DIFFUSION OF CAR OWNERSHIP AND USE IN FRANCE SINCE THE MID-70'S

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Abstract
For each quartile of income per consumption unit, annual time-series have been estimated from panel surveys, with annual waves of observations since 1974:

- INSEE\(^2\) Households' Continuous survey from 1974 to 1994,
- Sofres\(^3\) “Parc-Auto”\(^4\) panel survey since 1994.

In these data sources, household behaviour is described through:

- car ownership (proportion of households owning at least one car, proportion of multi-car households, average number of cars per adult over 18, which is the minimum age for obtaining a driving license in France),
- car use (annual mileage per household or per car).

The repeated sample structure of data has been used for improving the accuracy of time-series of variables highly correlated over successive years.

In the mid-70's, car ownership and use were quite low for the poorest income quartile, but the gap has much decreased with the three higher income groups, which have a more homogeneous behaviour. Thus, multi-car ownership, which is mainly structured by geographic and demographic determinants, has slowed -but not reversed- the social diffusion of automobile. After a period of stability between the mid-80's and the early 90's, the social diffusion of automobile has started again like in the 70's, especially for low-income groups and in low-density areas where no alternative to car use is available. However, the Q4/Q1 index has almost stabilised in the 2000's, at national level as well as in Paris region, showing that this diffusion seems to reach its limits.

As the curves representing car ownership (number of cars per adult) and car use (annual mileage per household) seem to become quite horizontal during the most recent period, logistic curves over time have been estimated for each quartile of the distribution of households by income per consumption unit. Saturation thresholds are estimated, as well as the date of the point of inflection.

Keywords: panel, automobile, car ownership, car use, income inequalities, saturation, France.

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4 “Car fleet” panel.
1. INTRODUCTION

In many countries like in France, most taxes on automobile were progressive when they had been decided. They have become neutral or even regressive because of the social diffusion of car ownership and use (Madre, 1985; Purwanto et al., 2002). Has multi-car ownership made this evolution slower? The answer to this question is probably different in low-density areas, where there is no alternative to automobile, and in large conurbations, where several destinations can be reached by foot or by bicycle and where public transport are available. Expenditure for car purchase are still concentrated in high income groups, as well as for toll motorways or parking, because cheaper (e.g. second hand cars) or free alternatives exist (Madre, 1991; Berri, 2005; Berri et al., 2009).

First, the data from two panel surveys, on which relies the calculation of annual time-series since 1974 for each quartile of income distribution, will be presented in section 2. Then, the methodologies used for the calculation of these time-series (interpolated quartiles, optimised estimate of time-series from panel surveys) and the inequality indicators will be described in section 3. A descriptive overview will give the first results (section 4). Finally, modelling in terms of logistic curves (Røed-Larsen, 2006) will be implemented in section 5 to characterize the trajectories over time of car ownership and use for poor, medium and rich households.

2. MORE THAN 30 YEARS OF ROTATING PANEL SURVEY DATA

This research is based on two annual nationwide household surveys describing both car ownership and use:
- the Household Continuous Survey ("Enquête de Conjoncture Auprès des Ménages" (ECAM)) conducted by the National Institute of Statistics (INSEE) among a sample of dwellings drawn from the French census: 10,000 to 13,000 households responding by interview each year, of which about one third had been also interviewed one year before; the period from 1974 to 1994 (year of end of this survey) is covered by the data files available at IFSTTAR;
- the "Parc-Auto" (Car Fleet) panel survey is a postal survey conducted by the private marketing research company TNS-Sofres; each annual wave includes 6,000 to 7,000 volunteer respondent households, of which about 3/4 had already responded the year before (even if they have moved, contrary to the ECAM survey); data files are available at IFSTTAR for all waves since 1984 and this survey is still on-going (Hivert and Pean de Ponfilly, 2000; Hivert et al., 2006). For a short description of these data, see also Kalinowska and Hivert (2005) or Papon and Hivert (2008).

Despite these differences in survey methodology, we have checked that these data source show consistent results for the period 1984-94, for which both datasets are available. Both questionnaires contain:
- the annual income of the household in about 10 brackets,
- a description of the household (socio-economics, demographic structure, place of residence, etc.).
- a description of cars (age, type of fuel, main driver, etc.) at the permanent disposal of the household (up to 2 cars per household in ECAM, to 3 cars in Parc-Auto),
- an estimate of the annual mileage for each car described (rounded and heaped (Hivert, 2001; Yamamoto, 2009), but unbiased according to odometer reading), as well as some information on the main purposes for which the vehicle is used (yes/no).

Thus, this information has to be homogenised mainly for income, which has been coded in brackets using different grids of nominal income over time (see below).

3. CALCULATION OF TIME-SERIES FOR EACH QUANTILE OF INCOME, METHODOLOGICAL ASPECTS

For the ECAM surveys conducted by the National Institute of Statistics, about 70% of households give for each person detailed information on their resources, including different sources of income (wages, retirement pensions, social benefits, etc.). About 25% give global information on a pre-coded grid, and 5 to 10% refuse. Thus, we chose to use these grids, particularly because the rate of non-response is much lower when using this pre-coded information.

Most of models rely on continuous quantitative variables, but responses given by households are often rounded for income as well as for annual mileage. Moreover, inflation was important before mid-80’s, and makes comparisons difficult over time. That is why income grids have been revised in 1977, 1983, 1987 and 1997. The grids have been also typically revised in 2002 in order to be converted from Franc to Euro.

Rather than conventional methods (Bhat, 1994) like simulated residuals (Lollivier and Verger, 1989), we have preferred a more robust method: interpolated quantiles from the middle of each bracket (Madre and Purwanto, 2003). It could be any quantiles (e.g. terciles or quintiles) but we have first to check that the number of brackets is much larger than the number of quantiles.

Let us consider the distribution of a variable of interest (e.g. the number of cars in the household) by income bracket. In order to locate the limits of each income quantile, the distribution is interpolated, and the average number of cars per household is calculated in each quantile with the rather strong hypothesis that car ownership is constant inside each bracket containing a limit between two quantiles (e.g. lowest quartile Q1, median or third quartile Q3).

This method has been tested on the respondents of the 1993-94 French National Travel Survey, which gave precise information in terms of income. The result is obviously better, when the upper and lower limits of a quantile are nearer to the thresholds of brackets on the grid. But surprisingly enough, splitting the sample into a larger number of brackets when dividing the middle of each class by the number of consumption units does not improve the quality of the interpolation, because even inside a bracket the income level is correlated with the composition of the household. Thus, the interpolation is more precise for total income.
household income than for the income per consumption unit, which is a more adequate measurement of the standard of living.

After obtaining homogenised income groups through quantiles, how to estimate time-series accurately enough despite of the small sample size of our panel survey data? Referring to Cochran (1977), we have implemented the method optimising the accuracy of the time-series for the most recent periods. This optimisation is crucial for the estimation of models using variables affected with small annual changes (often 1 or 2%). However, we had to smooth the time-series by moving averages over three consecutive years at national level and over five years for Paris region. Because we could not access again roar data from ECAM surveys, we have adopted Oxford scale for the calculation of consumption units, which was generally used in the 80's.

For the measurement of inequalities, we have calculated four indicators (see also Bureau et al., 2009):
- the ratio "Q4/Q1", i.e. the ratio between the means of the variable of interest for the extreme quartiles (Q4 representing the richest and Q1 the poorest), which is the indicator mainly discussed here,
- the Gini index (Gini, 1921), the Atkinson index, the Theil basic index are also presented as illustration (Atkinson, 1970 ; Atkinson and Stiglitz, 1980 ; Atkinson and Bourguignon, 1982 ; also mentioned in Madre, 1985 and Berri, 2005). Their evolutions over time present a quite similar shape as the Q4/Q1 indicator.

In order to avoid heterogeneity over time due to different income grids, these indicators have been calculated from only four points, which are the mean values for each quartile.

4. DESCRIPTIVE ANALYSIS

For each quartile of the distribution of income per consumption unit, time-series have been estimated since 1974 to 2011 for:
- the average income per household (income per consumption unit would have been homogeneous with the criteria used to define the quartiles, but this variable, which presents a quite similar trend, was not available in the database drawn from the ECAM surveys,
- the average number of cars per adult (i.e. aged over 18, which is the minimum age in France to hold a driving licence). The number of cars per household (or per capita) would have been more homogeneous with the other variables, but isolating the population concerned gives generally better estimates in modelling (see section 5),
- the proportion of equipped and of multi-car households,
- the average annual mileage per household or per car, separately nationwide, and for the Metropolitan Area of Paris (Paris region) in order to show the specificity of the inhabitants of a high population density region, where the diffusion of automobile has started earlier than elsewhere in France.
4.1. Income Trends

Nationwide (figure 1), the inequalities of income per household have decreased between the mid-70's and mid-80's, then have slowly increased till 2000 with a little peak during the 1993-94 recession. From 2000 to 2003, income has grown faster for the highest quartile than for medium or low-income groups, but this trend has reversed since then.

Figure 1: Evolution of inequalities for income per household (smoothed MA3)- France


In the Paris region (figure 2), inequalities have decreased more rapidly during the first period, then have remained almost constant only from mid-80's to early 90's. They have increased since the 1993 recession till mid 2000's, and have decreased again since then. Because of the relative stability of household structures, the evolutions of income per consumption unit follow the same patterns, as shown since 1994 on the Parc-Auto data.
4.2. Nowadays, multi-car ownership plays the main role in the diffusion of automobile

Concerning the proportion of motorised households (Figure 3), Q2 and Q3 have caught up with the highest quartile in the early 90's. The gap between the lowest and the highest quartile has also decreased till the early 2000's, then has remained almost steady. In the lowest income quartile the percentage of households with no car has dropped from 55% in mid-70's to 25% around 2002, while it has diminished only from 25% to 15% in the highest income quartile.

The proportion of multi-car ownership has increased quite linearly for the two lowest quartiles, while it has remained almost constant during the 90's for the upper quartiles (Figure 4). Multi-car ownership was indeed an increasing function of income till 1990; afterwards, Q3 then Q2 have passed over Q4 because well-off households live in more densely populated areas (e.g. in the Metropolitan Area of Paris).

At the national level, the average number of cars per adult is a concave function of time for all quartiles and, at any point in time, an increasing function of income per consumption unit (figure 5). This statement also stands for the inhabitants of Paris region (Figure 6). In this region, car ownership for the lowest quartile has remained almost constant in the 90's, and has been quite steady for Q2 and Q4 from the mid 90’s to the early 2000’s, while Q3 has almost caught-up with Q4 in the recent period.
Figure 3: Evolution of car ownership with time: share of equipped households by quartile of income per consumption unit (smoothed MA3) – France


Figure 4: Evolution of car ownership with time: share of multi-equipped households by quartile of income per consumption unit (smoothed MA3) – France

Figure 5: Evolution of car ownership over time: average number of cars per adult by quartile of income per consumption unit (smoothed MA3) - France


Figure 6: Evolution of car ownership over time: average number of cars per adult by quartile of income per consumption unit (smoothed MAS) - Paris region

What is resulting in terms of inequality? At the national level, the ratio Q4/Q1 for the average number of cars per adult has fallen from 2.0 in the mid-70's to less than 1.4 in the 2000's, somewhat stagnating with a ten-year intermediate plateau from the second half of the 80's (Figure 7). For the proportion of multi-car ownership, this ratio has been divided by 3 during the same three decades, falling from 3.3 to 1.1. Since the end of the 90's, the relative gap between Q1 and Q4 has remained almost steady in terms of proportion of equipped households, and during the 2000's, the gap has almost closed between Q1 and Q4.
in terms of multi-car ownership. Thus, after the first equipment, the second car has contributed to the social diffusion of automobile, but with an almost uniform distribution of multi-car ownership, this diffusion process seems to reach its limits. In Paris region, the ratio Q4/Q1 for the average number of cars per adult has decreased from 2 in the mid-70’s to 1.7 between the mid 80’s and the mid 90’s, and has then decreased again to about 1.4 in the 2000’s (as at the national level).

4.3. A Diffusion of Car Use determined by changes in Fuel Price

After two oil shocks in 1973 and 1979-80, fuel price has remained at a high level during the first half of the 80’s. It has sharply fallen between mid-1985 and mid-1986, and has remained at a low level during the 90’s, taking into account the substitution of petrol fuel by diesel fuel (which was 40% cheaper in France). After a first peak in 1999-2000, fuel price has risen constantly from 2003 to mid-2008, and is quite volatile since then, with a new record in 2012. Thus, the average mileage per car has declined. Despite a still increasing car ownership, the average mileage per household is declining since 2000 at national level; this turnaround has been particularly visible for quartiles Q2 and Q4 (Figure 8), but this new trend had started earlier in the wealthiest quartile of high density areas. For instance, in the Paris region, where car ownership and use has developed earlier than elsewhere in France and where public transport is attractive for local as well as for long distance trips, the global decline has started since the 90’s for the highest quartile (Figure 9). Nationwide and in the Paris region, the three highest income groups have recently converged in terms of cars per adult, while the lowest income quartile is remaining at a lower level of car ownership.

Figure 8 : Evolution of car use with time: average mileage per adult by quartile of income per consumption unit (in kilometres, smoothed MA3) – France

Figure 9: Evolution of car use with time: average mileage per adult by quartile of income per consumption unit (in kilometres, smoothed MA5) - Paris region

In terms of inequality at the national level, the ratio Q4/Q1 for the annual mileage per household has declined from 1.7 mid-80's to 1.3 mid-90's (i.e. in a context of cheap fuel), because of a slower increase for the highest income groups. In the 2000's with a rising fuel price, households from the lowest income group have been reluctant to drive less; indeed, they often live in low-density areas with no alternative to an already low car use.

In summary, after a period of stability between the mid-80's and the early 90's, the social diffusion of automobile has started again like in the 70's, especially for low-income groups and in low-density areas where no alternative to car use is available. However, the Q4/Q1 index has almost stabilised in the 2000's, at the national level as well as in the Paris region, showing that this diffusion seems to reach its limits.

4.4. Evolutions according to income growth

The two next figures present, for each quartile by consumption unit, the evolution of car ownership (per adult) and car use (per household), according to income, in constant 2011 Euros (considering all the annual waves together).

Globally, the scatter of points on figure 10 shows that, as expected, household car ownership has increased with their income. Indeed, the number of cars per adult has been about 0.40 for a real annual income of €15,000 while it is about 0.7 for incomes over €45,000 (constant 2011). The global shape of the scatter of points suggests a concave increase of car equipment with income. However, the slope seems different when comparing each of the four quartiles. Indeed, it is decreasing as the social position of the household improves. Particularly, car ownership is increasing faster with real income for the

average household in quartile Q1 than for the average household in Q4. Over the years, this has induced a reduction of social inequalities for car ownership, as shown on figure 7. Considering car use on figure 11, analogous conclusions roughly emerge. The average mileage of households in Q1 has been about 10,000 km/year for an annual income of €15,000. Over €45,000 in quartile Q4, it has globally ranged between 15,000 and 17,000 km/year. As on figure 10, the scatter of points on figure 11 could also suggest a concave growth of household car use with their real income. Taking quartiles separately, the slope of the annual mileage over real income also seems to decrease with their position in the standard of living scale.

The apparently concave relations on figures 10 and 11 suggest that the diffusion of automobile can reach saturation thresholds for both car ownership and use when the households are getting wealthy. Theoretically, the social diffusion of a good (either in time or in the income scale) can be represented using a sigmoid curve, ended asymptotically with a saturation level. It is modelled in the following section for car ownership and use (dependent variables), using time as explanatory variable.

Figure 10: Evolution of car ownership (average number of cars per adult) with household income – France

5. ESTIMATION OF LOGISTIC CURVES TO MODEL CAR OWNERSHIP AND USE

The average households for each of the four quartiles of annual income per consumption unit are observed annually, during 38 years from 1974 to 2011. Let Q1, Q2, Q3 and Q4 refer to these households by increasing order of resource. In this section, we assume that car ownership and use can be represented by logistic functions. The logistic model, which is exposed below, is applied on the data of each quartile-specific household.

5.1. The model

Let \( Y^*_t \) refer either to the number of cars per adult or the annual mileage in 10^4 kilometres for the household Qi at period t. Both these variables are modelled separately assuming a logistic specification. The explanatory variable is denoted \( X^*_t \) and the model is given by:

\[
Y^*_t = Y^*_t + \varepsilon^*_t = \frac{\exp(\gamma_1)}{1 + \exp(-\alpha_1 X^*_t - \beta_1)} + \varepsilon^*_t, \tag{1}
\]

where \( \varepsilon^*_t \) is assumed to be a zero-mean *i.i.d.* error term, and where \( \{\alpha_1, \beta_1, \gamma_1\} \) are the parameters to be estimated. For \( \alpha_1 \) positive, the formulation (1) implies that \( Y^*_t \) is increasing with \( X^*_t \) along a symmetrical sigmoid, bounded by two horizontal asymptotes: the lower plateau is fixed at \( Y^*_t = 0 \) while the upper plateau, corresponding to a saturation level, is
located at $Y_t^* = \exp(\gamma_i)$. The inflection point, for which the second derivative of $Y_t^*$ with respect to $X_t$ is zero, is located at $(X_t = -\beta_i / \alpha_i ; Y_t^* = \exp(\gamma_i) / 2)$.

5.2. Time as explanatory variable

In this section, time is used as explanatory variable of model (1). More precisely, $X_t$ is given by the index $t$, with $t=0$ for year 1974, $t=1$ for 1975... and $t=37$ for 2011. Tables 1 and 2 report the estimates for car ownership and use respectively.

Table 1: Estimates for the car ownership model as a function of time

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Hh. Q1</th>
<th>Hh. Q2</th>
<th>Hh. Q3</th>
<th>Hh. Q4</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\alpha$</td>
<td>0.05</td>
<td>0.05</td>
<td>0.05</td>
<td>0.06</td>
</tr>
<tr>
<td>$\beta$</td>
<td>-0.51</td>
<td>-0.34</td>
<td>-0.01*</td>
<td>0.60</td>
</tr>
<tr>
<td>$\gamma$</td>
<td>-0.32</td>
<td>-0.22</td>
<td>-0.18</td>
<td>-0.24</td>
</tr>
<tr>
<td>Nb. of observations</td>
<td>38</td>
<td>38</td>
<td>38</td>
<td>38</td>
</tr>
<tr>
<td>Saturation threshold (# of cars per adult) [90% conf. interval]</td>
<td>0.73 [0.61; 0.86]</td>
<td>0.80 [0.72; 0.88]</td>
<td>0.83 [0.76; 0.91]</td>
<td>0.78 [0.75; 0.82]</td>
</tr>
<tr>
<td>Date of inflexion</td>
<td>1985</td>
<td>1981</td>
<td>1974</td>
<td>1964</td>
</tr>
</tbody>
</table>

Note: the dependent variable is the number of cars per adult in households. The explanatory variable is time. All the parameters are significant at the 95% level, except those indicated by *.

As expected, the results show that individual car ownership and use have increased over time, despite a slight decrease in the mileages after 2001 caused by an increasing fuel price. Indeed, the parameters $\alpha$ are found to be positive and significant in every case on tables 1 and 2. For car ownership, the inflection has occurred in the 80’s for the two lower quartiles (Q1 and Q2), in the 70’s for Q3 and in the 60’s for the highest income quartile Q4. Although confidence intervals overlap for all the quartiles, the highest saturation levels seems to be for Q2 and Q3, then it decreases for Q4 because higher income groups live in more densely populated areas. For both car ownership and use, saturation thresholds are lower for Q1.

More precisely, the confidence intervals for the saturation level of quartiles Q2, Q3, Q4 overlap around 0.80 cars per adult, while that of Q1 is about 0.73 cars per adult (table 1). Regarding car use, the confidence intervals for the saturation level overlap around an average annual mileage of 16,000 km per household (table 2) for quartiles Q2, Q3 and Q4. This figure is lower for Q1: about 14000 km/year. Thus, constrained models assuming a same parameter $\gamma$ for the three upper quartiles are relevant. They yield these estimates: for the car ownership model, $\gamma = -0.22$ (s.e.: 0.021) and for the car use model, $\gamma = 9.67$ (s.e.: 0.016). The inflexion dates for each quartile do not differ much from those obtained in the unconstrained models (tables 1 and 2).

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5 This factor has not yet been taken into account in the model.
Table 2: Estimates for the car use model as a function of time

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Hh.Q1</th>
<th>Hh.Q2</th>
<th>Hh.Q3</th>
<th>Hh.Q4</th>
</tr>
</thead>
<tbody>
<tr>
<td>α</td>
<td>0.10</td>
<td>0.09</td>
<td>0.10</td>
<td>0.10</td>
</tr>
<tr>
<td>β</td>
<td>-0.54</td>
<td>-0.19</td>
<td>0.49</td>
<td>1.67</td>
</tr>
<tr>
<td>γ</td>
<td>9.53</td>
<td>9.69</td>
<td>9.67</td>
<td>9.65</td>
</tr>
<tr>
<td>Nb. of observations</td>
<td>38</td>
<td>38</td>
<td>38</td>
<td>38</td>
</tr>
<tr>
<td>Saturation threshold (km/year)</td>
<td>13900 [13000; 14800]</td>
<td>16200 [15200; 17300]</td>
<td>15900 [15200; 16600]</td>
<td>15500 [14800; 16200]</td>
</tr>
<tr>
<td>Date of inflexion</td>
<td>1979</td>
<td>1976</td>
<td>1969</td>
<td>1958</td>
</tr>
</tbody>
</table>

Note: the dependent variable is the annual mileage of households in kilometres. The explanatory variable is time. All the parameters are significant at the 95% level.

Let us discuss now the constraints implied by fitting logistic curves. Model (1) assumes the symmetry of the adjusted logistic curves with respect to the inflection point. This can be viewed as a strong hypothesis and asymmetric curves might be more relevant in our context. However, the assumption of symmetry is made necessary when considering our data. As shown on figures 5 and 8, the data do not seem to cover the lower and convex part of a presumed sigmoid, at the left side of the inflection point and near to the lower asymptote (set in zero). As there is no empirical information about this part, its representation has to rely on some assumptions concerning the location of the inflexion point, as in the logistic model. An ideal solution would have been to extend the observation period farther in the past, at least back to the end of World War II. But unfortunately, detailed data about car use and equipment between 1945 and 1973 are not available.

Chapman-Richards sigmoid curve (Richards, 1959; Chapman, 1961; Draper and Smith, 1981) gives a more flexible functional form, with a starting point that can be set on a chosen date (e.g. 1920), no constraint of symmetry, and an upper asymptote which can depend on fuel price and/or income level (Collet et al., 2013; Grimal et al., 2013). But this sophistication is more forecasting oriented, and is not necessary for the analysis of inequality.

6. CONCLUSIONS

The social diffusion of car is a major feature of economic growth in Occidental Europe after World War II. This paper describes this phenomenon in France for four income groups from 1974 onward. Multi-car ownership has interrupted but not reversed this long term trend: after a period of status quo between mid-80's and mid-90's, the social diffusion of automobile continues like during the 70's, especially in low density areas, whose inhabitants are more car-dependent even if their income is low.

However, the growth of car ownership becomes slower and slower, which shows that saturation levels are not far from already reached levels. In order to determine these thresholds, we have adjusted logistic curves separately for each income quartile. Geographic
factors (as density, distance to city-centre, size of conurbation) probably explain why it is not for Q4 that saturation levels are the highest, which could be checked by estimating the same models only for the inhabitants of the Metropolitan Area of Paris.

For both car ownership and use, the confidence intervals of saturation levels for each quartile overlap. These saturation thresholds depend more on the zone of residence than on the standard of living (Grimal et al., 2013); indeed, it seems to be lower for the highest income group, who lives generally in more densely populated areas.

However, the curves do not show monotonous changes towards saturation. Figure 8 indicates that car use has peaked around 2001 and has declined afterwards. The main factor that contributed to this trend is certainly fuel price, which could be introduced as explanatory variable. Additional factors could also include rising vehicle prices, tax policies, demographics (aging population and declining employment rates), improvements in alternative modes (walking, cycling and public transport), and changing consumer preferences.

This heterogeneity opens theoretical discussions about cross-sectional versus longitudinal estimates. Another example is an important change over time of cross-sectional income elasticities, which makes impossible to consider them as a proxy for long-term longitudinal elasticities (Gardes and Madre, 2005). There is still much to do with these data. Considering modelling, fixed-quartile effect models can be estimated on pooled data. At national level, it gives a more accurate estimate of saturation levels, which do not differ significantly across quartiles of the distribution of income per consumption unit. This yields a better estimation of the inflection periods, and allows to check whether each quartile follow the same trajectory. Moreover, introducing fuel price and/or real income as explanatory factor for car use should allow to derive saturation thresholds for the annual mileage in different economic conditions, which could give an important information for building scenarios for sustainable development. However, we should take into account that even fuel price elasticity depends on income level (Kemel et al., 2009).

Differences in vehicle ownership and mileage rates between different income classes are often presented as an inequity, with the implication that, as lower-income households own more vehicles and drive more annual miles, they are better off overall. Yet, these trends could be not as much positive as that. Indeed, lower-income households may have to spend an excessive portion of their budget for transportation, due to a lack of more affordable alternatives. Lower-income households might be better off, for example, if there were more affordable housing in urban neighbourhoods with good walking, cycling and public transit, which would reduce their vehicle ownership. These assumptions about what is considered equitable and desirable are still to be discussed.

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