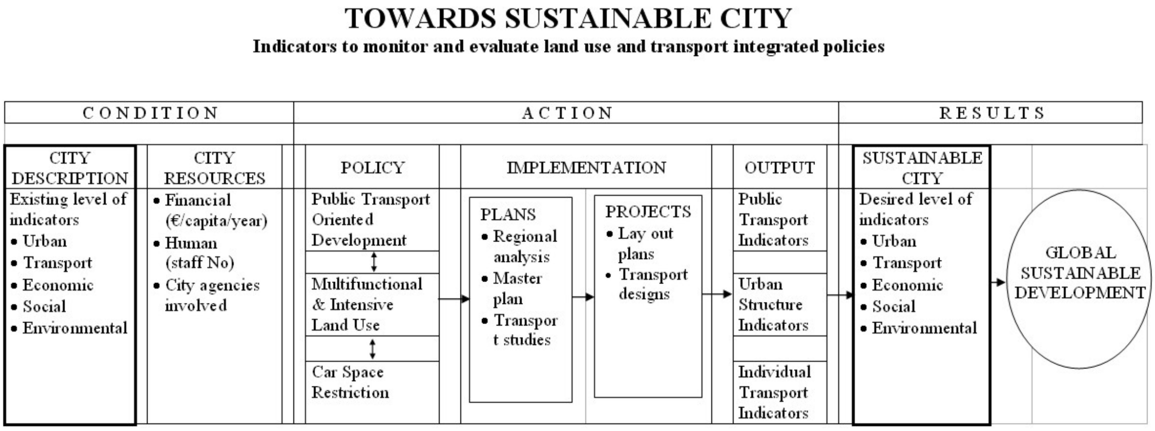
2. Car use in urban areas will be reduced if:

- Cities follow Karlsruhe good practices;
- Costs of car use are not underestimated (individuals often only take into account fuels costs which may be less than the public transport fare);
- Accessibility of city centre by car is made more difficult;
- Shopping habits change – shopping in hypermarkets needs a car;
- Possessing a car will not be a condition of recruitment for a new job.
- Car use costs are not reimbursed by the employer;
- Car ceases to be a measure of social status.

3. Attractiveness of other transport modes could be greater if:

- Public transport modes are more accessible, reliable and comfortable;
- City land use is intensive and multifunctional;
- Public transport is subsidized and employers reimburse season tickets;
- Walking from PT stops at night can be made safer;
- Bicycle routes are improved and made safer;
- Spatial planning considers pedestrian needs;
- People understand the value of better environment;
- Sanctions for drink driving, parking offences, speeding, etc. are increased;
- Habit of drinking alcohol after work in the city becomes more popular.

4. The below scheme for a coordinated policy transport & spatial planning for urban areas is probably a quite effective and socially acceptable way of changing modal split and driver behaviour.



4 Land use, car ownership and travel behaviour

"Urban sprawl and current unsatisfactory state of traffic in historical East and Central European cities has a number of causes. One of them is the discrepancy between the layout of the urban structure and the present-day requirements made by the volume of traffic. The physical environment of Czech towns and cities was formed for less demanding modes of traffic. Other traffic problems are caused by the distribution of urban activities, which is unsuitable at the present time, this distribution having been strongly affected by the strict segregation of functions. As a result, the origins and destinations of traffic have been spread throughout a large area, resulting in an enormous growth of internal urban traffic." (Schmeidler, 2004)

This conclusion is surely not specific to the Central and Eastern European cities. It is a development that is common for all European cities. In this synthesis we will discuss the effect of the development and try to figure out if the development is still worsening the effects. The synthesis includes advice for changing urban development to reduce environmental problems and congestion.

Nine COST335 presentations representing 6 countries are focused on land use. Most of the papers are concern the transport related and environmental effects of land use but two focus on the social effects of the development (Berri, 2006, Meschik, 2004/05). One is of more general character (Schmeidler, 2004).

The effect of land use development is different dependent on the size of the city and the city region. This is illustrated partly by two of the papers (Dargay & Hanly, 2004 and Berri & Madre, 2002) and partly by differences between the papers which represent cities from the Paris region to medium size Norwegian cities and Austrian villages. This paper distinguishes further between residential and workplace localisation.

4.1 Residential localisation

The localisation inside the city or city region can be considered in relation to:

1. the city centre
2. public transport
3. other types of land use

Different types of localities can also be considered:

1. densely populated cities
2. suburban areas
3. smaller towns and the countryside.

Christensen (2004) performed an analysis of travel distances in the Copenhagen Region (1.3 million inhabitants) using micro-level data from the National Travel survey correcting for a number of factors including income and car ownership. The paper shows strong correlation between distances travelled and the urban structure expressed in terms of variables describing the location of the residence. Thus it is likely that the relationships found can in fact be attributed to the urban structure and are not due to socio-economic differences.

The analysis shows an increasing transport volume, car ownership and kilometres by car the farther away from the city centre the residence is located. The effect is observed up to around 20 kilometres from the city centre. The analysis shows that locating residences close to the city centre of the region can reduce transport volumes and car traffic considerably. The results further show that urban residential development in smaller cities in the periphery around the core centre of the region reduces travel demand relative to an alternative development of suburbs and small towns at the same distance from the city centre. Urban sprawl to rural areas and villages are likely to generate the highest level of traffic. Finally, location close to rail stations significantly reduces car traffic.

Lian (2004) looks at car ownership and mileage per car by distance from the city centres of Oslo (0.8 m. inhabitants) and Bergen (0.2 m. inhabitants) based on the Norwegian travel survey from 1992 and 1998. Lian finds that the main distance effect is on car ownership. Mileage per car varies only to a small extent as a function of distance from city centre. Car ownership increases clearly by distance from city centre, but the distance effect diminishes after 6 km from the city centre (the curve flattens out). Car kilometres increase up to 20 km to the city centre. Since changes in settlement patterns are very slow, effects on car travel through the development is also relatively weak.

Engebretsen (2005) made a new study of the two Norwegian cities based on the 2001 National travel survey. This study includes Trondheim (0.15 m. inhabitants). The results show increasing overall kilometres of all modes up to 15 km from the city centre in Oslo and Bergen. In Trondheim the presentation stops at 10 km from the city centre. Car ownership is increasing up to 20 km from the city centre in Oslo, to 10 km in Bergen and to 6 km in Trondheim. Only 50 % of inner city households have access to car as opposed to 80-90 % in the rest of the city. Inner city travel is dominated by walking and cycling.

Dargay & Hanly (2004) analyse the effects of land use characteristics on mode choice and car ownership. The study is based on a large sample of individuals from the National Travel Survey of Great Britain for the years 1989-91 and 1999-2001. Land use characteristics are defined as population density, size of the municipality, accessibility to public transport and local amenities, such as shops and services. Mode choice (shares of total travel by car, public transport and walking) and car ownership are modelled using multinomial and binomial logit models respectively, which include a large number of socio-economic factors (income, age, gender, household structure and employment status) as well as land use indicators.

In summary, the results indicate that land use characteristics – population density, municipality size, local access to shopping and other facilities and accessibility of public transport - do play a significant role on car ownership and mode use. Car ownership and use increases and public transport use and walking decline as population density decreases. Municipality size is less important in determining mode share and car use.

Most significantly, far lower car ownership and car use is noted for London, along with greater use of public transport. In addition, higher car ownership and multiple-car ownership is evident in towns under 3 thousand inhabitants. Access to public transport, as measured by bus frequency appears to be a more important determinant of mode choice and car ownership than proximity to the bus stop. As the frequency of service increases, the use of public transport increases and car use declines. Public transport frequency also affects car ownership: as the service increases, car ownership and multiple-car ownership also declines. Finally, access to amenities (shops, services etc.) is also important in travel decisions. Proximity to local amenities encourages walking in lieu of car travel and discourages car ownership and particularly multiple-car ownership. These results have clear implications for transport policy and sustainability: reducing car use and its negative external effects can be facilitated by a well-considered land use planning that encourages local shops and facilities and a frequent public transport service while and discouraging widely outspread residential development. The existence of local shops and facilities will also have wider effects on personal health and the quality of community life.

4.2 Social aspects of residential localisation

Berri (2006) analyses the budget shares devoted to transport and housing by households of the Greater Paris region (11 million inhabitants), by residential location, living standard and dwelling occupancy status (owner outright, home-buying or renting). Data are from four Expenditure surveys (1978-79, 1984-85, 1989 and 1994-95) covering a long period that witnessed a progression of car diffusion and contrasted changes in prices. The study distinguishes the City of Paris and three concentric zones surrounding it. This zoning accounts for differences in accessibility to public transport and preserves the hierarchy of housing prices.

The results raise doubts about the reality of a trade-off between housing costs and transport costs, at least in the case of low-income households. The housing budget share is roughly the same irrespective of the zone of residence. However, the further a household lives from the city-centre the higher is its transport budget share (mainly car purchase and running costs). Despite decreases of fuel prices, the dynamism of motorisation of low-income households living in the periphery causes the share of their budget that they devote to car use to be maintained over time, whereas it decreases for rich households.

In other respects, as one moves away from the centre, household size, accommodation surface per person and home-buying households' proportion increase whereas living standards fall. Moreover, the proportion of low-income households living in the city-centre decreased whereas that of those living in the suburbs increased. Thus, high housing prices and insufficiency of low-cost accommodation in the centre force low-income households to locate in the periphery to have a dwelling suited to their size, particularly when they want to acquire their homes. This peripheral location involves high car expenditures, thus endangering their financial condition, particularly their ability to repay their loans.

Therefore, actions to limit urban sprawl and car traffic should be part of an integrated approach of transport and housing. Solvency evaluation procedures should take account of transport costs, in addition to housing costs. Besides, measures improving the housing market conditions in most accessible zones by public transport are to be considered. Lastly, the limited choice of travel mode for inhabitants of zones badly served by public transport should be accounted for. Increasing car use costs (particularly fuels) via raises of uniform taxes would lead the least wealthy to bear a heavy burden that they cannot avoid. Area-specific measures may be more appropriate.

Meschik (2004/05) presented an Austrian study as part of the European research project ARTS implementing improvements of public transport in several very sparsely populated European regions. In rural areas in Austria and elsewhere changes in social and economic structures have led to a concentration of workplaces and supply services in urban centres. In the field of mobility we find increasing motorisation and longer distances driven with cars, causing a decreasing demand for public transport (PT) and a decreasing demand for local supply, resulting in a decrease of PT services, and fewer local supply services.

These changes have already led to disadvantages for persons having no access to a private car, but dramatic changes are to be expected within the next few decades. The disadvantaged people in this development are either persons too young to drive a car or senior citizens – predominantly women - who do not hold a driving license. Although one might think that nowadays there is a car in every household, in some Austrian rural regions 13 % of the households do not own a car, and one out of three households owns only one car, which is not available to another family member, if one person drives the car to work.

It can be shown that driving license holders cover almost twice the distances of persons without a driving license per day. Without a car of their own, people make their trips as car passengers, walking, by public transport, or cycling, whereas car owners use the car for three quarters of their trips. Elderly drivers use the car even more frequently. Where people are not so dependent on the car, for example in large villages, where supplies needed for daily life are near at hand, it was shown that people older than seventy made more than 80 % of their trips on foot. Generally people use non-motorised modes more frequently, when a grocer or a supermarket, the doctor or child-care facilities etc. are located within the village at short distances (up to one kilometre). The farther away the next grocer is, the more frequently the car is used to get there. It could also be shown that supermarkets within a distance of five to six kilometres caused local grocers to close their businesses even in villages of several hundred inhabitants. Local supply can only “survive” in medium to small villages, if supermarkets are farther away.

The most interesting projects of ARTS were those implementing demand responsive public transport (DRT) services. Whereas in northern and western countries DRT and intermodality linking different forms of PT are commonly best practice, PT is almost nonexistent in the rural south and east of Europe. Consequently, basic steps towards DRT were made in ARTS, for example, opening school busses to the general public in Galicia (Spain) – and thus providing PT in this region for the first time.

To be able to provide good PT services in the future it is concluded that, two prerequisites must be met:

- Extensive building of detached houses on green fields should be contained. Villages must be built more densely, so that local settlement-nuclei allow affordable PT services.
- PT must become more flexible in terms of vehicle sizes and operation. Standard bus services, which only operate between bus-stops, have to be complemented or substituted with more flexible door-to-door services.

4.3 Commuting and working place localisation

Christensen (2004) repeated the analysis in the Copenhagen region of residences for localisation of working places. The conclusion from the analysis seems to be that work-places ought to be decentralised in order to reduce the level of transport. Transport kilometres per person are lower the farther away from the city centre the working place is located. The same is the case for kilometres of car traffic except for the important difference that for the first 6 kilometres from the centre of the city the traffic level is very low. This might be explained as a result of limited parking opportunities in City and the dense neighbourhood areas of Copenhagen.

The most likely reason for the declining travel distance with longer distances from the Central municipality is that residences are decentralised already. This means that work-places near the residences might mean shorter distances between home and work for people on average. However, this conclusion needs further consideration before policy recommendations could be based on it.

The models include the effect of distance to a rail station. The result shows that the effect of locating a workplace within 5 minutes walk from a rail station decreases total travel by 10 percent and travel distance by car to 50 percent. The corresponding estimates for the location of the residence show a 7 percent reduction in total travel when the residence is less than 10 minutes away from a station and a 33 percent reduction in car travel when the residence is less than 5 minutes walk from a station.

Hence, it can be concluded that a policy giving priority to locating workplaces close to stations rather than residences is likely to contribute to reducing the demand for travel. Of course this conclusion depends upon the actual density of the established areas. Offices and firms with few square metres per employee will typically have one employee per 30-50 in-door sqm. New residences will have one adult or older child (10-84 years old) per 40-70 indoor sqm. This means that the reduction in car kilometres from localising workplaces densely around rail stations related to residencies are even greater than calculated above. Buildings with offices can normally be established more densely than residential areas which add extra to the conclusion.

Engebretsen (2005) made a more detailed study of the effect of localisation of working places in the Oslo region. He finds that Inner city people working in outer city areas use car to the same extent as the rest of the city which means that trip destination is an important determinant of travel mode. This observation might not be in opposition to the analysis from Copenhagen. In line with Copenhagen, public transport is important for trips from suburbs to city centre. The same is true for the conclusion that although there is good public transport accessibility at certain nodes outside the city centre, car travel still dominates.

Engebretsen concludes that good public transport accessibility is not sufficient, restrictions on car travel, especially lack of parking space or very high parking costs like in the city centres are necessary in order to achieve a change from car travel to public transport travel. But from the Copenhagen study it can be concluded that even without parking restrictions a localisation very close to a station is better than farther away.

Lian (2004) analyses localisation of working places in Oslo and finds that localisation of jobs has changed considerably over the last twenty years. The number of workplaces has decreased at central locations, while the number is increasing in the outer parts of the city. The portion of work trips made by car varies from 20 % in the inner city to 70 % for work places located in the outer suburbs. What he has not taken into account is that kilometres per trip to the city centre might be much greater than the distance to the work place in the suburbs so that resulting car kilometres are not as great.

Aguilera (2004) analyses the influence of the formation of employment subcentres within the Paris Region on home-to-work distance and on car use for home-to-work trips. The study is based on Census Data from 1990 and 1999.

The results show that home-to-work distance and car use are dependent on the type of commute. Distance is short and car use is limited for people living and working inside the city centre (the municipality of Paris), inside the same subcentre, and for those who live in a subcentre or in another suburban municipality but work in the city centre because public transport network to Paris is very well developed. However, car use is important for all other type of commutes, especially from one subcentre to another and also between the suburban municipalities and the subcentres. There is indeed a lack of public transport between the main employment subcentres.

To reduce car use generated by commuting trips two directions can be taken by public authorities. The first one is to encourage people to live inside or close to their employment subcentre. Some subcentres obviously have a lack of housing. The second direction is to develop public transport between the main employment subcentres.

4.4 Changes in localisation patterns

Lian finds that the population growth was substantial in both Oslo and Bergen regions during the 1980s and 90s. The growth was stronger in the outer parts of the region than in central areas. However there was a slight re-urbanisation tendency in the nineties onwards in Oslo.

Lian concludes too that the spread of work places and shopping centres is a more important determinant of increased car travel than population sprawl. But the study of Christensen from the Copenhagen region indicates that this conclusion is not necessarily correct. At least it might not be correct for the Copenhagen region if you get long enough away from the City Centre.

Aguilera (2004) finds that the type of commutes that have increased over the study period (1990-1999), are those for which car use is the highest (especially commutes between subcentres and from suburban municipalities to subcentres). Despite data for car use are not available for 1990, this evolution has probably been responsible for the growth of car use within the Region.

Berri & Madre (2004) analyse differences in behaviour of household mileage by zone of residence according to conurbation size and distance to the centre. They include impacts of demographic factors (age and generation) as well as those of economic factors (household consumption and fuel prices). The conclusion is that accounting for the future development of urban sprawl and for modifications in the population of households, both in level and in structure, is necessary for the long term projection of car traffic.

Inspection of the respective influences of urban sprawl and of economic growth on the projected volumes raises some remarks about the scenarios envisaged. Indeed, although the choice of growth scenarios is arbitrary, the scenarios of urban sprawl seem more contrasted. Yet, the relative gaps in 2020 are greater according to the economic variants than to those of sprawl. Thus, at the national level these differences are of the order of 8 and 4 percent points respectively, though the situation differs according to urban area type. To some extent, this may be due to the formulation of the hypotheses adopted.

5. Policy measures to influence behavioural change

The rapid growth in person travel, particularly car travel, is clearly unsustainable in the long run. This is particularly the case in urban areas. Europe’s cities cannot cope with increasing car traffic; the problems of congestion, poor air quality, noise and traffic accidents are reducing the quality of life in our cities. This was highlighted in section 3, using different cities as examples and possible solutions were suggested. It is clear that improvement of the public transport system and provision for walking and cycling is essential; an alternative to the car is required.

The particular role of land-use planning on transport demand was discussed in section 4. Suburbanisation and urban sprawl has made it difficult to get about without a car, making us more car-dependent. More sensible land-use policies could have a significant effect on travel behaviour: both on the distances travelled and on the modes used.

There are, of course, other externalities of transport that are less localised. The most obvious is its contribution to green house gas emissions, and thus to global warming. More general policy measures will be more appropriate here. Fuel and vehicle taxation are the most commonly used policies, although regulation and subsidies can also play a very important role.

One of the priorities of COST355 is to investigate the question of how various policies can be used to encourage more sustainable travel behaviour. A number of studies provided an insight into these issues.

5.1 Overview

A general overview of potential policy tools to influence consumer behaviour was presented Vincent Lyk-Jensen (2005) from the ERA-NET Action "Policy tools to influence vehicle purchasing behaviour". The focus is behavioural change in terms of purchasing cleaner vehicles and its potential to reduce greenhouse gas emissions. Vincent Lyk-Jensen also presented the Danish car choice model and the possibility of applying similar models in other countries was discussed. A major problem in many countries is the lack of suitable data.

The impact of taxation on car travel in Germany was presented by Kunert, Zumkeller and Chlond (2004). They discuss the potential influences of different taxation schemes on the demand for petrol and diesel powered cars as well as the effects of rising fuel prices on travel demand. In most European countries, diesel is cheaper than petrol. Kalinowska, Kuhfeld and Kunert (2005) demonstrated how taxation schemes affect the split between petrol and diesel. An assessment of the tax systems across the EU gives evidence of significant differences. This analysis was followed by an in depth analysis of the French and German passenger car fleets with regard to vehicle attributes and utilization patterns (Kalinowska, STSM). Similar results were presented by Hivert (2004) based on the PARC-AUTO SOFRES Survey. The phenomenon of the "new dieselists" was addressed and their relatively high car use.

5.2 Taxation

The influence of taxation can be implied from estimates of the price elasticities of demand for car ownership and use. Studies concerned with this were presented for a number of individual countries. For Denmark, Fosgerau (2004) estimated a dynamic model of car ownership and use using aggregate time-series data. Car ownership is relatively low in Denmark in comparison to other EU countries due to exceptionally high car registration taxes. For car ownership, long-term elasticities are found to be -0.48 with respect to the price of cars and –0.55 with respect to operating costs, the latter implying a fuel price elasticity of -0.33. For car use, the average annual distance driven per car, the long-term elasticity with respect to operating costs is found to be –0.37 corresponding to a fuel price elasticity of –0.22. Combining these estimates leads to long-term elasticities for the total kilometres -0.48 with respect to the price of cars, -0.92 with respect to operating costs and –0.55 with respect to the fuel price.

In a study for Greece, Vythoulkas (2006) estimates car ownership in Greece on a regional level. The results show that both the price of cars and fuel prices have significant effects on demand and that the elasticities vary considerably by region. Concerning other measures, in the early 90s the Greek state gave financial incentives for scrapping old technology cars. As a result in the period 1991-92, 285,000 passenger cars and 47,200 light goods vehicles were withdrawn from traffic.

Vythoulkas and Dargay (2007) investigate the determinants of car ownership in Greece and the UK using a pseudo panel model. They find the elasticity with respect to purchase price is about -0.2 in both countries. However, the elasticity with respect to the fuel price is greater in the UK (-0.33) than in Greece (-0.19), which is explained by the higher fuel prices in the UK and the observation that the elasticity increases as prices rise.

The response of car ownership and commuting by car to car purchase costs and fuel prices in Britain was also investigated by Dargay and Hanly (2004) using panel data. Their results show that increasing car purchase costs and fuel prices reduce the likelihood of commuting by car, with car purchase costs having the stronger effect.

5.3 Standards versus taxation

There is an intense debate over whether fuel economy standards or fuel taxation is the more appropriate policy instrument to raise fuel economy and reduce CO2 emissions of cars, as potential fuel savings due to autonomous technical progress in the past have been counterbalanced by changes in consumer preferences towards safer and more comfortable cars.

Gühnemann (2005) estimated the determinants of car registrations in Europe by car type to investigate the impact of various factors on greenhouse gas emissions. She concludes that technical factors have played the most important role and that fuel prices have only had a minor influence. The relative importance of technology and prices was also addressed by Zachariadis (2007) in a study of 18 countries. They found that fuel economy standards were the most important factor in fuel economy improvements and that very high fuel prices would have been needed to achieve this with taxation.

Zachariadis (2006) investigates a number of policy scenarios on the basis of a model covering the entire transport sector (road and rail transport, inland shipping and aviation) in the 15 countries that were EU Member States in the beginning of 2004. The results reconfirm the widely expressed assertion that individual policy measures are not sufficient to address the diverse sustainability concerns associated with transport. In order to achieve improvements in energy intensity, CO_2 emissions, congestion and air pollutant emissions, a package of measures is necessary. Strategies that promote advanced technologies can mainly affect air pollution and to a lesser extent energy demand, whereas traffic-related measures can primarily improve congestion and thus energy intensity and emissions as long as appropriate clean technologies are in place. Thus a suite of policies combining promotion of advanced ‘conventional’ technologies and alternative fuels with interventions to reduce demand for transport would be most suitable to address the variety of sustainability issues.

5.4 Other measures

Another policy measure, mostly relevant in larger towns, is parking control. An overview of this was provided by Klementschitz and Stark (2006). Three different measures were discussed: limiting the total number of private off-street parking spaces, obligatory charging for private off-street parking and defining and negotiating trip-contingents based on a mobility plan. It was shown that where such measures have been implemented, the experience is generally positive.

Christensen (2007) considers the potential for mode shift from cars to cycling and walking for short trips in Denmark. The effects of possible policy instruments are estimated using model simulations. These instruments include 25 % higher travel time by cars, 10 % lower travel time by bike and fewer or more expensive parking lots combined with an extensive policy for promoting bicycling. The effect of all policies combined could be about 16 % of the short trip kilometres or 2.5 % of all car kilometres. She concludes that even with very substantial efforts walking and biking will never play an important role in reducing car traffic, without the introduction of economic measures to make car use much more costly.

A much discussed, but much less-used measure for reducing car travel is road pricing. The implementation of road pricing in the EU has been in either in the form of toll roads (in France, for example) or cordon tolls in larger cities. Following on the presumed success of the London congestion charging scheme, an experiment using a similar scheme was implemented in Stockholm. Carle (2006) gave a presentation of the scheme and of it effects. The result of the trial was that motor traffic decreased more than expected, that the accessibility improved significantly and the road traffic reductions lead to an improved environment. The effects on regional trade and commerce was marginal, the technical system worked well and the attitudes turned more and more positive as people experienced the effects. The charges were estimated to be socio-economically profitable although the administration costs were high.

5.5 Unintended effects of policy

Transport taxation policies can also have secondary effects, which could be positive or negative. The effects on income distribution and equity are often addressed and are discussed in the next section.

An example of the negative effects of taxation is provided by Järvi (2006), which considered the effects on the Finnish car fleet of changes in taxes on imported second-hand cars. The number of imported used cars increased sharply during the recent years: imports by individuals were encouraged by a large gap between domestic prices and prices abroad, and relatively high taxes rates on car purchases (25% to 30%). Though they seem to have no major effect on the sales of new cars, the increasing imports of used cars (with a growing average age at import) may lengthen the average age of the fleet with an impact on future emissions.

Another question is the issue of safety. Are fuel-efficient cars less-safe than others? Zachariadis (2007) investigate this using a sample of 193 European car models and their safety ratings and find there is no trade-off between safety and fuel efficiency. Safer cars demonstrate slightly better fuel economy than less safe cars of the same size and year.

Boucq (2007) looks at the role of transport infrastructures on residential property values in urban areas. The example is of the T2 tramway, opened in Hauts-de-Seine department in September 1997, which noticeably improved accessibility in the department. Using a hedonic analysis method, she shows that the T2 tramway accessibility improvements are, indeed, capitalized into housing prices.

6 Car ownership and use inequities

We've seen in the introduction that over the past decades car ownership has become more equally distributed over the income spectrum both amongst and within countries. Cars are no longer a luxury for the privileged few, but have become a necessity in many countries, so that even many of the relatively poor have access to a car. However, there are still large disparities.

6.1 Different types of individuals

The example of Great Britain (Dargay, 2005) shows that despite the lowest income groups having the highest growth in travel, there are still large disparities between income groups, particularly by car, thus reflecting the lower car ownership among the poorest. It is also shown that travel poverty is associated with social vulnerability. Those who travel least are elderly, unemployed women with low incomes and living in large cities (over 100,000 inhabitants). Most of their travel is by walking (30% of total kilometres, against only 2% for the average individual!) and public transport.

The ageing of the population in most European countries imposes anticipating the problems posed by the future increases in the mobility needs of the elderly. A prospective exercise for the Czech population (Schmeidler and Pesak, 2005) shows the types of issues to be faced. One scenario assumes an increase in morbidity and a massive increase of people with mobility handicaps. In this case, the main issue would be in terms of accessibility to the transport network, particularly for those who have settled during their working life in peripheral locations poorly served by public transport. Another scenario, "active ageing" hypothesizes a reduction of morbidity with retirees accustomed to car use and with strong mobility needs. As a consequence, traffic safety problems would be of great concern.

The specific travel patterns of women are illustrated in Lenz and Nobis (2007). They find that in the German context, gender differences continue to be important and that travel patterns of women differ considerably. Travel patterns of men and women are much alike when they are single, but there are substantial differences between men and women in households with children: family life affects the travel patterns of women much more than of men. The high share of car use for escort trips supports assumption that the car is often a precondition for women to fulfil work and family duties at the same time.

These examples suggest that taxation on cars and fuels can have more serious consequences for some individuals than for others, particularly the elderly and women.

6.2 Transport expenditures: inequalities and redistributive effects of taxes

The growing importance of the automobile in personal mobility found expression in a large progression of household expenditures on transport. Two studies illustrate this Berri (2004) and Dargay (2004). Thus, for instance, while in 1960 the average share of transport in French households' budget was two and a half times less than that of food, it became the second most important expenditure category (after housing). It increased from about 10% in 1960 to around 15%. This transport budget is essentially composed of expenditures on the automobile, of which taxes constitute a large part. However, there are significant differences at the household level (data from Family Budget surveys conducted since the end of the 1970's). Thus, the share of transport in the total budget differs greatly according to the standard of living and grows with income (the gap between the first and last quintiles is up to 9 percentage points). Over the whole observation period the temporal patterns were contrasting: slight increases for the poorest and slight decreases for the richest. This partly reflects the diffusion of the car: the number of cars per household increased more strongly for the lowest incomes. Unlike private transport, which constitutes the bulk of transport expenditures, the share of local public transport declines with income, in particular when focus is put on the Greater Paris region (with very good PT network). Data on British households show similar patterns. A notable difference from the comparisons is that lowest income households in the UK have many fewer cars than their French counterparts.

Car taxes are a source of public revenues as well as a policy tool to reduce traffic nuisances. Most of them were instituted in a time where the car was a luxury good (e.g. the French *vignette*, an annual tax on vehicles owned, in 1956). Social diffusion of this good is likely to have lessened their progressivity. The protests in several European countries against the rapid increase in fuel prices during autumn 2000 highlighted the sensitivity to the burden of fuel expenditures, not only of professionals but also of households, particularly the suburban ones who are more car-dependent.

Analysis of French households' expenditures (Berri, 2005) highlights the effect of automobile social diffusion on inequalities of transport consumption and on the redistributive effects of taxes on various categories of these goods and services. Indeed, the relative contribution to global inequality of car use items, especially fuels, decreased regularly over time, reflecting the fact that the car is more and more necessary. Moreover, fuel taxes are regressive (i.e. they affect the poor more than the rich), while the progressive character of taxes on the remaining car use commodities (repairs, lubricants, tires…) weakens over time. The pattern for the UK (Dargay, 2005) is slightly different. Fuel taxes affect the middle income groups more that others, and are not regressive as in France.

In France, the progressivity of taxes on transport as a whole is mainly due to the progressive character of taxes on automobile purchases (strongly linked to income and with a higher budget share that for the other expenditures) and, to a lesser extent, to the progressivity of taxes on long distance public transport services. Taxes on local public transport services too appear to be neutral at national level, but this result hides a diversity of situations in terms of availability of these transport means according to the degree of urbanisation and population density of the place of residence. Effectively, these taxes prove to be regressive when focusing on the Greater Paris region, a large urban area very well endowed with public transport infrastructure.

In the UK, taxes on public transport have neutral effects overall. This is explained by the observation that taxes on rail tend to be progressive, while on bus tend to be regressive. Thus, the large rail subsidies that exist in Britain today favour those with higher incomes.

6.3 For a conciliation between car use reduction measures and equity

Therefore, the design of policy measures to reduce car use and thus attenuate its nuisances for the environment (pollutant emissions, congestion and noise) should take into account the imperative of equity in order not to worsen social inequalities, if not reducing them. Increasing car use costs, notably fuel prices, through an increase of uniform taxes would be particularly inequitable. In particular, the least wealthy of car-dependent households living in low-densely populated areas would face a heavy burden that they cannot avoid. Indeed, as shown by the example of the Greater Paris region, the peripheral location of modest income households, because of high property prices in the centre of the urban area, involves transport expenditures that increase with the distance is from the centre. These expenditure levels are not necessarily chosen, but are induced by the absence of a credible alternative to the car.

Area-specific measures may be more appropriate. In the case of dense urban areas, urban tolls and restrictions of access are examples of such measures. In parallel, public transport supply needs to be improved in terms of service, speed, punctuality, comfort, etc. In addition, a global approach should include actions on the housing market (stimulation of construction and promotion of low-cost accommodation in the most accessible zones by public transport) so as to increase the density of the urban fabric and attenuate the sprawl tendency.

7 Is car use compatible with sustainable transport?

Whether or not the car can be made compatible with sustainable transport is one of the major issues to be addressed by WG2 and one about which there is a good deal of controversy. This question was discussed at the Turin meeting and some of the arguments are summarized below.

Although idea of sustainability is widely discussed, it is useful to begin with a definition what is meant. Implementing sustainable development is to support economic growth with minimal harm to the environment and minimal depletion of natural resources. In the case of sustainable transport this means using less energy, minimizing pressure on land use through infrastructure investments, decreasing the risks to safety and health, and minimizing local air pollution and the more global problem of greenhouse gas emissions.

Jacek Malasek (IBDiM, PL) argued that the greatest challenge of sustainable transport policy in urban areas is to decrease car use in densely populated areas where the highest traffic flows are observed. He also pointed out that personal mobility has increased our living standards and been an important achievement of our civilization, and we must ensure that any restrictions on car use will not decrease “indispensable” mobility. A number of policy measure that were discussed in Section 4 have this aim in mind and suggest that there are possibilities of reducing car use, without necessarily limiting mobility. Most of the measures suggested are “carrots” (attracting people to public transport) rather than “sticks” (banning car use or making it more expensive). An example is car-pooling, where cars with more passengers use bus lanes. For interurban traffic, improvements the in rail and coach services can encourage people out of their cars. The use of high-occupancy vehicle lanes for coaches and cars with more occupants can also play a role. In general it was felt that it is only a matter of political will and education to prevent global warming and create a better environment.

Uwe Kunert (DIW Berlin) agrees with the above statements that call for better planning, the availability of alternatives to car use, including non-travel-options, and the improvement of public transportation especially for service in urban areas. However, he stresses that the car is and will remain the main mode of transport and in some European countries will even increase its modal share. Thus, the car has to be made compatible with sustainable transport.

Over the last decades, the energy efficiency of European economies increased substantially, but much less so or even not at all in the transport sector, especially in the car use segment. Looking at the general picture and not just at densely populated urban areas or congested corridors, Kunert believes the improvement of efficiency in terms of energy use and pollutant emissions per unit of output (e.g. vehicle mileage or person kilometres) will be the most important contribution to a less unsustainable transport system. Nowadays only few countries have other measures in effect than the excise duties on fuel that may support this goal (and even these duties are low in some countries compared across Europe). Therefore there is a need and much room to actively pursue the enhancement of car technology via policies that induce technological and behavioural change. The measures taken may be taxation, regulation and incentives/disincentives, depending on the national or regional circumstances. In time better technology will be on the road – also for the new member countries. This will also mean that we have to accept higher prices for cleaner but at the same time more economic (in terms of running costs) cars.

A similar response to the question "*Is car use compatible with sustainable transport?*" was given by Magnus Carle (Ellemce Hb, Sweden): YES, it MUST be! Must, because mobility is one essential cornerstone for social and economic development. But he also stresses that there should be OPTIONS; options to choose different destinations to satisfy your needs, options to use alternative modes of transport and not least options to use environmental friendly energy sources. The use of cleaner fuels can make a substantial contribution to the sustainability of car use, and is probably more important than many other measures. Carle also suggests that efforts towards decoupling transport emissions from economic growth should be more focused on structural and technical factors and that the external costs of car travel should be internalised in the price as it should be for all modes of transport.

This "economic" view is countered by Simonova (TIN, IT), who adopts a psychological and sociological perspective. She also believes that reconciliation between the automobile and sustainable development is possible by the use of two complementary strategies: building up favourable conditions for all types of alternative mobility and rendering car use less easy or more expensive. Although there are strong reasons to implement these strategies, there is much resistance especially from politicians convinced that people are car dependent. Our society (represented by politicians) seems to be still ambivalent whether individual mobility is a collective or private question.

Simonova points out that many people like their cars. They desire one and if they have it, they tend to use it more than necessary. Various reasons can explain why cars exercise such as strong attraction, not least the fact that literally everyone is exposed daily to massive marketing: cars are associated with emotionally appealing images evoking power, success, beauty, social and sex appeal, happiness, safety, security etc. All these futile and often unrealistic representations are stored in our brain and improperly increase the value of cars by bestowing on them additional qualities, while the negative consequences of car use are suppressed. In this way perceptions are constantly manipulated, artificially augmenting the desire to have a car, which consequently also determines mobility choices.

Simonova also argues that a major problem is a the lack of understanding of individuals' mobility needs, which are not only the necessity of moving from A to B. Travelling is always a complex experience, therefore qualitative criteria like connectivity, comfort, accessibility, security, safety, aesthetic etc. represent fundamental travel conditions influencing one's perception of different modes.

Only recently has it been recognised that the decision-making process is based on emotions and feeling, rather than exclusively on rationality. Transport does not seem to be an exception. Just imagine an ordinary situation when some outdoor business needs to be done. All available travel options (car, walking, bicycle, PT) are automatically represented in the mind and labelled in terms of specific quality of goodness or badness. In fact the entire, extremely quick process will be experienced as a "feeling" favouring the choice that is more acceptable, appealing or emotionally sustainable.

Travel choices might be simply a result of both conditioning and/or heuristic processes, with few, if any, rational arguments. A specific travel decision (e.g. accompany children to school by car) will be justified with various arguments creating an illusion of rational decision-making. The mental short-cut will not always be recognized. In fact, many individuals increase their feelings of ambivalence toward cars only when confronted directly with the negative consequences of car use, such as energy consumption, noise pollution, CO_2-emissions, traffic safety, land use, accident costs, health consequences, etc. showing more willingness to change travel habits. Obviously such reasoning is soon forgotten if travel by alternative modes is significantly worse than travel by car.

From this, Simonova concludes that a better integration of psychological and sociological concepts into existing transport thinking is essential if we are to understand the motivations of car users. Only then will it be possible to provide a transport system which can encourage more sustainable choices.

The discussion could be summarised as follows:

The car is likely to remain the main mode of transport in European countries for the foreseeable future. This is must be made compatible with sustainability. This can be done by:

1. technological improvements in fuel efficiency and the use of cleaner fuels;
2. internalising the external costs of car travel;
3. improving the public transport system and provision for walking and cycling;
4. encouraging the use of other modes, particularly in urban areas;
5. understanding the needs and motivations of travellers to provide alternatives that that meet their requirements.

List of Presentations

Aguiléra, A (2004): Urban polycentrism and car use (INRETS, FR)

Berri, A (2004): Dynamics of inequality among French households with regard to transport consumption (INRETS, FR)

Berri, A (2005): A cohort analysis of household car ownership in different countries (INRETS, FR)

Berri, A and J-L Madre (2004): Urban sprawl and household car traffic growth in France: projections to the years 2010 to 2020 (INRETS, FR)

Berri, A (2006): Residential location and household expenditures on transport and housing: the example of the Greater Paris region (INRETS, FR)

Boucq, E (2007): The effects of accessibility gains on residential property values in urban areas: the example of the T2 tramway in the Hauts-de-Seine department, France (INRETS, FR)

Carle, M (2006): Congestion Charging Trials in Stockholm – to be or not to be? (SWE)

Chlond B (2006): The diminishing marginal utility of additional cars – effects on future travel demand growth? (IFV, DE)

Chlond, B and T Kuhnimhof (2007): The development of car ownership in Karlsruhe (IFV, DE)

Chlond B and D Zumkeller (2005): "Car dependency" in Germany (IFV, D)

Chlond, B, Kunert, U and D Zumkeller (2004): Car ownership and use in Germany and possible influences of taxation (IFV and DIW, DE)

Cholava, R (2006): Environmental impacts of individual transport (CDV, CZ)

Christensen, L and M Fosgerau (2004): Impacts from different land-use strategies on travel distances (DTF, DK)

Christensen, L (2007): Switching from car to walking and biking for short trips (DTF, DK)

Dargay, J (2004): Evidence of transport inequality in Great Britain (U of Oxford, UK)

Dargay, J (2005): Car ownership in Europe – evidence from the European Community Household Panel (U. Oxford, UK)

Dargay, J and M Hanly (2004): Effects of land use patterns on car ownership and travel behaviour in Great Britain (U of Oxford, UK)

Dargay, J and M Hanly (2004): British Household Panel Survey (Univ. of Oxford, UK)

Dargay, J, L Hivert and D Legros (2006): The dynamics of car ownership in EU countries: an analysis based on the European Community Household Panel (INRETS, FR):

Diana, M (2004): The relationship between the specific (dis)utility and the frequency of driving a car (POLITO, IT)

Engebretsen, Ø (2005): Location and travel behaviour: An analysis based on geocoded travel surveys and studies of changes in urban land use (TOI, NO)

Fosgerau, M (2004): Dynamic time series models for Danish car ownership and use (DTF, DK)

Gaia, A (2006): Alternative methods and their reliability for the evaluation of transport social costs: An application to an Italian medium-sized city

Gelová, E (2005): Public transport in the CR: today successes and future chances (CDV, CZ)

Gühnemann, A (2005): An econometric model on the determinants of car registrations in Europe (IVF, D)

de Haan P and M Mueller (2005): Trends and changes in vehicle ownership in Swiss households (ETH, CH)

Hivert, L (2004): INRETS and « Parc Auto » panel survey (INRETS, FR)

de la Hoz, D (2006): Car Use in Madrid (UPM, ESP)

Järvi, T and J Rasanen (2004): Changes in the car fleet due to economy and taxation policies (VTT, FI)

Järvi, T (2006): Effects of changes in taxation of imported second hand cars on the Finnish car fleet (VTT, FI):

Kalinowska, D, Kuhfeld, H and U Kunert (2005): The diesel trend in Europe: does taxation matter ? (DIW, D)

Kalinowska, D and H Kuhfeld (2007): Assessment of car use and its determinants for Germany (DIW, GE)

Klementschitz, R and J Stark (2007): Mobility characteristics of car park users in Vienna and its surrounding provinces (BOKU, AU)

Krakutovski, Z (2007): Household transport survey in Skopje (UKIM, MAC)

Kohlová, M (2006): Travel behaviour and mode choice in the Czech Republic (CUP, CZ)

Lenz, B and C Nobis (2007): Mobility patterns and car use of women depending on household structures - the German case (DLR, DE):

Lian, J I (2004): Urban sprawl and transport - the case of Oslo and Bergen, a presentation of research activities at TOI (TOI, Norway)

Malasek, J (2004): Changes in travel behaviour in Warsaw (IBDIM, PL)

Malasek, J (2007): Latest trends in urban modal split in Warsaw (IBDIM, PL)

Meschik, M (2004): Mobility developments and supply deficits in rural areas. (Institut für Verkehrswesen, A)

Nielsen, J E (2006): Real estate ownership and the demand for cars in Denmark – a pseudo-panel analysis (DTF, DK)

Ottmann. P (2006): Car Use and Mobility: Changes over a Human Lifetime

Papon, F and L Hivert (2005): Analyses from French panel data on car rental and household car sharing (INRETS, FR)

Rocci, A (2006): Travel behaviour: a comparison of Paris, London and Nagoya on the basis of in-depth interviews (INRETS, FR)

Schmeidler, K (2004): Growing mobility and land use in Czech cities (CDV, CZ)

Schmeidler, K (2005): Transportation, urban planning and quality of life of urban population (CDV, CZ)

Schmeidler K and A Pesak (2005): Mobility of senior citizens in the Czech Republic (CDV, CZ)

Spassov, V and K Krastanov (2005): Car parking systems for Sofia, Bulgaria (HST, BG)

Vincent Lyk-Jensen, S (2005): Policy tools to influence vehicle purchasing behaviour (DTF, DK)

Vythoulkas, P (2006) Car ownership in Greece (NTUA, GR)

Vythoulkas, P and J Dargay (2007): Car ownership in Greece and UK: a comparison based on pseudo panel analysis (NTUA, GR and U of Leeds, UK)

Wróblewski, T (2005): Traffic management model with preferences for public transport modes in urban areas (RBRI, PL)

Yatskiv, I and E Yurshevich (2007): Transport network in Riga (Latvia): state, problems and perspectives (TTI, LV)

Zachariadis, T (2006): Engineering-economic simulations of sustainable transport policies (UCY, CYP)

Zachariadis, T (2007): Fuel consumption of European cars: the effect of standards, taxation and safety (UCY, CY)

WP 3 Overview of national transport survey

Jimmy Armoogum and Kay Axhausen

1. Introduction

Changes in behavior are necessary to reverse worrying long-term trends of growing mobility, with increasing oil consumption and GHG emissions. Most data on mobility are collected through conventional instruments. The analysis of changes in behavior supposes the comparability of these instruments over time, but also between countries and urban areas all over Europe. Travel survey data are needed, both to portray the existing situations and to help identifying problems related to the operation of transport systems, and to estimate/validate the models, which are quintessential for planning activities. In fact, the most typical (and more difficult) need is for data to allow calibrating the strategic transport-planning models used to forecast the effect of medium to long-term policies for project evaluation and environmental assessment.

A first issue is whether these surveys are conducted from time to time (generally with increasing time intervals) or on a continuous basis (e.g. in the U.K., the Netherlands or Denmark). New technologies may have a large potential to bring better quality. Since all data needed for a comprehensive analysis of changes in behavior can't be collected in the same survey, pairing different data sources (e.g. trip based surveys with time use or family expenditure surveys) is an important issue.

We will focus our attention in this synthesis in 3 topics:

- Temporality, for the description and analysis of trends, as well as of changes in behavior, conventional travel surveys (only one week day in winter out of school holiday periods, i.e. when traffic flows are maximal) are not enough: for environmental issues, mobility has to be described all along the year (e.g. 24 hours of the day, seven days of the week, and even possibly all seasons of the year, i.e. 365 days);
- The use of new technologies may decrease the survey cost but they have good impact an the data quality, for example Web based survey may improve response rate and the quality of the responses and new devices like mobile phone, GPS and Galileo may help at improving the accuracy for time (departure, arrival, trip duration) and location (origin, destination, trip distance);
- Other interesting methods, such as qualitative approaches may help at getting ideas for data quality and innovative quantitative analyses of mobility surveys.

2. Temporality

Recent years show that the transport demand development in developed and developing countries is increasingly characterized by external factors, e.g. processes like economic growth or stagnation, growing or declining incomes, demographic changes like the ongoing process of overaging in numerous western societies, the globalization with the impacts on working structures, income developments and even changing political structure as the upheaval in Eastern Europe and now the integration in the European Union.

In view of these developments, numerous endogenous interventions i.e. interventions in the transport system (telematics, public transport improvements, high speed rail-systems) have been conducted or are at least planned.

It can be assumed that not only these endogenous interventions initiate the future intended behavior al changes but also exogenous transport-related aspects, e.g. types of housing, changes in working patterns and increasing leisure time. The impacts of all these developments become clearer if one tries to understand them as behavior al changes resulting from changes of temporal, monetary and organizational budgets and regimes as well as the personal status on the individual level.

On the other hand it is necessary to understand, in which way measures and interventions are likely to impact individual behavior. This makes it necessary to get a clearer image about individual behavior and the impacts determining it. Budgetary implications are also an important consideration in deciding to move to a continuous survey. Indeed, it is easier to obtain funds when up and running (each year almost the same budget), than for one "big bang" survey. With a periodic survey there is an uneven requirement for funds, so large amounts have to be found at the time of the survey. If the political climate is not conducive to providing this funding, the survey could be delayed or not undertaken at all. It is acknowledged that a withdrawal of funding could occur at any time during a continuous survey, however it is anticipated that if the survey is progressing successfully and producing relevant results, its prospects of continued financing would be enhanced. It is also expected that there might be significant economies of scale from undertaking the survey on a continuous basis.

In most countries and urban areas, personal travel surveys, are conducted infrequently (e.g. every decade) and using evolving methodologies which often make the comparison difficult between subsequent surveys for the assessment of trends (e.g. when the American NPTS has shifted from a trip-based to an activity-based approach). These one-off surveys are subjects to unpredictable events (e.g. strikes or extreme weather conditions) and do not allow a clear distinction between long-term trends and short-term events (economic boom or recession). Another important question for continuous surveys is:

- either a new sample each year, but drawn with a strong geographical (e.g. in the same post-code sector in Great Britain or the same block in Sydney or New Zealand) and temporal (a pre-allocated day is essential, contrary to what is done in France) set up, or
- a true panel survey, which allows measuring changes at an individual level if the survey period each year is long enough (seven days is better than two days); the drawbacks from selection bias and attrition are lower with a rotating panel (e.g. each household withdrawn after three years).

Although there are many advantages associated to collecting mobility data on a continuous basis, managing to do it in practice is not easy. We have considered advantages and drawbacks of their methodologies according to:

- survey administration: training and fatigue of interviewers, etc.,

- sampling issues: subsequent cross-sections vs panel survey, sample size, weighting, etc.

Panel survey is an important issue to be addressed (attrition bias, refreshment, etc.) as well as the specificity of nationwide vs urban mobility surveys.

2.1 Continuous surveys (excluding panel survey)

Most of ongoing continuous mobility surveys data are collected in Europe or in the southern hemisphere but very few of them are at national level (Great Britain, Denmark, The Netherlands and New Zealand). Indeed there are a large number of regional level surveys (Melbourne, Sydney, Perth, Santiago, Halle, Leipzig, Nuernberg, Burgenland / Niederoesterreich, Wien and Wiesbaden) probably because, it's easier for a region to fund a survey when the budget is spread on many years than for a country. Regional continuous surveys from the Southern Hemisphere are wide enough areas to enable analysis on urban sprawl, which is a major determinant of changes in travel behavior.

The specificity due to unpredictable events can be checked by comparing to other periods, and surveying all over the year allows to control for seasonal effects (e.g. long distance trips for holidays, bicycle use, walking, etc.). Moreover, subsequent years can be aggregated for the analysis of sub-groups (e.g. regions). A critical deficiency of discontinuous surveys is that there is an unavoidable loss of staff and knowledge in the inter-survey period which has to be re-established for the next survey. This applies to both project management staff in the government organization conducting the survey, and staff in the market research organization conducting the fieldwork. According to British experience, the team has to remain the same at the sponsor level, even if the field organization can change after a new tender, and it is worth to notice a recommendation from Sweden to avoid a loss of motivation once the contract is obtained. However in Denmark, the main reason for the substantial increase in the zero trip rate can only be related to interviewer performance: an increasing number of interviews were conducted by a small number of interviewers with much higher zero trip rates than the rest.

For all type of surveys (continuous, cross-sectional surveys and panel surveys), response rate is declining. This is a potential cause of discrepancy between national accounts or traffic counts and survey results (For instance in the Netherlands, the response rate had fallen from 51% in 1985 to 35% in 1998). A solution would be to re-design the survey, but this introduces some heterogeneity in the time-series. Taking care of respondent burden should maintain "high" the response rate, for example in the Netherlands, as well as in the German urban areas where the New Kontiv design is also used, it consists in:

– asking respondent as little as possible (e.g. pre-coded items + an open answer);
– letting respondent to choose the survey instrument (face-to-face, phone or preferably mail back), and thus obtain a lower non-response rate for households only accessible by mail;
– proposing optional follow-up surveys to obtain additional data for specific subgroups (e.g. disabled people, children under six) or research topics (e.g. public transport, road accidents);
– decentralizing the organization: everybody involved in the interview process has to know as much as possible about the survey.

2.2 Panel surveys

In the past, data collection for infrastructure planning used to be oriented to traffic modelling and focussed on peak hours for an "average" weekday i.e. when the volume of traffic is maximal. But as the main interest now is shifting from designing infrastructure to a better understanding of individual behavior to be able to influence it in a way that improves the use of our infrastructure. If one wants to understand, how people behave, in which way they are behaving in different situational contexts data are necessary which are catching the same people in different situations. Indeed, the variability in behavior, the flexibility of a person to react and the identification of constraints and regimes can only be detected from a perspective, which is in temporal terms long enough. Moreover, it can be argued that a solution to environmental issues is a change in travel behavior towards a more sustainable mobility. However, the usual cross-section or snapshot-oriented surveys of the behavior of one day give only poor descriptions of ongoing changes and hardly allow to distinguish real changes in behavior from external evolutions caused by specific trends in their explanatory factors (for instance, low growth rate and high unemployment in Continental Europe during most of the 90's).

The main two advantages to achieve panel surveys such are:

- They allow the measurement of effects of any changes in external factors for individuals and households. A contrario, the repetition of cross sections only allows for comparing aggregate values or margin distributions (net-changes): by means of panel surveys it is possible to catch also the gross-changes within the transition matrix and
- Using the temporal and intrapersonal aspects the building of models about the dynamics of change is becoming more promising.

There are also some drawbacks:

- Panel conditioning, people are adapting their behavior to the topic of the survey. That is a problem in surveys in which attitudes or opinions are asked. It can be assumed that this case is not critical for the case of surveys about transport behavior and activities;
- Attrition, mortality and fatigue effects;
- The sample, as for panel surveys it’s primary to have volunteers to respond for many waves, it’s not easy to have purely random sample;
- Selectivity phenomena, as a consequence of these biases it becomes likely that a multi-stage recruitment process and repetition within a panel certainly creates selectivity related to the characteristics of participating households;
- Refreshment of the sample, for a “running” panel always kept up to date it makes sense to keep it representative by replacing the drop outs by new households (rotating panel). A simple replacement of drop-outs by households with the same (socio-economic or demographic) characteristics would be a solution, but it would be better to distinguish between “new units” (e.g. young individuals who have just left the household of their parents) and “rotating units” who replace drop-outs.

The selective impacts on the data quality have been studied for the German Mobility Panel. The middle Class is over-represented (good education, good income, middle aged); there is a mobility interest bias: drop out of non-trippers (particularly elderly, with permanent disability). Considering the heterogeneity between its members, surveying households counter-balances selectivity. From a larger perspective, one can conclude that balanced recruitment of different mobility styles is vital. It is important not to trade data quality for a high response rate, especially in the case of a panel survey where the quality of data is crucial for the measurement of changes.

A sample scheme chronologically and geographically balanced (even if not a panel) can improve the accuracy of time-series. It is important to choose a survey design giving a high and non-decreasing response rate (e.g. the New Kontiv) and a permanent and motivated staff is essential. In the future, new technologies (e.g. follow-up by GPS or GALILEO) could help surveying during longer period, providing more accurate data on the spatial and temporal framework of mobility, with a relative low burden for interviewees.

3. Use of new technologies

New technologies such as automatic satellite localisation and mobile phone may improve the accuracy of the temporal framework (departure and arrival times, trip duration,...) and of the geographical framework (location of activities, origin and destination, trip distance, itinerary...) of each trip. In addition, computer assisted interview systems allow the detection of errors during the interview. Geo-coding encounters problems, on which there are experiences to share. Beside these improvements, the utilisation of new technologies may reduce respondent burden and the survey cost which should have first-class impacts on data accuracy and quality.

3.1 Web based survey

The development of web-survey in many domains is very fast. It is therefore important to analyze if web-based survey could be helpful for collecting travel data.

There are some obvious advantages to collect data with a web-base survey, such as:

- Interactivity, this advantage is shared by all computer-assisted survey. Web-based surveys allow real-time entry of data which improves the data consistency and quality;
- Availability of the interviewees to the respondent when they are vacant to;
- Confine individuals who do not respond to other survey modes. People who travel the most are often more difficult to contact by administered surveys, in particular because they are less often at home. Web-based surveys, like postal surveys, allow respondents to make contact and respond when they wish to;
- The survey cost is low, because there is no need to have interviewers, no need to enter data;

There are also some drawbacks:

- There are no sampling data bases that are representative of the whole population;
- Likes other self-administered survey the response rates are low;
- Measurement errors may cause serious bias as definitions of mobility concept are not so trivial;
- Technical problem such as the server unavailability, soft browser (presentation of the survey on the screen), excessively long data loading times (high speed/low speed internet), …

The use of the Web for transport surveys is likely to increase, in the same way as its use by the population. In view of the problems of coverage and Internet skills, its application as a single survey instrument is for the time being mainly restricted to the study of a specific population for which the construction of the sample can be controlled. Its use as a survey mode in combination with others is very promising in view of the steady rise in non-responses for other survey modes in many countries. As household travel surveys response rates are decreasing. To reduce this bias of non-response Bonnel & al. (2007) have tested a web-based survey in parallel of the household travel survey on the area of Lyon. The idea is to propose to those households who refuse to respond or are not reachable after a certain number of attempts to respond by the web. The two main objectives of this research are to test the feasibility of a web survey for non-respondents and compare mobility results of both survey modes.

The importance of the Web for marketing surveys is increasing considerably and seems particularly suitable for SP surveys involving controlled samples. Even in countries where access to the Internet remains quite limited, the Web appears to be quite useful for surveying a targeted population in the context of SP surveys (Hojman *et al.*, 2004). The authors give the example of two Web-based surveys conducted in Chile to determine willingness-to-pay to reduce accident risk which have given results very consistent with those from other studies. However, beyond these application domains, it is necessary to specify the domains and conditions, in which Web-based surveys are applicable, both when it is the only survey mode used and when it is combined with other media.

3.2 GPS based survey

In the travel behavior field, since the mid 1990s, attention has focused on the potential of location-aware systems such as GPS (Global Positioning Systems), RDS (triangulation on FM radio stations) or GSM (Global System for Mobile communications). RDS is interesting for freight transport or long distance travel, but does not provide accurate enough data for the analysis of daily mobility. Initially, the use of GPS was mostly limited to travel in private motor vehicles, because the power requirements of equipment in continuous use could easily be met with a connection to vehicle electrics, the problems of reception were minimized, and the linking of movement to ground features was simplified by staying on road networks. Nevertheless, even in the 1990s, some experiments took place to use GPS to survey personal mobility in all modes of transport and off road networks. These successful experiences in the US, in Canada, in Japan, in Australia or in Europe have been conducted on relatively small samples, generally at a local/regional level. Very positive technical improvements (smaller units, better precision, greater storage capacity, less power-hungry units) and decrease in prices allow its application to large scale surveys like National Travel Surveys, and let us hope that it could replace conventional methods in the future. This paper describes the design of a first nationwide experience embedded in a traditional survey, which is an opportunity to compare measurement tools before a larger use of new technology, while keeping the ability to measure long term trends.

Data accuracy is a combination of sampling errors and non-sampling errors. Therefore it is not obvious to compute confidence interval due to the non-sampling errors such as non response errors and measurement errors. Because respondents are often not able to describe exhaustively their travel behavior and have a vague or even biased perception of the main characteristics of their trips (for instance the distance traveled). Interviewees are generally unable to describe their mobility with the accuracy suggested in the questionnaire (e.g. in the 1993-94 NTS, 1 min for departure and arrival time, 1 km for car annual mileage and daily mobility, even 100 m for trips under 2 km). For most analysis we do not need so much accuracy, but we have to be aware that rounding modify variables' distributions.

Summarizing the main findings obtained by comparing different instruments used in previous NTSs, it appears that:

- Time variables are less rounded when reported in diaries than when collected by interview;
- Fortunately, memory effects affect time (of departure or arrival) more than duration, which needs to be known more accurately especially for modeling;
- The deterioration due to memory obviously increases when the facts reported have occurred a long time before the interview (during the last weekend or three months ago);
- The car-diary is more accurate than the other methods, probably because of the clock which is displayed on most car boards.

The measurement of trip distances is also an important issue. Controlled by the odometer, trip distance is well estimated by car diaries. If we compare trips by class of crow-flight distance between origin and destination, we notice a substantial underestimation of trip distance for trips with their origin and destination in the same municipality (about 25%); this underestimation is also observed for travel time, but it is less important. For longer trips (between municipalities within 15 km) the underestimation has dropped from 10% in the weekly stage-diary of 1981-82 to 5% in the 1993-94 interview. This improvement is probably due to the local maps which were given to interviewers. On the other hand, long distance trip length seems a little overestimated.

In many surveys concerning car use a question is asked on the mileage driven on different types of network (generally motorways, urban networks and normal roads). Often it is only a yearly proportion, but it is sometimes more precise (e.g. during one week in the SECODIP panel). In the 1993-94 French NTS we asked for the distance driven on these three types of network for each trip made by individual modes of transport (car or two-wheels, as driver or as passenger). The maps given to interviewers could be used to check these distances. For comparison with vehicle based data sources, only car driver trips are considered here. The proportions of "Road" and "Urban network" depend on survey methods: more precise is the question (referring to recent trips), lower seems to be the share of urban traffic. It is even lower when we modify the initial answers according to the geographical characteristics of the origin and destination of the trip (in the same urban area or in the same rural municipality).The different estimates of the share of motorway traffic are convergent. It increases as new infrastructures are built. However it is about 10% higher than traffic count data, because people consider many roads offering a high level of service as motorways although they do not have this administrative status (e.g. the ring road around Paris).

Since households are reluctant to answer questions on types of network used, because they have a too vague idea of real figures, in the main part of the 2007-2008 NTS we will derive this information from origin/destination through a network assignment software. The sub-sample of GPS data will allow to check for the quality of this assignment.

However a GPS datalogger allows the measurement of some details that are never given by respondents in conventional surveys:

- Description of very short trips, which are often forgotten;
- Route choice;
- Precise information on access/egress time and waiting time;
- The description of short trips made from an unusual place of residence (e.g. during holidays or long professional trips).

Moreover, the relatively low burden for the respondent (once she/he is trained) allows substantially extended survey duration: at least one week with GPS, compared to two days with the conventional questionnaire. The gain in accuracy is less because of cluster effect (travel patterns are quite similar on weekdays for the same person).

We should point out, that there are some drawbacks such as:

- A device problem such as energy (battery last about 15 hours);
- A signal reception problem;
- A problem from the interviewee, for example:
    - The interviewee may forgot to take the GPS receiver with him (for some trips; some days ...);
    - The interviewee may borrow the GPS receiver to another person;
    - The interviewee may want "to play" with the device and therefore we record more trips than it should be.

But the last item may happen also in "conventional" survey, especially in face to face interview, where the selected individuals want to appear socially well integrated and therefore may not describe what they think it is not acceptable and may invent some other records.

GPS is certainly a promising technology for surveying travel behavior, because it provides much more accurate spatial and temporal data than conventional methods. But raw data are not directly usable:

- Traces are not segmented;
- There are missing segments;
- There is information neither on transport means nor on trip purposes.

Thus, for post-processing these data, more or less sophisticated software packages have to be elaborated depending on the accuracy needed by the users (e.g. much more spatial accuracy for the assessment of advertising by posters than for other users of travel survey results). To reduce interviewees burden, research program should focus on:

- Imputation of modes and transfer places from average speed and its variability, route, etc.;
- Imputation of purpose from destination location, arrival time, etc.; and
- On longer term, the question of missing data: automated reconstitution of continuous sequences in space as well as in time (omitted parts, technical problems).

The comparability with data collected in the other countries is also important. EUROSTAT harmonizes several surveys in most of Member States in Europe (e.g. on time use or family expenditure), but nothing seems to be planned for surveys on daily mobility. The generalization of GPS-based survey may introduce some data harmonization.

4. Other survey methods

4.1 Qualitative approaches

The qualitative method has the advantage of being able to identify information that could not be captured through the questionnaire, from the speech and story of individual's perception and experience. This approach emphasizes the individual circumstances and highlights the complexity of the systems of shares actors, which is hardly observable by the quantitative approaches. By highlighting the diversity of hits, models of arbitration and the different systems of constraints related to it, this approach makes it possible to understand in greater detail individual choice. The main drawbacks of such technique are they are not representative of to population (the sample size is very low according to more quantitative approach) and it's burdensome (duration of an interview may last for hours).

Mixing approaches qualitative and quantitative

Qualitative approaches have its strengths and weaknesses, as well as the quantitative approaches, we must try to exploit and maximize the benefits of both, In the case of a mixed methodology, the sample quality can be reduced because it has no representative referred or completeness. Interpretation of results is made easier while taking a lot of information from both the qualitative and quantitative be crossed without technical assistance. Some crosses or results may escape the sagacity of the researcher.

If we have no a priori on the subject of study, it is clear that a qualitative phase is essential before drafting a quantitative survey. A return to qualitative approach after a quantitative phase could clarify the meaning of the results and explain them. Indeed, therefore, qualitative approach can be used to complement the quantitative approach at different levels:

- When we have to produce a quantitative survey questionnaire, the qualitative approach should help to ask to adequate questions and also its modalities (different categories) and;
- When we are analysing a quantitative survey,, a qualitative approach should aim to enrich, and provide lighting and meaning to the results;

It's difficult with the qualitative approach to generalize the results, we only can show a typology of behavior. Due to the complexity and diversity it's complicate to produce correlation statements of individuals surveyed (complementing ad contradicting at the same time). While the qualitative approach has a clear interest in terms of thorough understanding of the behavior, it is not enough by itself to political decision-making. Indeed political action based on a few instances would certainly be doomed to failure without a macroscopic. If the qualitative studies offer insights essential to understand the behavior, to work in politics becomes necessary quantification.

4.2 Biography

Mobility trends on the long run have raised growing concerns about sustainability issues. The knowledge of mobility partly relies on household transport surveys. In France, such surveys have been conducted nationally four times since 1966, giving four cross-section points about the nation's travel behavior. But the derivation of change over time from comparing these four points lacks insight in two respects: the monitoring of individual change in behavior , and the narrative of a history of mobility. For both of these aspects, biographic surveys can bring new field data.

While historical sources describe the history of transport technology and the economic and social changes involved, asking people which mode they traveled in years as early as 1930 can record enough data from the persons' memories to enable the writing of a history of mobility, with the following details:

- studying the development of motorization, both two and four wheelers, from 1920 onwards by social category and geographical area;
- re-constituting modal share and mileage since 1940 for home to work travel, and since 1930 for home to school travel, of from 1940 for all purpose, by using existing household travel surveys conducted in 1966-1974-1982-1994 to adjust the fitting of the results, and stratifying by type of place, occupation, age-gender, taking into account the structural evolution of population and differential survival laws by categories;
- focusing on the mobility transition from walking to the car, that took place in France in the 1950's before any transport survey, and in particular its geographical, social and generational diffusion;
- understanding the stakes of this evolution for sustainable development during the 21st century, inertias and possible inflections for the future.

In France, biographic surveys have been conducted on other topics, such as "family, work and migration biography survey" by INED in 1981 (Riandey, 1985), "biographies and entourage" by INED in 2000-2001 (Lelièvre et al. 2002), or "history of life" by INSEE in 2003. Lelièvre (1999) supervised a review of 14 previous biographical surveys.

Transport biographic surveys have been conducted in the UK (Pooley and Turnbull, 2000) and are developed for Switzerland (Axhausen, 2006). For the next French National Travel Survey, a new biographic section has been introduced. The survey is based on a chronological grid where all events are recorded (four elements are asked: place of residence by municipality; number of motor vehicles (two- and four-wheelers) available in household; main activity (school or work) and place of activity by municipality; usual transport mode for commuting, or overall if no commuting occurs). The main expected outputs of these additions are the following:

- a better understanding of personal travel behavior through the individual's personal history, making it possible to assess the likelihood of future changes, with far greater appropriateness than the usual cross-sectional elasticity estimates and

a sketch of the general history of mobility in France from 1930's, with adjusted vehicle ownership, modal share and commute mileage, where historical sources are lacking quantified data;

5. Conclusion

Within the last four years of this COST action about 50 papers have been produced, and some of them address statistical methods such as:

- sampling issue, with a paper on regional sample add-on the German mobility Panel;
- non-response and how to avoid the decline of response rate in a continuous survey;
- measurement errors, in the analysis of interviewers effect on the number of reported trips;
- data fusion, by adding the trips expenses in a mobility survey;
- small area estimation, by building a synthetic population for mobility estimation at local level, etc.

We have many presentations of mobility surveys at local and national level, unfortunately they are not harmonized which complicate international comparison at the mobility level. It's impossible up to now to study the impact on mobility of a policy at an European level.

In the future the use of GPS devices to collect mobility survey should aims not only at gathering high level quality data but also at helping on data harmonization with a probable change of the mobility definitions .

This cooperation was an opportunity for young researchers to present their work.