Which socioeconomic factors explain CO_2 emissions relating to individual mobility?
2007 French National Transport Survey example

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Summary

Environmental concerns are at the very heart of current political debates. Taking account of people's mobility behaviour and knowledge of the resulting carbon dioxide emissions are therefore essential in the combat against the greenhouse effect. Emissions relating to mobility of the French population have been calculated using travel information gathered during the 2007 National Transport Survey.

Emphasis on the different socioeconomic factors conditioning mobility behaviour of the individuals surveyed provides better knowledge of mobility trends. It also enables better targeting of carbon dioxide emission reduction policies by better defining their stakes in terms of sustainable development and taking account of their social impacts.

In this article, after presentation of the calculation method for these emissions, two major types of mobility, of very different dynamics, will be discussed: local mobility and long distance mobility. The socioeconomic factors explaining individuals' behaviour and the resulting emissions will then be analysed.

Keywords: *CO_2 emissions, greenhouse effect, socioeconomic analysis, individual behaviour, 2007-2008 national transport survey, local mobility, long distance mobility.*

Introduction

In 2005, transport represented 27% of greenhouse gas emissions in France, of which 75% were caused by road transport (MEEDDAT, 2007). According to a recent OECD report, petrol demand could increase by 1.3% per year from 2004 to 2030 (OECD, 2008). Such a situation would lead us to question the future of the transport sector and more exactly, people's mobility.

This leads us to the concept that it is essential to have better knowledge of the impacts of individual travel movements in terms of carbon dioxide production. The emission inventories regularly produced in France are only provided by geographical region (CITEPA, 2008), and do not give information about individual behaviour. Yet, only specific surveys on individual travel movements can help to better target reduction measures for pollutant emissions.

The National Transport and Travel Movements Survey of 2007 was the fifth transport survey of its kind in France, conducted by the National Institute of Statistics and Economic Studies (INSEE). Like previous studies, the survey's aim was to gain a panoramic view of the French population’s mobility in terms of modes of transport (both individual and collective), reasons for travel and type of vehicle used.

This very complete survey provides information about the individuals questioned, mode of transport used, combination of several modes (intermodal transport arrangements), reasons for travel, the individual’s geographical location, date of travel and distance travelled. It also enables measurement of the impact of urban sprawl on local daily travel movements.

The aim of this article is to firstly present the methodology for calculating carbon dioxide emissions stemming from mobility in France. We will distinguish between two types of very different mobility: local mobility and long distance mobility. We will then focus on the socioeconomic characteristics of the people surveyed using a typology designed to answer our main questions: Who travels? Why do they travel and what is the impact in terms of CO_2 emissions?

1. Estimation methodology for CO_2 emissions relating to travel movements in France

1.1. French National Transport and Travel Movements Survey

Led jointly by INSEE and the French Ministry for Sustainable Development (MEEDM), the National Transport and Travel Movements Survey (ENTD) was conducted on over 20,220 households in France between April 2007 and end of April 2008 (INSEE, 2008). Interviewers visited the individuals surveyed twice at their homes. Between these two visits, households were to complete a car logbook, indicating the total number of travel movements made with their vehicle over a one-week period, an a dosser of descriptive datasheets about the vehicles available for their use.

At the start of the interview, the interviewer randomly selected two individuals, aged 6 or over, capable of answering the questions. The first person gave information about his/her travel movements from the previous day (Friday if the interview was held on Monday) and from the weekend before the day of the survey: 115,134 travel movements were thus recorded. The second person was asked questions about his/her long distance travel (80km as the crow flies from home) undertaken during the three months preceding the survey: 18,718 further travel movements were thus recorded. This second person was chosen by favouring the household member most likely to travel long distances (for example, the father).

All the households surveyed provided information about their socioeconomic conditions as well as about the vehicles available to them. Given the issue we would like to resolve, socioeconomic factors provided a basis for behavioural analysis of people’s travel movements and information about vehicles helped to precisely calculate CO_2 emissions using equations provided by the COPERT 4 model and French Environment and Energy Management Agency (ADEME) data from the 2008 Deloitte report.

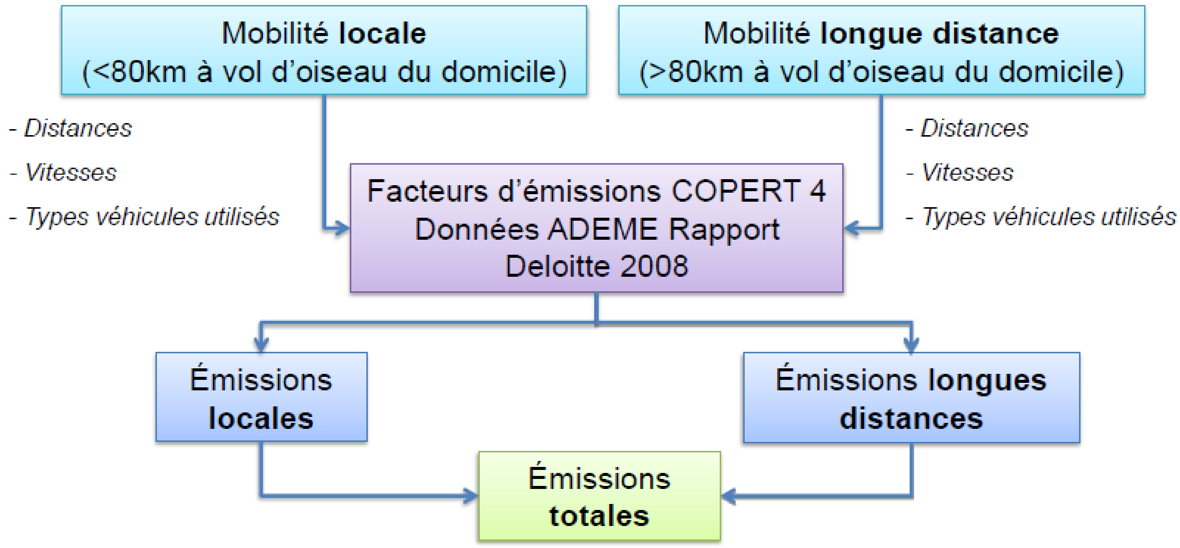

Figure 1: Schematic diagram of CO_2 emissions calculation methodology

1.2. CO_2 emissions calculation hypotheses

Continuing upon the work completed by the National Transport Survey of 1994 (Raux et al. 2005, Nicolas, David, 2009), we calculated CO_2 emissions stemming from the travel movements gathered during the 2007 survey by using the calculation hypotheses detailed below.

The database of information supplied is very rich. Two main tables served as support for processing this data:

- "Local travel movements" table produced using the file of weekday and one or two weekend day trips (115,134 travel movements from the first person surveyed from the household), of which only travel movements of less than 80km from home were taken into account (98% of all travel movements).
- "Long distance travel movements" table which brought together information about the journeys made by the second person surveyed during the 13 weeks preceding the interviewer's visit. This file included 18,718 travel movements in total, of which we kept only those of over 80km as the crow flies from the home. It should be noted that long distance journeys, less frequent than local daily travel movements and gathered over a longer period of time, are described a little less precisely than local mobility.

All travel movements, both private and professional, were taken into account in these two tables. Only work travel information for people whose job requires extensive travel (truck drivers, delivery people, taxi drivers, etc.) has been omitted. What is more, given our issue to be resolved, much of the other survey elements were also used. As such, the socioeconomic characteristics of the households and people surveyed provided a backdrop for behaviour and travel movement analysis. Detailed description of vehicles used also enabled more precise calculation of CO_2 emissions.

It is important to acknowledge that whatever the type of mobility, cars are the privileged mode of transport in France: used for more than 70% of the total distances travelled. Other modes of transport appear more marginal in terms of distances travelled: air (12.2%), rail (5.9%), urban and regional public transport (7.2%) and others (3.5%). All calculations of their CO_2 emissions were made using the COPERT 4 model (cars, motorbikes, buses and coaches) and using the ADEME emissions report (trains and planes).

We first spent time going through the data. In particular to make up for various lacking data and to put to one side any incongruous values. It is also important to mention that, contrary to the 1994 survey, distribution of the distances travelled by type of road system was not provided and it was not possible to estimate the average speeds depending on the type of trip made. We therefore used traditional calculation of average speed. Once speeds were calculated and technical characteristics of vehicles reconstructed, we proceeded with drawing up vehicle categories as recommended by ADEME within the scope of using the IMPACT DEED application. These categories were created according to vehicle age, engine capacity, taxable horse power and fuel type used. Each vehicle was classified under an Individual Vehicle Category (IVC) for which energy consumption and carbon dioxide emissions could then be recalculated using the COPERT 4 equations.
The CO_2 emissions calculated in this way were allocated to the person surveyed, proportionally to the number of passengers in the vehicle.

For other modes of transport, in particular air, rail and public transport, we used the average emissions per traveller.km given in the ADEME Deloitte report (2008). This method gives average coefficients results which were used to calculate total emissions for each trip. For some travel movements, in particular air travel, we only disposed of the origin and destination of journeys. Hypotheses of distances travelled in accordance with external data helped us to make the most realistic estimations possible. The table of emissions shown below gives an idea of CO_2 emissions per traveller.km in terms of mode of transport chosen and average number of passenger rates.

Local mobility	
Mode of travel	**gCO_2/pass.km**
Un-motorised (walking, bicycles, etc.)	0
Motorised 2-wheels	83
Cars	177
Urban & Regional PT	43
Other	34

Long distance mobility	
Mode of travel	**gCO_2/pass.km**
Un-motorised (walking, bicycles, etc.)	0
Motorised 2-wheels	42
Cars	105
Urban & Regional PT	49
Plane	128
Train	10
Other	83

Table. 1: average CO_2 emissions from different modes (g/passenger.km)

2. Which factors impact travellers' CO_2 emissions?

People's socioeconomic status conditions their travel behaviour. Analysis of these factors and their impact on CO_2 emissions provides better understanding of travel behaviour and therefore emission trends. It can also help to better target sustainable development policies. We saw that we can distinguish between two major types of travel, with very different characteristics: local mobility and long distance mobility. People's socioeconomic determining factors are therefore presented separately and distinctive analyses of individual determining factors are given.

2.1. Local mobility, long distance mobility: two very different modes of travel

The French population generates approximately 820 billion traveller-km per year. Whatever the type of mobility, cars are the privileged mode of transport in France: used for more than 70% of the total distances travelled. Other modes of transport appear more marginal in terms of distances travelled: air (12.2%), rail (5.9%), urban and regional public transport (7.2%) and others (3.5%).

In the next part of this article, we have distinguished between two types of very different travel which both imply specific methods of information collection:

Local mobility lists all trips made in a radius of less than 80km as the crow flies from home, undertaken the previous day and weekend preceding the interview. On a national level, in 2007 this type of travel corresponded to 160 million daily travel movements (an average weekday), in other words 98.7% of all travel movements inventoried and almost 60% of the total distances travelled. Local mobility therefore represented an average of 20 trips and 167 kilometres per week and per person, in other words approximately 8,700 km/year/person.

Long distance mobility includes journeys made more than 80km as the crow flies away from home during the three months preceding the interviewer's visit. There were approximately 197 million travel movements of this kind over a period of 13 weeks, in other words 14 trips per year and per person representing 5,900 km/year.

So while local mobility corresponded to 98.7% of travel movements for 60% of all distances travelled, long distance mobility respectively corresponded to 1.3% of travel movements for 40% of the total distances travelled.

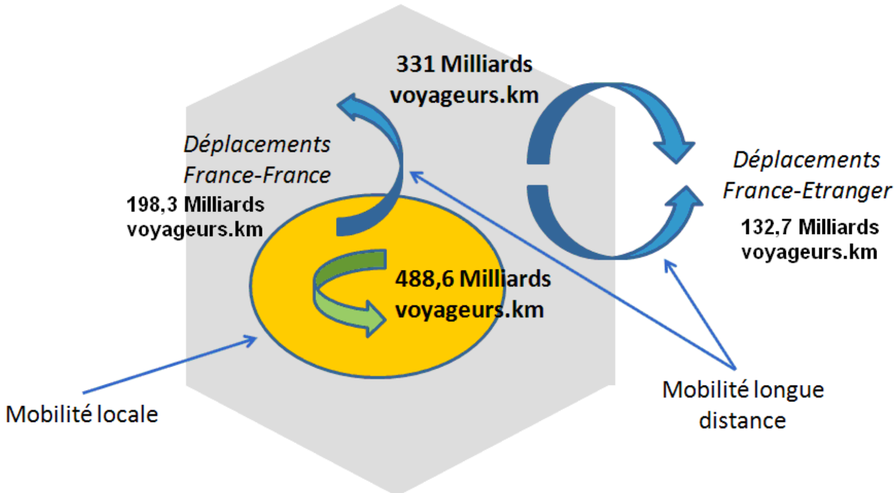

Figure 1: Spatial level covered by the survey

The modes of transport used varied as a consequence. The car remains the main mode of transport in both cases, but drops from 85 to 51% of the kilometres travelled between local and long distance, to the advantage of air travel (30%) and rail (14%). In terms of CO_2 emissions, excessive aircraft emissions are compensated by the excellent performance of trains and coaches and out of the 1,924 kg emitted on average per person, per year on travel, 70% (1,358 kg) comes from local travel and 30% (566 kg) from long distance travel, in proportion to the distances travelled.

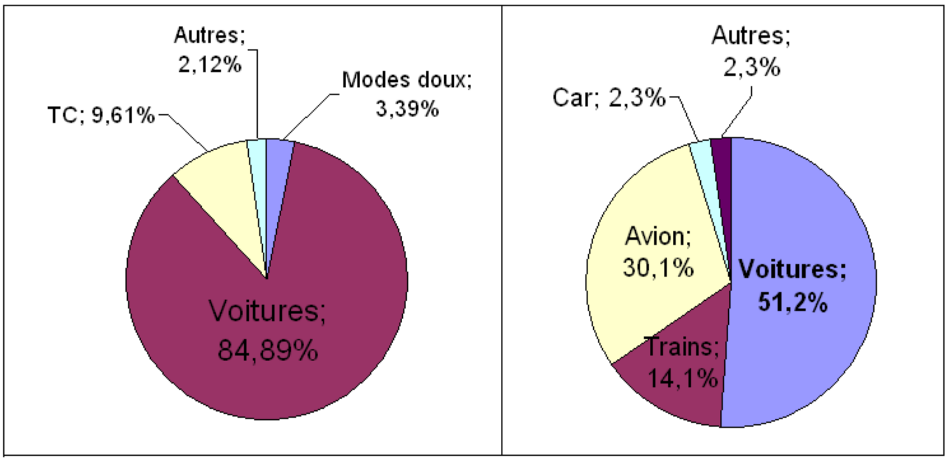

Figure 2: Modal share of local and long distance mobility relatively to distance covered

2.2. Status, income and location: the 3 key variables explaining mobility and CO_2 emissions

Previous studies (Nicolas et *alii*, 2001, local level; Raux et al., 2005) highlight the main factors explaining individual mobility which have served here as an analysis grid for emission results. Four amongst them emerge in particular:

- ✓Status (school pupil, student, working, unemployed, at home or retired), largely matching up with age and life cycle, and influencing the activities which structure and give rhythm to daily life.
- ✓Household income level, given in terms of consumption units[1], is divided here into 6 equal categories. Household income level always facilitates access to private cars for people of driving age, even though car use is widespread today (Dupuy, 1999); it also opens up wide possibilities for long distance leisure travel.

[1] Due to the economies of scale within the household, INSEE proposes counting the first person as 1, then all other adults as 0.5 and children under 15 as 0.3.

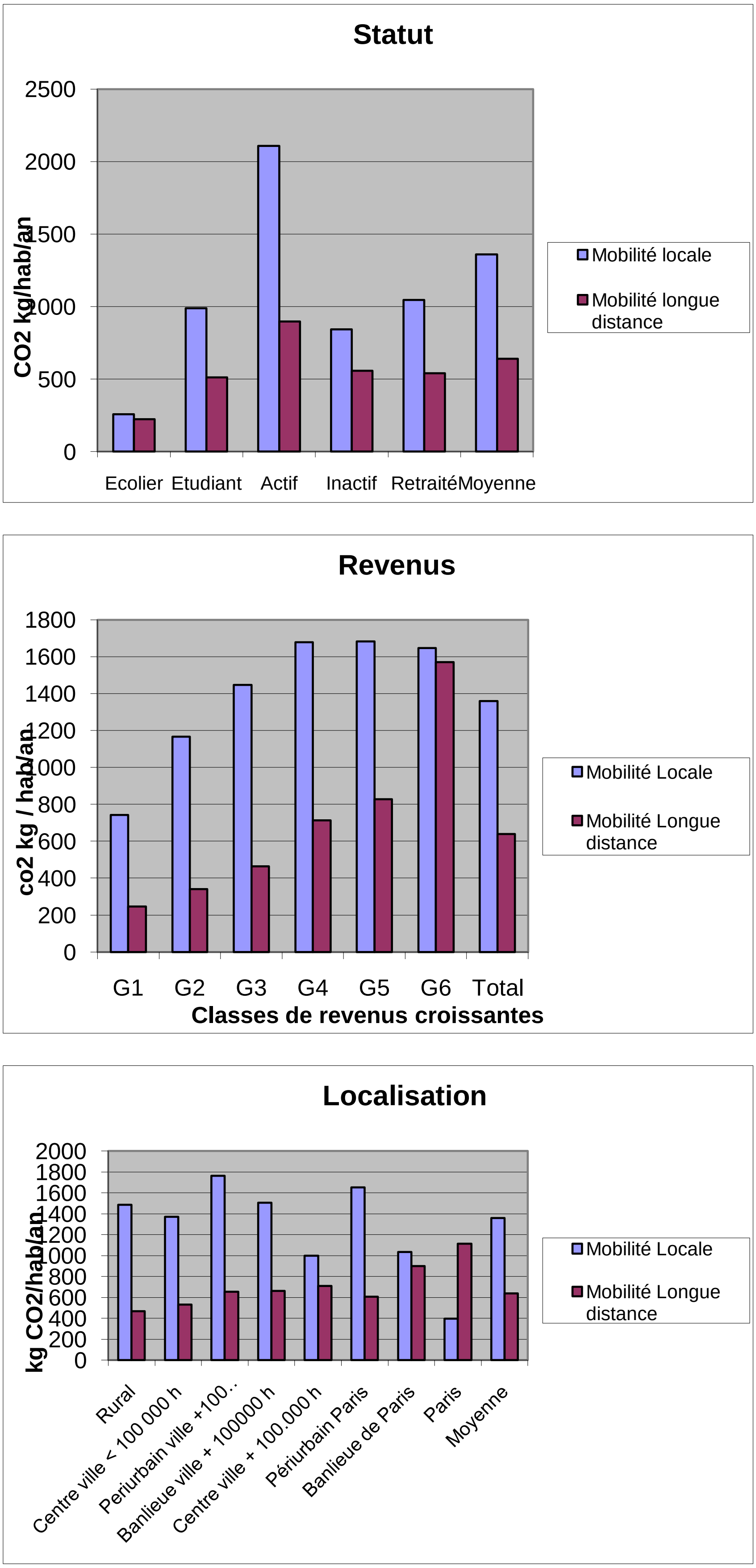

Figure 3: Average CO_2 emission (kg/year) and individual characteristics

For local daily mobility, status and home location play the most important role. Access to a car is also a noteworthy factor amongst people of driving age.

Working individuals, compelled by their home-work travel movements, cover much longer distances than others and tend, as a result, to use a car for local travel during the week (225 km/week, of which 88% by car, for 40 kg of CO_2 emitted). The male/female distinction within this group highlights the fact that women's workplace remains on average closer to home, with a tendency to reduce their overall emissions by approximately 30% compared to their male counterparts. Location is of course a decisive factor, even though distances travelled remain nevertheless significant: a city centre male professional travels 217 km/week for 33 kg of CO_2 compared to 303 km and 39 kg for a country dwelling male professional, with comparisons being of the same order for working women. Within this group, income levels hardly affect distances travelled locally and the resulting emissions. However, not having private transportation reduces distances travelled to 125 km/week and emissions to 7.2 kg.

For young people, empowerment and progressive distancing of teaching establishments leads to a high difference between urban primary school children (77 km/week for 4.3 kg of CO_2) and non centralised students (215 km for 21.3 kg of CO_2).

For non-working, unemployed or stay-at-home individuals, access to a car appears to be decisive (81 km and 5.3 kg of CO_2 for an unemployed person, 75.6 km and 4.7 kg for a non-motorised person who stays at home, compared to 132 km and 12.7 kg of CO_2 on average within this group). Location becomes a secondary factor. Overall household income seems therefore a key variable for enabling people in this group to have access to car travel. Retired individuals appear less mobile than others (86 km/week and 8.6 kg of CO_2). Age is decisive within this group, with younger, motorised and mobile retired people on the one hand, and more elderly persons (the limit is usually around 75 years old), who use cars less, both for health reasons and due to generational habits (Pochet, 2003).

We can also look more closely at the special case of Ile de France (Paris and greater Paris area). Indeed, while the size of this agglomeration means that distances travelled are clearly longer than elsewhere, significant use of a mainly electric public transport network leads to local emissions being within the average of other agglomerations. For example, inhabitants of Ile de France travel 70% further than inhabitants of Lyons, whatever their location in their respective agglomerations, but their CO_2 emissions are identical (Nicolas et *alii*, 2001).

Long distance mobility does not refer to the same logic and is not based on the same individual factors of explanation. Income level in this case is foremost, followed by far by the person's position in the life cycle. One can associate income to more opportunities for professional long distance travel in the working population. Beyond this and in terms of leisure travel, possibilities for travel and "escapades" are completely different for affluent and more modest households. As such, between the sixth most modest and sixth most affluent of the population, CO_2 emissions go from 216 to 1,343 kg/year. The special case of inhabitants of Ile de France, who emitted up to twice as much CO_2 than inhabitants of the rest of France for their long distance mobility in 2007 (903 kg/year/person compared with an average of 565 kg/year/person) is essentially explained by this factor (Orfeuil, Soleyret, 2002). However, if we observe mobility overall, we can note that Parisians are less significant CO_2 emitters (with

1,298 kg CO_2/year/person compared to an average of 1,924 kg CO_2/year/person) due to their very low local emissions thanks to massive use of public transport.

Working or not working status is absorbed here by this income variable. The rate of non-working people in the household reduces income per CU, unit of consumption serving as indicator in this instance. However, age and position in the life cycle still provide some explanation. Young adults, more than often single and without children, travel more than older individuals who are more often settled in households with children. What is more, retired people over the age of 75 tend to be less mobile than the rest of the population and in particular less than retired people under the age of 75 (Mézière, 2003). The latter emit approximately 1,367 kg CO_2/year in local travel (compared to an annual average of 1,358 kg of CO_2) and 676 kg CO_2/year on long distance travel (compared to an annual average of 565 kg of CO_2).

3. Discussion: pro adapted public policies

The analysis of socioeconomic individual characteristics proves to be very necessary to understanding CO_2 emissions relating to people's mobility and for clarifying public policies on CO_2 emissions regulations.

Two very different mobility segments can be seen. On the one hand, mobility structured by daily activities in a localised area, highly conditioned by the person's social status which influences the activities this person undertakes; and by the person's home location which affects the distances to be travelled and the mode of transport used. On the other hand, long distance mobility, more exceptional as it only represents 1.3% of travel movements but corresponds to 40% of the distances travelled and 32% of CO_2 emissions. Income is the decisive influencing factor in this case.

As such, the debate on urban sprawl, type of urbanism and location of economic and residential activities is a real challenge on a local level; this remaining the area where the highest levels of emissions are generated. However, an increase in the cost of car use (higher taxes or price increase of petrol), will impact the most modest households much more than more affluent ones, especially working people for whom cars are a necessary tool these days to travel between work and home. Plus the high increase of property prices leaves, at this level, little chance of adjusting via residential mobility.

Long distance mobility has increased the most during the last few years. For example, air traffic in France increased by approximately 20% between 2001 and 2007 (DGAC, 2010). Even though air traffic "only" represented 32% of CO_2 emissions in France in 2007, it is no less a significant challenge when observing evolution trends in the long term. A price increase here seems to generate less inequality than the previous case, as long distance travel is less necessary and mainly affects the most affluent members of the population. It can have a considerable impact when we observe the strong link it has with income growth. In terms of this long distance mobility and its determining factors and evolutions, the existing statistical bases in tourism would undoubtedly merit more thorough exploitation in France. Likewise, the finer and more widespread statistical tracking which is being implemented at present will, without a doubt, provide the basis for better knowledge of the dynamics which underpin this type of mobility.

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