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## **Are French millennials less car-oriented ? Literature review and empirical findings**

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Declaration of interest: none

### Abstract:

Generation effects play a key role in shaping long-term trends in travel behaviors. Though cohorts born until the 1970's have been increasingly car-focused, a reversal of this trend was noticed among the millennials. Determining whether this break-in-trend resulted from changes in living conditions and economic difficulties, or demonstrates a shift in attitudes away from the car, is critical to future travel trends. We bring a contribution to this debate in the French context, through a literature review followed by empirical findings, using the French Base of Local Household Travel Surveys. Through age-cohort analysis, we find evidence of changing travel patterns among the millennials, taking the form of a shift from driving to transit, along with a decline of car ownership. However, travel attitudes of the millennials play little role, as they do not differ substantially from their elders. Besides, we show that generation effects disappear once a large number of structural factors are controlled for. It looks like the main driver of change in travel behaviors comes from a shift in residential patterns, in relation with longer studies and a delayed entrance into the workforce, and possibly because of increasing work pressure, degraded transport conditions and changes in residential attitudes and desired lifestyles. In the end, these assumptions should be further explored, along with complementary research tracks, including the role of economic factors, the effects of learning experience, as well as heterogeneity in travel patterns, in relation with issues of social and spatial equity.

Keywords: *Millenials, Life course, Travel patterns, Living conditions, Attitudes.*

## 1. INTRODUCTION

Generation effects play a key role in shaping long-term trends in travel behaviors. They partially derive from the historical period where people grew up, as habits acquired during the youth tend to persist later on (Bodier, 1996; Lyons and Swinbank, 1998). Though, they may also reflect economic, social and spatial factors of structural change. Up to cohorts born in the 1970's included, the expansion of car-based mobility was stimulated by women's entrance into the workforce, suburban growth, a higher average income and decreasing vehicle costs. However, a reversal was noticed among the millennials - sometimes also designed as « generation Y » - with decreasing access to driving license and car ownership, along with a lower car mileage per adult. Interestingly, this generation attained majority during the early 2000's, in a period of transit renewal, either through the construction of new metro and tramway lines, the extension of urban transport perimeters, or higher frequencies and comfort standards (e.g., Hass-Klau and Crampton, 2005). As a result, the millennials might have experienced enhanced transit conditions, resulting in a better image of this mode. However, in order to forecast the future of travel demand, it is essential to determine whether the observable shift in travel patterns was caused by living conditions and economic difficulties, delaying the access to car-based mobility, or demonstrates a deeper shift in attitudes away from the car. To tackle this issue, we use an original dataset, the French Base of Local Household Travel Surveys, relying on a large sample and including attitudinal variables, thus allowing us to study their influence on car ownership and travel patterns. The first part is descriptive and relies on age-cohort profiles of different travel indicators along with living conditions and attitudes. Thereafter, we implement a joint model of residential choice, personal car availability and regular transit use, including age and generation effects, while simultaneously controlling for travel preferences, socio-demographics and the built environment. Though many studies deal with travel patterns of the millennials, they are still a few in the French context. Besides, few of them have tried to model directly the influence of attitudes on travel behaviors, and disentangle them from more structural factors. None of them, to our knowledge, jointly models different life choice dimensions, also controlling for self-selection mechanisms. The approach is not only original in its methodology but also in its results. We believe it will bring a significant contribution to the debate, by showing that travel attitudes among the millennials do not differ significantly from their elders, while generation effects disappear once structural factors and endogenous regressors are controlled for. Changing residential patterns are likely to be the main explanation for new travel behaviors, along with longer studies, and possibly because of increasing work pressure, degraded transport conditions and changes in desired lifestyles. The rest of the article is organized as follows. Section 2 is dedicated to a literature review about travel behaviors of the millennials. In section 3, we present the original dataset. In Section 4, we expose descriptive results, including age-cohort analysis, while section 5 is dedicated to model definition and estimation. We conclude in section 6, by reminding the main results, before discussing them and drawing out future research tracks.

## 2. LITERATURE REVIEW

During the last decade, there were many signs of a shift in travel behaviors of young adults, generally consisting in the decline of the car to the benefit of various transport

alternatives such as transit, train, walking and cycling. Such a transformation occurred in many countries – Germany, Great Britain, United States, Australia, and Netherlands – and could be captured through many indicators, either about driving license, car ownership or car use. For instance, Kuhnimhof et al. (2012a, b) showed car use to level off among young adults from the mid-90's - especially among men - to the benefit of cycling and transit, making behaviors more multimodal. Similar results were found in the Netherlands (Van den Waard et al., 2013) and the United States (Davis et al., 2012), sometimes coinciding with a decline in total mobility, implying that the fall of car use was not always compensated by a larger recourse to other modes, especially in rural areas where alternatives to the car are limited (Davis et al., 2012; Van den Waard et al., 2013). This apparent decline was not limited to car use but also affected car ownership and driving license. Falling license rates were first recognized in Sweden, Norway (Berg, 2001; Ruud and Nordbakke, 2005) and Great Britain (Noble, 2005), before spreading out to Australia, North America and Japan, along with a large number of European countries (Davis et al., 2012; Sivak and Schoettle, 2012; Delbosc and Currie, 2013). Even more, when holding a driving license, young adults were found to drive less than before (Raimond and Milthorpe, 2010; Sivak and Schoettle, 2012). Reduced access to driving license obviously resulted in the decline of car ownership among young adults, in Great Britain and Germany (Kuhnimhof et al., 2013) for instance. According to several authors, new travel patterns of young adults strongly contributed to the stagnation of average car mileage per adult which was recorded in many countries during the 2000's (Davis et al., 2012; Kuhnimhof et al., 2013; Van den Waard et al., 2013), giving birth to the « peak car » hypothesis (Goodwin, 2011). However, there is usually no single interpretation to this phenomenon. Significantly, instead of “young adults”, some of these works also refer to « generation Y » or “the millennials”, tacitly suggesting that new behaviors could be durable and persist later on in the lifecourse, as reflecting a deeper conversion of mental habits and attitudes away from the car.

Though, while authors from different backgrounds usually don't agree about the main drivers of travel behavior change among the millenials, they nevertheless recognize it to result from an interaction between a diversity of factors (Delbosc and Currie, 2013). However, not all of them are of equal importance, or can be equally supported by empirical evidence. The most convincing is probably the emergence of new living conditions, reflecting a longer transition towards adulthood, which is manifested through longer studies, a delayed entrance into the job market, and later family foundation. In parallel, these different stages have become less automatic and more uncertain, in line with increasing economic and relational precariousness (Billari and Liefbroer, 2010). These factors would long tend to maintain less car-dependent lifestyles, given the absence of strong professional and family constraints, thus delaying the need to drive a car. Either for Metz (2013) or Delbosc and Currie (2013) for instance, a general delay in the lifecourse appears to be the most significant explanation for young adult behaviors. For instance, being a student or having a part-time job was found to reduce the probability of being licensed (Noble, 2005; Kuhnimhof et al., 2012a,b, 2013; Kalinowska et al., 2012; Delbosc and Currie, 2013), so that longer studies represent a key factor of decreasing car use, by postponing entrance into the job market. Yet, as was shown by Taylor et al. (2012), an increasing proportion of young adults are studying, while the number of young professionals diminished. In addition, as living in a family and young children were proven to be additional cases for being licensed (Delbosc and Currie, 2013), the longer period

preceding family foundation and parenthood (Mitchell, 2006; Metz, 2013) constitutes another reason to delay driving (Oakil et al., 2016; Hjortol, 2016). On the other hand, many young adults remain longer at the parental home (Cobb-Clark, 2008; Mitchell, 2006), giving them opportunities to use their parent's vehicles, with the economy of a rent leaving resources to support vehicle costs (Licaj et al., 2012).

However, young adults leaving the parental nest tend to experiment increasing economic difficulties through low financial resources, higher unemployment (Berg, 2001; Davis et al., 2012; Van den Waard et al., 2013) and job precariousness (Kuhnimhof et al., 2012a,b, 2013; Kalinowska et al., 2012), hindering access to the car with respect to its costs, either for driving license training (Delbosc and Currie, 2013; Licaj et al., 2012), car ownership (Klein and Smart, 2017) or car use (Van den Waard et al., 2013). By the way, economical reasons are frequently mentioned by young adults to explain their temporary renouncement to pass driving license exams and own a vehicle (Berg, 2001; Noble, 2005; Williams, 2011). Beyond the cost of exams, several authors also mention their increasing difficulty, following reforms oriented by road safety goals (Noble, 2005; Senserrick, 2009; Masten et al., 2011; Raimond and Milthorpe, 2010). However, the influence of economic drivers is not always so clear, as the decline of car use among young adults sometimes preceded the economic crisis (Berg, 2001; Davis et al., 2012), and included higher-income groups not so limited yet by financial resources (Davis et al., 2012; Stokes, 2012). In addition, assessing accurately the resources of young adults is complicated by financial transfers from the family (Delbosc and Currie, 2013), though parents may themselves be affected by growing economic precarity. In the end, economic precariousness along with the reinforcement of several budgetary items (Bigot, 2009; Rougerie and Friggitt, 2010) might have contributed to reduce available income to support transport-related costs among young adults, thus encouraging them to more severely controlling their budget.

The third explanation consists in joint evolutions of transport supply, residential choices, and working/studying places of young adults. The influence of residential location on travel behaviors in relation with contrasted transport amenities and land-use patterns is a well-known result (e.g. Ewing and Cervero, 2001; Cervero and Duncan, 2003). *De facto*, young adults living in dense urban areas are less licensed than those dwelling in suburban and rural areas (Noble, 2005; Raimond and Milthorpe, 2010; Licaj et al., 2012; Hjortol, 2016; Oakil et al., 2016). By the way, the opportunity of ensuring their travel needs otherwise is often mentioned by young adults as an important reason for not driving (Berg, 2001; Noble, 2005; Williams, 2011). As a result, the increasing concentration of students and young professionals in high-density areas and largest cities (Hjortol, 2016; Oakil et al., 2016), characterized by better transit supply, close proximity of university clusters, highly qualified jobs, functional mixity and lower distances between activities, may have contributed to change travel behaviors of young adults (Lachmann and Brett, 2011; Davis et al., 2012; Van den Waard et al., 2013). However, residential choices may themselves partially derive from travel preferences, a phenomenon usually designed as residential self-selection (Cao et al., 2009). In this case, changing residential choices could happen to be an epiphenomenon rather than the primary cause for new travel behaviors; more, both residential and travel choices of the young could be the expression of a more general shift in the way of life (Puentes, 2013). The

improvement of transit supply in great cities during the 90's and 2000's (Hass-Klau and Crampton, 2005; Buehler and Pucher, 2012), has also probably contributed to promote new lifestyles and change travel behaviors, especially as greater facilities were offered to the young, making transit very affordable (Noble, 2005; Kuhnimhof et al., 2012a,b, 2013; Van den Waard et al., 2013).

In contrast with prior explanations, other authors hypothesize a more profound transformation of mental habits and attitudes away from the car. Indeed, there is a significant amount of research to find an influence of attitudes on travel behaviors, included car ownership decisions (Flamm, 2009; Beirao and Cabral, 2007; Simsekoglu et al., 2015). Yet, formerly a symbol of social status and independence (Steg, 2005), the car would have lost part of its attractiveness among the millenials, dethroned by more up-to-date items coming from the digital world such as mobile phones and social networks (Cisco, 2011). For a part, this discourse is supported by empirical findings, in particular the analysis of different surveys which tend to confirm that the car would be less conveying an image of social status, luxury and prestige (Noble, 2005; Cornut, 2017; Delbosc and Currie, 2014; Vincent-Geslin et al., 2017). However, it still remains associated with notions of freedom, independence and autonomy (Steg, 2005; Noble, 2005; Cornut, 2017) as well as adulthood and maturity (Delbosc and Currie, 2014). Attitudes towards the car would then tend to become more opportunistic, with the car becoming a simple transport mean among others, and its benefits and shortcomings more systematically compared with alternatives (Vincent-Geslin et al., 2017). However, other studies find aspirations to drive a car to remain strong (Kim, 2014; Demoli, 2017), and still associated with an image of social prestige (Steg, 2005; Van den Waard et al., 2013), while their realization is hindered out by unfavorable economic conditions. Other authors suggest that changing mobility patterns could be driven by greater environmental awareness (Kalinowska et al., 2012; Hopkins, 2016). However, there are few empirical findings to support this statement, as many studies *a contrario* demonstrate that generation Y is not necessarily more sensitive to environmental concerns, while contesting the validity of the stated relation between environmental awareness and effective travel behaviors (Department for Environmental Food and Rural Affairs, 2002; Noble, 2005; Cornut, 2017). In the end, there is limited evidence for a significant shift of mental habits away from the car, apart from a tendency to being more opportunistic, which may contribute to explain why young adults delay driving as long as they don't really need it. However, changing attitudes might also reflect new living conditions and the economy, rather than being the primary cause for changing behaviors. In addition, the relative magnitude of the influence of attitudes on the decision process is also a matter of debate, by comparison with more objective constraints experimented by households, either geographical, professional or family-related.

To conclude this panorama, information and communication technologies are often considered as a potential trigger for changing travel behaviors. Indeed, though the diffusion of digital innovations is rather general, the millenials have been usually presented as more fond of them. Yet, ICT would favour transit use by increasing the primary utility of travel through allowing young adults to stay connected in order to perform different on-line activities and get real-time information about travel

conditions (Davis et al., 2012). In addition, some research works have suggested that ICT would allow reducing travel needs by substituting virtual networks to direct physical interaction (Choo et al., 2005; Williams, 2011; Rentziou et al., 2012; Sivak and Schoettle, 2012). However, this issue remains partly speculative because of the lack of a clear understanding of the relationship between ICT and travel. Several authors also pointed out the weakness of these results (Sivak and Schoettle, 2012; Le Vine et al., 2013) and the complexity of the interdependencies between ICT and travel (Mokhtarian, 2003; Andreev et al., 2010; Boyd and Ellison, 2007), which may also include phenomena of complementarity - as ICT may help maintaining some relationships (Delbosc and Currie, 2013) - or induction, as increasing information about opportunities may generate additional travel (Van den Berg et al., 2009).

All these explanations may finally be reduced to the subject of determining whether travel behaviors of the millennials illustrate a structural shift in mental habits and lifestyles away from the car, or simply result from a general delay in the transition process towards adulthood along with new living conditions, possibly aggravated by economic precariousness, to be resorbed at a later stage of the lifecourse, along with greater travel needs and professional achievement. This issue is obviously critical to the future of travel, as new generations will be the majority tomorrow (Polzin et al., 2014). While under the second assumption, long-term consequences on transport demand are likely to be limited, they could be more substantial in the first case, as new behaviors would then tend to be durable. In favor of this last statement, some studies found low driving license rates to persist at a later stage of the lifecourse in generation Y (Noble, 2005; Raimond and Milthorpe, 2010; Stokes, 2012; Delbosc and Currie, 2013). However, other works demonstrate that young adults are simply postponing their access to the car until the moment where they really need it (Kim, 2014; Garikapati et al., 2016). In addition, the literature suggests that there is little evidence of changing attitudes in generation Y, apart from a tendency to rationalization (Cornut, 2017; Demoli, 2017; Vincent-Geslin et al., 2017), implying that decline of the car could rather be the manifestation of a frustrated desire than the consequence of a personal choice (Licaj et al., 2012; Demoli, 2017).

### **3. DATASET: THE FRENCH BASE OF HOUSEHOLD TRAVEL SURVEYS**

From 1976, more than 190 local household travel surveys were realized over the French territory, to answer the growing demand for knowledge of local authorities, including travel behavior analysis, infrastructure and planning, measure of transport externalities, etc (Guilloux et al., 2014). They all rely on a standardized methodology designed as CEREMA-Certified (EMC2), allowing comparison of travel behaviors through space and time, focusing on regular travel habits of a typical weekday<sup>1</sup>. Different types of surveys were implemented over time, including Household Travel Surveys (HTS) for great cities using a face-to-face protocol, Travel Surveys for Average Cities (TSAC) conceived for smaller cities with data collection realized by phone, and Travel Surveys for Large Territories (TSLT) with a hybrid data collection method, mixing face-to-face and the phone for less accessible areas. Survey protocols for less populated areas were introduced in the 2000's to satisfy wishes from local

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<sup>1</sup> From Monday to Friday, between October and June, except during public holiday and school vacations.

authorities to cut unitary costs, get larger samples and extend survey perimeters. From 2009, all surveys were aggregated into a single database - the French Base of Household Travel Surveys, which is completed every year. The vintage 2016 was used within the scope of this research.

Table 1. Distribution of travel surveys by survey type from 1976 to 2017

| Period | Data collection method | Year of first implementation | Number of surveys |              | % of total population covered |              | % of sample |              |
|--------|------------------------|------------------------------|-------------------|--------------|-------------------------------|--------------|-------------|--------------|
|        |                        |                              | All               | Unified base | All                           | Unified base | All         | Unified base |
| HTS    | Face-to-face           | 1976                         | 120               | 18           | 82.8                          | 51.2         | 69.8        | 34.7         |
| TSAC   | Phone                  | 2000                         | 43                | 26           | 4.4                           | 10.1         | 9.8         | 17.3         |
| TSLT   | Hybrid                 | 2006                         | 26                | 18           | 12.8                          | 38.8         | 20.4        | 48.0         |

Source: French Base of Local Household Travel Surveys (see below)

The dataset is built out of several files, corresponding to the different parts of the questionnaire: households, individuals, loops, trips, journeys and opinions<sup>2</sup>. Household-level information includes household composition, residential location, housing type, occupational status, the number of vehicles.

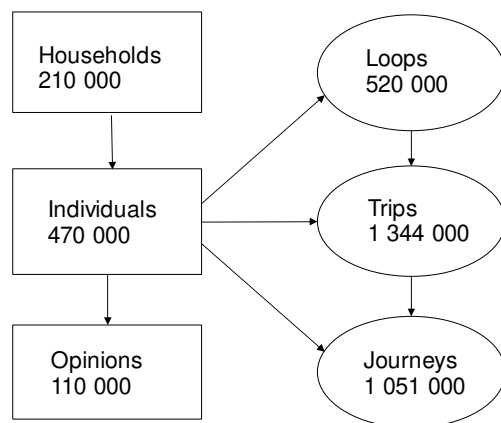


Figure 1: General Structure of the Unified Base of Household Travel Surveys - Vintage 2016

Individual-level information includes socio-demographic attributes (age, sex, educational level, working status, socioprofessional group, link to the household head), travel capabilities (disposal of a driving license, of a transit card, of a vehicle), and regular travel habits (trip frequency by walk, cycling, transit, motorized two-wheelers, car as a driver, car as a passenger). Selected individuals also had to answer the trip questionnaire<sup>3</sup>, by describing all trips<sup>4</sup> realized the day before: time of departure and arrival, travelled distance, purpose and mode. Every trip is further divided into journeys, being defined as the use of any motorized mode (transit, car, motorized two-wheelers, etc.)<sup>5</sup>. In addition, trips are assembled into loops, defined as chains of successive trips between two successive home returns.

<sup>2</sup> The number of observations in every table is detailed in figure 1.

<sup>3</sup> All individuals aged more than five are selected in the face-to-face protocol, while only one or two among those aged more than eleven are retained in the phone protocol.

<sup>4</sup> A trip is defined by a purpose, for instance going to work or escorting children to school.

<sup>5</sup> For instance, a trip may be built of a journey by car to go to the train station, followed by a journey by train to destination.

Table 2. Opinion questionnaire

| Importance of | Agree or Disagree with  | Choose three adjectives out of these to design travel modes (car, transit and cycling)  |
|---------------|---|---|
| Road safety   | One should keep on building car parks;  | Quick, cheap, practical, ecological, safe, comfortable, makes autonomous or free, quiet, relaxing, useful, pleasant, vital/necessary, friendly, associated with leisure, easy, healthy, convenient, other positive.<br>Slow, expensive, unpractical, polluting, dangerous, uncomfortable, constraining, noisy, tiring, useless, unpleasant, stressful, inappropriate, crowded, dirty, cumbersome, unreliable, insufficient, other negative. |
| Noise         | Bicycle in town is the future;  |   |
| Pollution     | In town using a car is necessary;   |   |
| Transit       | Restricting car use in town is hindering economic activity;                     |   |
| Walking       | One should keep on developing transit, even at the price of disturbing drivers; |   |
| Cycling       | To improve traffic conditions, car use should be restricted in town;            |   |
| Parking       | Illegal parking should be more severely punished;                               |   |
| Traffic       |   |   |

Finally, surveys also include an opinion component, focusing on transport-related attitudes and concerns. The different questions of the opinion module are displayed in table 2. As only 110 000 individuals answered the opinion questionnaire, a restricted subsample had to be used for the analysis.

## 4. DESCRIPTIVE RESULTS

### 4.1 Generational structure

Table 3. Distribution of individuals by cohort in the whole sample, the restricted sub-sample, and in the general census 2019

|              | Whole sample |      | Sub-sample |      | National census 2019 |      |
|--------------|--------------|------|------------|------|----------------------|------|
|              | Number       | %    | Number     | %    | Number               | %    |
| Born 1908-44 | 72,576       | 15.4 | 16,787     | 18.1 | 6,218,848            | 9.3  |
| Born 1945-59 | 100,561      | 21.4 | 22,867     | 24.6 | 11,282,643           | 16.8 |
| Born 1960-79 | 127,734      | 27.2 | 30,787     | 33.2 | 17,491,354           | 26.1 |
| Born 1980-99 | 95,817       | 20.4 | 22,345     | 24.1 | 15,841,657           | 23.6 |
| Born 2000-19 | 73,813       | 15.7 | -          | -    | 16,158,197           | 24.1 |

Lecture: - irrelevant data

By grouping cohorts appropriately, one can compare their distribution with the national census. Generation Y is well represented with about 20 % of the whole sample, and 24 % of the restricted dataset<sup>6</sup>. Cohorts born before 1960 are over-weighted, while generation Z is under-weighted, and cohorts from 1960 to 2000, including the millennials, are correctly figured out<sup>7</sup>. However, millennials from the

<sup>6</sup> Weights are different in the restricted subsample notably because individuals born after 2000 (generation Z) don't figure in it, as only adults were asked about their opinions.

<sup>7</sup> Differences with the national census may have several origins: first, only children aged more than five are questioned in local travel surveys; in addition, retired people may be easier to join than occupied workers; finally, though corrective weights are applied to ensure representativity, these are specific to each travel survey, and therefore cannot be aggregated at the national scale.

sample might differ partially from their counterpart in the whole population, as most travel surveys focus on urban areas, resulting in a lack of knowledge of travel patterns among young countrymen and suburban adults.

## 4.2. Age cohort analysis

In this sub-section, we proceed to age cohort analysis of travel patterns according to a number of indicators, in relation with living conditions and attitudes, to determine if a substantial gap can be established between the millennials and preceding cohorts<sup>8</sup>. Given the low number of survey waves, only three points of observation could be estimated for every cohort<sup>9</sup>. Eight indicators were figured out for travel behaviors, against six for either living conditions or opinions, which were listed in table 4.

Table 4. Indicators for travel behaviors, living conditions and opinions

| Travel behaviors                                   | Living conditions                     | Opinion variables  |
|--|---------------------------------------|--|
| Driving license rate                               | Employment rate                       | Importance of alternatives to the car  |
| Personal car availability rate                     | Proportion of students                | Importance of car externalities (noise, pollution...)                                  |
| Proportion of daily car users                      | Proportion of singles                 | Importance of traffic efficiency (parking and congestion issues)                       |
| Proportion of regular transit users                | Proportion of adults without children | Agreement to pro-car statements  |
| Average daily trip frequency by car as a driver    | Proportion of core city dwellers      | Agreement to anti-car statements   |
| Average daily trip frequency by car as a passenger | Proportion of unemployed              | Image of the car, transit and cycling based on adjectives to design them (cf. table 2) |
| Average daily trip frequency by transit            |                                       |  |
| Average daily trip frequency by active modes       |                                       |  |

Opinion constructs were obtained according to the following method: (a) Importance variables - of car alternatives, of car externalities, of transport efficiency - were increased by + 1 every time a given issue was considered important by the interviewee<sup>10</sup>, by 0 if an issue was regarded as unimportant, and by 0.5 if no opinion was expressed; (b) Score variables for the degree of agreement to pro- and anti-car statements were increased by + 1 if an individual agreed with a statement, diminished from - 1 if he/she disagreed, and unchanged by neutral opinions; (c) Score variables were calculated for every mode, based on adjectives to design them (cf. table 2). The value +1 was attributed to a positive qualifier, -1 to a negative one, and zero when no opinion was given. However, adjectives were weighted according to their rank<sup>11</sup>, which may reflect their hierarchy of importance in the mind of the interviewee.

<sup>8</sup> Cohorts are defined here as five-year birthdate intervals, resulting in eighteen groups starting from 1908-15 up to 1995-99. Likewise, age groups are split into five-year intervals, from 16-20 to more than 95, resulting in eighteen groups.

<sup>9</sup> The restricted subsample only contains observations from 2009 to 2015. As a result, any given cohort, for instance 1980-85, is observed only over an eleven year period of its lifecourse, e.g. 24-35 in this case, which corresponds only to three age groups: 20-25, 25-30 and 30-35.

<sup>10</sup> For instance, if an individual judged as equally important transit, walking and cycling, the importance variable for transport alternatives was attributed the value +3.

<sup>11</sup> 1 for the first qualifier, 1/2 for the second, and 1/3 for the third.

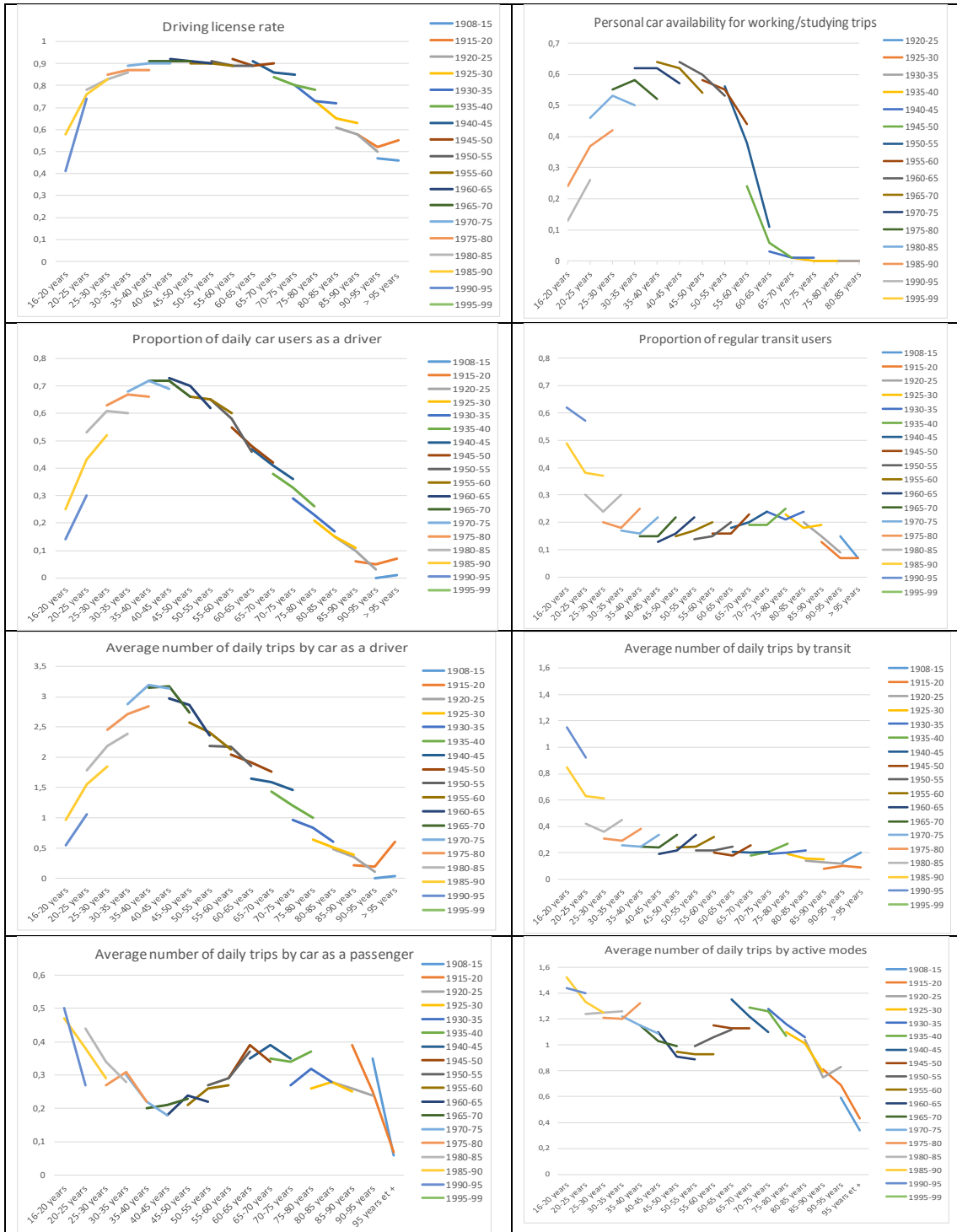


Figure 2 (use color online only): Indicators of travel behavior by age and cohort  
 Lecture: The proportion of daily car users as a driver in cohort 1985-90 between 25 and 30 equals 52%. The average number of daily driving trips in the same group equals 1.85.  
 Source: French Unified Base of Household Travel Surveys

*De facto*, age-cohort analysis reveals the existence of significant change in car ownership and travel patterns across cohorts. Such change is limited for driving license diffusion which, after increasing across cohorts born before 1950, remained stable thereafter. Even among the millennials, only a slight decline of license diffusion is noticed from cohort 1975-80, suggesting that driving license is still

considered a necessity by the vast majority of young adults. Results are different when it comes to personal car availability, daily driving and the average number of daily trips by car, which follow a bell-shaped curve according to age, reaching a peak by forty-five, and decline in cohorts born after 1975, with an acceleration in cohorts born after 1985. By contrast, the proportion of regular transit users and the average number of daily transit trips have increased among the millennials, with an acceleration in cohorts born after 1985. The lifecourse profile for these indicators is also characterized by decrease until forty-five, stability until seventy-five, and decline thereafter. Finally, no significant generation effects are found for average daily trip frequencies by car as a passenger and by active modes (walking and cycling).

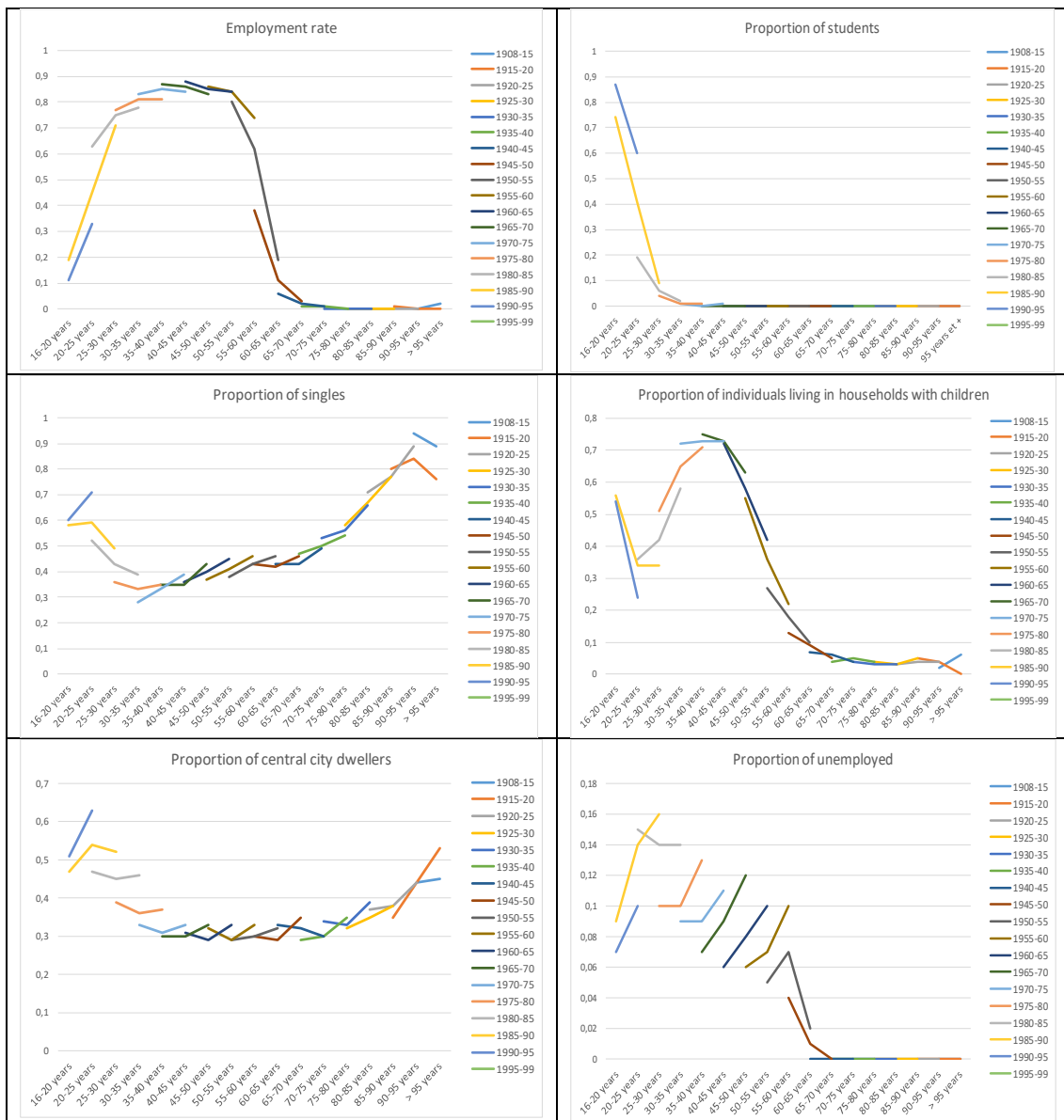


Figure 3 (use color online only): Indicators of living conditions by age and cohort  
 Lecture: The proportion of central city dwellers in cohort 1985-90 between 25 and 30 equals 52 %.  
 Source: French Unified Base of Household Travel Surveys

Living conditions might bring a significant contribution to these trends as substantial change is noticed across cohorts, either for the proportion of students and activity

rates, cohabitation patterns or residential locations. In particular, after a steady growth in cohorts born before 1960<sup>12</sup>, the proportion of working adults decreased in cohorts born after 1965, with a clear acceleration in those born after 1985, along with a significant rise in the number of students. This result can be explained through the fact that longer studies generalized among French millennials, with the lowering of university standards. In addition, the proportion of unemployed constantly increased across post-war cohorts. Besides, family foundation was delayed in cohorts born after 1980, with a growing proportion of young adults living alone and without children. Finally, cohorts born after 1975 tend to be increasingly concentrated in central cities, where car ownership is less of a necessity and transit more efficient, while using a car is also made increasingly difficult by limited parking supply, anti-car regulations and growing congestion.

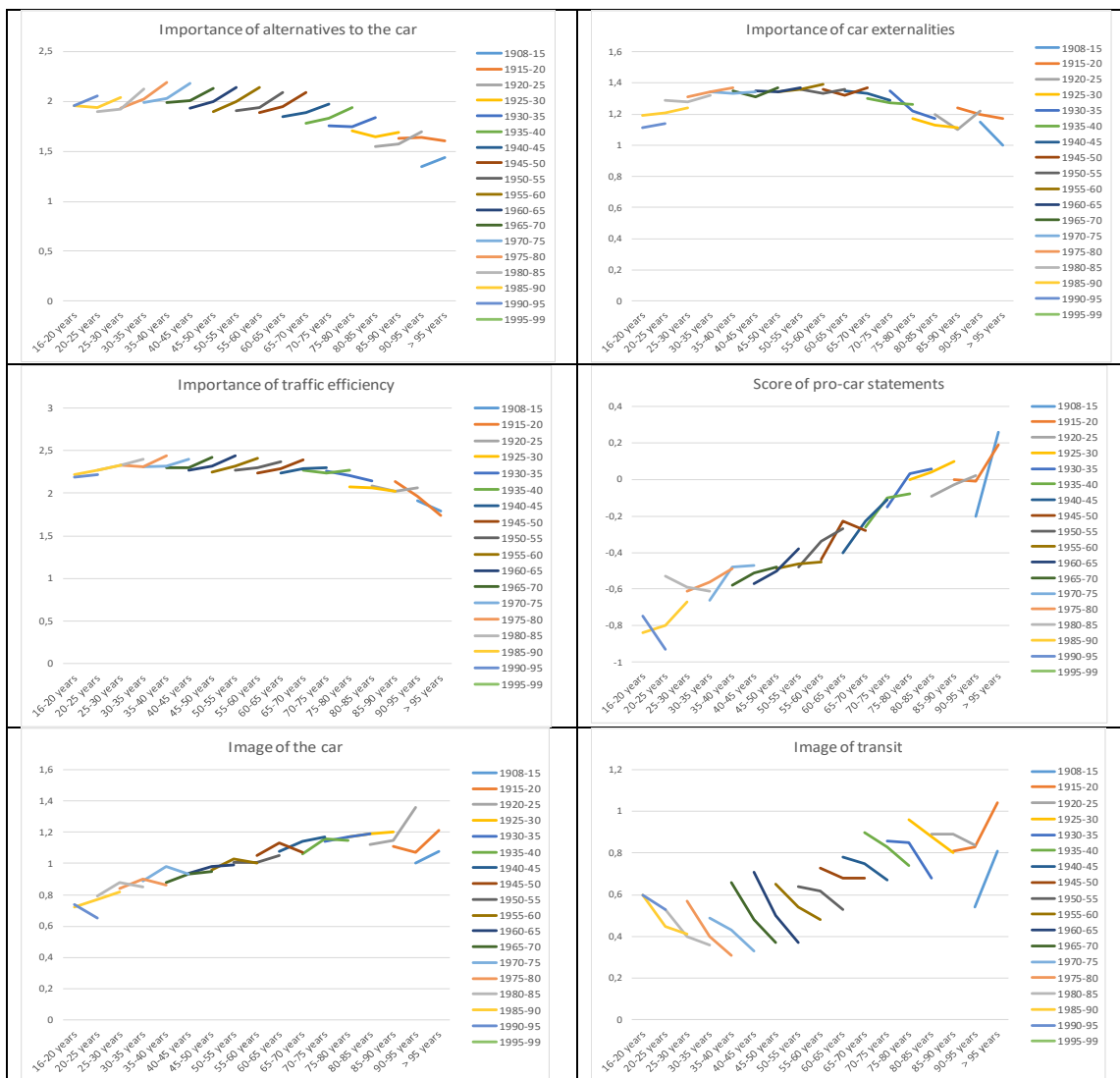


Figure 4 (use color online only): Synthetic indicators of opinion by age and cohort

Lecture: The importance attributed to alternatives to the car equals 2.04 in cohort 1985-90 between 25 and 30

Source: French Unified Base of Household Travel Surveys

<sup>12</sup> In relation with the massive entrance of women into the workforce and the thirty-year post-war boom.

By contrast, synthetic constructs for opinions and attitudes show no evidence of significant generation effects. This is true, for instance, of the sensitivity to car alternatives, car externalities and traffic efficiency. In particular, the absence of specific environmental awareness among the millennials tends to confirm prior findings from the literature. The same can be said of the degree of agreement to pro- and anti-car statements, and of the score of different modes, based on adjectives to design them. On the contrary, age effects are found for several indicators. These are weak for the sensitivity to either transport alternatives, car externalities or traffic efficiency, and limited to a higher degree of concern in the middle lifecourse, possibly because individuals become more aware of these issues in relation with their daily driving experience. By contrast, the degree of agreement to either pro- or anti-car statements is characterized by substantial age effects: paradoxically, people tend to agree more with both pro- and anti-car statements when ageing, possibly because older people would tend to agree more easily to any given proposition. The score of every mode seems to be influenced by the same acceptance bias, with all modes getting a better image in the eyes of older people, while the young tend to be more critical<sup>13</sup>. However, the relative perception of the car tends to improve with age, especially after sixty-five, possibly because of its benefits in terms of comfort, autonomy and efficiency, in relation with diminishing physical capabilities. Finally, period effects might also exist, with the degree of concern about car alternatives and transport efficiency increasing over time, while the image of transit got worse during the period of observation. Transit supply could possibly generate increasing worries about its comfort, safety and efficiency, in relation with overcrowding and the growing number of security events, malfunctions and disruptions (e.g., OMNIL, 2011).

## **5. Modelling**

### **5.1 Model structure and specification**

In order to further tackle this issue, one can try to determine whether car ownership and travel patterns are still influenced by generation effects, once a large number of structural determinants are controlled for, and how much attitudes contribute to these decisions. In attempts to model travel patterns across the literature, car ownership was often found very influential, impacting almost all aspects of travel behaviors, and in particular transit attendance (e.g., Christiansen et al., 2017; Bresson et al., 2004). In addition, residential location and the built environment are considered important determinants of either car ownership or travel decisions (e.g., Bhat and Pulugurta, 1998; Cervero and Duncan, 2003). As a result, a classical approach is to consider these different decisions as reflecting a hierarchy of choices involving different time horizons, from long-term - residential location - to mid-term - car ownership - and short-term - modal choice - decisions (e.g., Ben-Akiva and Atherton, 1977; Bhat and Guo, 2007). In this framework, car ownership plays the role of a go-between,

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<sup>13</sup> An exception being the bicycle, with a very positive image in the early lifecourse which tends to deteriorate after fifty, probably in relation with the decline of physical capabilities and increasing safety concerns.

transmitting the influence of different variable sets to travel choices. However, a difficulty arising is the potential endogeneity between these different life choices, which might be correlated through travel preferences and desired lifestyles. For instance, the estimated influence of car ownership on travel patterns can be made inconsistent by the fact that car ownership decisions are themselves predetermined by desired travel patterns (e.g., Golob and Van Wissen, 1989; Hensher et al., 1992). In the same way, individuals tend to self-select into residential environments likely to satisfy their travel aspirations, resulting in a spurious association between the built environment and travel behaviors (Bhat and Guo, 2007; Cao et al., 2009; Kitamura et al., 1997), a problem usually known as residential self-selection<sup>14</sup>. In addition, different life choice dimensions may represent particular expressions of desired lifestyles, which cannot necessarily be separated (Salomon and Ben-Akiva, 1983). As a result, these choices might be partially simultaneous (e.g., Pinjari et al., 2007). An alternative is therefore trying to model these different choice dimensions jointly. Though different joint models of either residential location, car ownership and/or travel choices exist through the literature<sup>15</sup>, few of them model jointly these three life choice dimensions as the outcome of a single decision process. One can quote, nonetheless, works from Lerman (1976), or more recently, Salon (2009), for instance.

$$y_{1i}^* = \alpha_{123}X_i^b + \alpha_{12}X_i^{12} + \alpha_{13}z_i^2 + \beta_1y_{2i} + \gamma_1y_{3i} + u_i \quad (1a)$$

$$y_{2i}^* = \alpha_{213}X_i^b + \alpha_{21}X_i^{12} + \alpha_{23}z_i^1 + \gamma_2y_{3i} + \varepsilon_i \quad (1b)$$

$$y_{3i}^* = \alpha_{312}X_i^b + \alpha_3z_i^{12} + \alpha_{31}z_i^2 + \alpha_{32}z_i^1 + \eta_i \quad (1c)$$

$$\text{With } \begin{pmatrix} u_i \\ \varepsilon_i \\ \eta_i \end{pmatrix} \sim N \left[ \begin{pmatrix} 0 \\ 0 \\ 0 \end{pmatrix}, \begin{pmatrix} 1 & \rho_{u\varepsilon} & \rho_{u\eta} \\ \rho_{u\varepsilon} & 1 & \rho_{\varepsilon\eta} \\ \rho_{u\eta} & \rho_{\varepsilon\eta} & 1 \end{pmatrix} \right] \text{ and} \quad (1d)$$

$y_{1i}^*$  relative utility of regular transit use - the reference case is no regular transit use;  $y_{2i}^*$  relative utility of personal car availability - the reference case is no personal car availability;  $y_{3i}^*$  utility of a central residential location (core city) - the reference case is no central location;  $X_i^b$  variables common to all decision levels;  $X_i^{12}$  variables common to car availability and regular transit use models;  $z_i^1$  variables common to residential choice and car availability models;  $z_i^2$  variables common to residential choice and regular transit use models;  $z_i^{12}$  variables specific to the residential choice model;  $y_{2i}$  dummy for personal car availability;  $y_{3i}$  dummy for central residential location.

In the ensuing analysis, we retain a hybrid approach, assuming a hierarchy of choice between residential location, car ownership and travel decisions, but allowing them to be partially endogenous. We consider the model structure above, built of one main equation for the probability of regularly using transit<sup>16</sup>, with a central location and

<sup>14</sup> For instance, individuals oriented towards walking and cycling are likely to choose a residential location where there can more easily practice these modes.

<sup>15</sup> E.g., Train (1980), Bhat and Pulugurta (1998) for joint models of car ownership and car use/modal choice; Pinjari et al. (2007), Cervero (2007) for joint models of residential and travel choices; Bhat and Guo (2007), Bagley and Mokhtarian (2002) for joint models of residential choice and car ownership.

<sup>16</sup> For any given mode, frequencies of use are described according to different modalities in the dataset: daily or almost daily, at least twice a week, at least twice a month, exceptionally, and never. Among these modalities, using a mode at least twice a week appears as an attractive and natural indicator of regular travel habits, in relation with travel attitudes. It is an indicator of the lack of reluctance to use transit, while daily use may look too restrictive, as changes in travel patterns may be progressive and

personal car availability<sup>17</sup> as dummy endogenous regressors, and two auxiliary equations for the endogenous regressors. The dummy variable for a central location is used again as an endogenous regressor in the equation for personal car availability<sup>18</sup>. It is therefore a trivariate *probit* model with two dummy endogenous regressors, where variances are normalized to one for model identification (Nerlove and Press, 1976), and correlation between error terms is authorized in order to account for unobserved heterogeneity with joint influence on all decision levels<sup>19</sup>. In addition, instruments are habitually required for model identification, i.e. variables correlated with the endogenous regressors but not with the main dependent variable, which are figured out by the variable sets  $z_i^1$  and  $z_i^{12}$ , respectively in the personal car availability and central location models.

## 5.2 Variable choice

Five main groups of determinants of car ownership and travel patterns can be identified according to the literature: (1) purely economic, or crypto-economic, variables: income, fuel prices, transit fees, travel time; (2) socio-economic (activity participation) and socio-demographic (family composition, sex, age and generation effects ...) factors; (3) residential location and built environment attributes: density of population/employment, land use diversity, parking supply at home/workplace, distance to city-centre...; (4) attributes of the transport system: car ownership/availability, quantity of transit supply (train\*km), transit accessibility, territorial coverage...; (5) Subjective drivers of travel behaviors: opinions, attitudes, preferences, lifestyles. For every group of factors, variable choice is the result of a compromise between their recognized influence on travel behaviors, and considerations of data availability.

With respect to our purpose, the introduction of age and generation dummies is obviously required<sup>20</sup>. Sex is also usually found to be an influent determinant of car ownership (Pinjari et al., 2007; Giuliano and Dargay, 2006) and modal choice (Chiou et al., 2015). Among other socio-demographic factors, household composition is an important determinant of car ownership/use, generally increasing with the number of

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operate through multi-modality, for instance, rather than completely shifting from a mode to another. On the opposite, transit use on a monthly basis is too spaced to be considered as regular. By the way, this threshold was also retained by other authors (e.g., Lee and Hickman, 2011).

<sup>17</sup> The definition of personal car availability differs between the descriptive and the modelling section. In the descriptive part, disposal of a vehicle to go to work/studying place is declarative. By contrast in the modelling section, personal car availability is defined by the analyst. Vehicles are attributed to household members under the condition that they are adult and licensed, both accounting for their link to the household head and the number of household vehicles. Vehicles are therefore attributed in priority to the household head, then to its partner and finally to adult children at parental home.

<sup>18</sup> The reason to choose a central location as a regressor is that we assume it to be associated with a gap in population density, transit territorial coverage and accessibility, which is reflected in car ownership and travel patterns. However, in order to account for built environment attributes which could influence car ownership and travel decisions in a more continuous manner, other variables are included, that are detailed in section 5.2.

<sup>19</sup> Though we include attitudinal variables as controls for travel preferences, unobserved heterogeneity with joint influence on all choice dimensions may still remain. Indeed, as was noticed for instance by Bhat and Guo (2007), even if a significant number of attitudinal variables can be collected, it is unlikely that they are able to capture all relevant attitudinal factors with joint influence on all choice dimensions.

<sup>20</sup> These are defined in the same way than in the descriptive section.

adults and children (Bhat and Pulugurta, 1998; Giuliano and Dargay, 2006; Buehler, 2011). It will be accounted here through cohabitation patterns – being single or having a partner – and the presence of children.

Car ownership and travel decisions are also influenced by socio-economic factors. Car ownership/use usually increase with household income (e.g., Bhat and Pulugurta, 1998; Dargay and Gately, 1999), to the expense of transit (Chiou et al., 2015; Buehler, 2011)<sup>21</sup>. Unfortunately, income is missing in local travel surveys. Instead, we use socio-professional category<sup>22</sup> as a *proxy*, as well as the occupational status (owner or tenant). Working status also has important effects on car ownership/use, in relation with the longer and more frequent trips generated by professional activity (Pinjari et al., 2007; Giuliano and Dargay, 2006). Seven categories of activity status were distinguished in the dataset: workers (full-time or part-time), students at parental home, autonomous students, unemployed, retired, other persons at home, and other.

Built environment attributes have effects on both car ownership (Bhat and Pulugurta, 1998) and travel patterns (Cervero and Duncan, 2003). Among the most quoted, are densities at home/workplace (Pinjari et al., 2007; Christiansen et al., 2017; Salon, 2009), parking facilities at home/workplace (e.g., Christiansen et al., 2017), and distance to the city centre (Pinjari et al., 2007; Salon, 2009). Land use diversity is also sometimes associated with less car use and more transit (e.g., Buehler, 2011). In addition, a number of studies point out the influence of the quantity and quality of transport supply on travel behaviors: territorial coverage, accessibility, frequency, speed and connectivity of transit all contribute to reinforce its use to the expense of the car (e.g., Christiansen et al., 2017; Train, 1980; Buehler, 2011). Distance to the city centre is retained as a good *proxy* for either travel distances/times, density at homeplace, land use diversity, residential parking supply or transit accessibility, with respect to the radioconcentric structure of most urban areas. In order to account for local density variations which cannot be entirely figured out through a radioconcentric scheme, we also include a variable of density of population at the zipcode scale, as well as a dummy for individual housing. Besides, as travel patterns also depend on characteristics of the workplace, we add distance to work/studying place and population density at work/studying place as additional regressors. Density at the workplace can be considered a *proxy* for traffic and parking difficulties associated with commuting trips<sup>23</sup>.

Though price effects were usually found influent in the literature, either on car ownership (e.g., Golob et al., 1979) or car use (e.g., Johansson and Schipper, 1997) and transit attendance (Bresson et al., 2004; Maley and Weinberger, 2009), we did not retain them into the model, for two reasons: (a) price fluctuations over time apply in the same way to all cohorts, and therefore may not well explain differences between

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<sup>21</sup> Though this association tends to be increasingly challenged (e.g., Ingvarsson and Nielsen., 2018), in relation with the growing concentration of highly-qualified workers in the largest metropolitan areas, where traffic and parking conditions are increasingly difficult and car use is less of a necessity.

<sup>22</sup> For retired, socio-professional status is the status of the ancient profession.

<sup>23</sup> Though there is a variable mentioning the existence of parking difficulties at the workplace in the dataset, it happens to be endogenous with travel choices. Indeed, people mentioning parking difficulties are generally those who experience them because they are regularly commuting by car, while transit users might not be conscious of them.

them. In addition, all cohorts are observed during the same short period of time (2009-15), where price fluctuations are limited<sup>24</sup>; (b) differences between individual costs are endogenous to car ownership and travel decisions. For instance, intensive users tend to privilege diesel cars to cut fuel costs<sup>25</sup>.

Finally, travel behaviors are not determined only by external factors but also depend on subjective constructs: preferences, opinions, attitudes, mental habits and lifestyles (e.g., Golob et al., 1979; Kitamura et al., 1997). An originality of the dataset is to incorporate opinion data for a subsample of the interviewees, therefore allowing us to introduce attitudinal variables as additional regressors directly into the model<sup>26</sup>.

In the end, estimation of a joint model with endogenous regressors also requires instruments in the car ownership and residential choice equations. In our case, we use population density of the city-centre, which is usually found to be negatively associated with residential attractiveness (e.g., Salon, 2009). We also use generic opinion variables figuring in the dataset. In particular, cross-analysis indicates that sensitivities to housing and transport issues are correlated with decisions to live in a central location and to use transit, but have little relation with car ownership, and can therefore be used as regressors in the transit use and residential location models. On the opposite, sensitivities to education, employment and leisure issues are correlated with car ownership but have little relation with transit use, and can therefore serve as instruments in the car ownership model.

### 5.3 Estimation methodology

The model is then estimated through maximum likelihood, which results in consistent and asymptotically efficient estimates. As  $y_{1i}$ ,  $y_{2i}$  et  $y_{3i}$  are dummy variables, the joint events  $(y_{1i}, y_{2i}, y_{3i})$  can be gathered into eight different categories. The sample log-likelihood can then be written as:

$$\text{Log } L = \sum_{j,k,l \in \{0,1\}^3} \sum_{i \in I_{jkl}} \log P(y_{1i} = j, y_{2i} = k, y_{3i} = l) \quad (2)$$

With  $I_{jkl} = \{i \in I / y_{1i} = j, y_{2i} = k, y_{3i} = l\}$ , and  $I$  referring to the whole sample. By using conditional probabilities, every term  $P(y_{1i} = j, y_{2i} = k, y_{3i} = l)$  can also be written as:

$$\begin{aligned} P(y_{1i} = j | y_{2i} = k, y_{3i} = l) P(y_{2i} = k, y_{3i} = l) = \\ P(y_{1i} = j | y_{2i} = k, y_{3i} = l) P(y_{2i} = k | y_{3i} = l) P(y_{3i} = l) \end{aligned} \quad (3)$$

$P(y_{3i} = l)$  can be easily obtained through the marginal distribution of  $\eta$ .

By setting  $a_i = \alpha_{312} X_i^b + \alpha_3 z_i^{12} + \alpha_{31} z_i^2 + \alpha_{32} z_i^1$ , we have :

<sup>24</sup> More, behavioral adjustments over time are usually progressive, which makes difficult to analyze price effects out of a dynamic modelling framework, which would require a longer period of observation to separate short from long-term effects (e.g., Johansson and Schipper, 1997).

<sup>25</sup> These arguments may apply in the same way to fix costs. Indeed, though fix costs – driving license preparation, insurances, technical control – might not depend as much as variable costs on individual choices, cheap alternatives also exist through the second-hand market and pay-as-you-drive insurances, for instance.

<sup>26</sup> The same behavioural constructs that were used in the descriptive section are recycled.

$P(y_{3i} = l) = \phi(a_i)^l [1 - \phi(a_i)]^{1-l}$ , where  $\phi(\cdot)$  stands for the cumulative density function of the standard normal distribution.

Besides,  $P(y_{2i} = k | y_{3i} = l)$  as well as  $P(y_{1i} = j | y_{2i} = k, y_{3i} = l)$  are probabilities derived from conditional laws.  $P(y_{2i} = k | y_{3i} = l)$  can be obtained through the conditional law of  $y_{2i}^* | \eta$ , and  $P(y_{1i} = j | y_{2i} = k, y_{3i} = l)$  through the conditional law of  $y_{1i}^* | \varepsilon, \eta$ . Using the expression for the expectation and variance of a conditional normal law, we have:

$P(y_{2i} = k | \eta) = F_{y_{2i}^* | \eta}(0)^{1-k} [1 - F_{y_{2i}^* | \eta}(0)]^k$ , where  $F(\cdot)$  stands for the cumulative density function of the distribution of  $y_{2i}^* | \eta$ , of expectation  $E(y_{2i}^* | \eta)$  and variance  $1 - \rho_{\varepsilon\eta}^2$ , with:

$$E(y_{2i}^* | \eta) = \alpha_{213} X_i^b + \alpha_{21} X_i^{12} + \alpha_{23} Z_i^1 + \gamma_2 y_{3i} + \rho_{\varepsilon\eta} \eta \quad (4)$$

In addition, we have  $F_{y_{2i}^* | \eta}(0) = 1 - \phi\left(\frac{E(y_{2i}^* | \eta)}{\sqrt{1 - \rho_{\varepsilon\eta}^2}}\right)$ , using the expression for the cumulative density function of a normal law of any given expectation and variance, so that one can finally write, by setting  $b_i = \alpha_{213} X_i^b + \alpha_{21} X_i^{12} + \alpha_{23} Z_i^1 + \gamma_2 y_{3i}$ :

$$P(y_{2i} = k | \eta) = \phi\left(\frac{b_i + \rho_{\varepsilon\eta} \eta}{\sqrt{1 - \rho_{\varepsilon\eta}^2}}\right)^k \left[1 - \phi\left(\frac{b_i + \rho_{\varepsilon\eta} \eta}{\sqrt{1 - \rho_{\varepsilon\eta}^2}}\right)\right]^{1-k} \quad (5)$$

Following Wooldridge (2002),  $P(y_{2i} = k, y_{3i} = l)$  can then be obtained by integrating  $P(y_{2i} = k | \eta)$  over the validity domain of the conditional law  $\eta \leq -a_i$ , finally bringing the following expression, after multiplying by  $P(y_{3i} = l)$ :

$$P(y_{2i} = k, y_{3i} = l) = \left\{ \int_{-a_i}^{+\infty} \phi\left(\frac{b_i + \rho_{\varepsilon\eta} \eta}{\sqrt{1 - \rho_{\varepsilon\eta}^2}}\right)^k \left[1 - \phi\left(\frac{b_i + \rho_{\varepsilon\eta} \eta}{\sqrt{1 - \rho_{\varepsilon\eta}^2}}\right)\right]^{1-k} \varphi(\eta) d\eta \right\}^l * \left\{ \int_{-\infty}^{-a_i} \phi\left(\frac{b_i + \rho_{\varepsilon\eta} \eta}{\sqrt{1 - \rho_{\varepsilon\eta}^2}}\right)^k \left[1 - \phi\left(\frac{b_i + \rho_{\varepsilon\eta} \eta}{\sqrt{1 - \rho_{\varepsilon\eta}^2}}\right)\right]^{1-k} \varphi(\eta) d\eta \right\}^{1-l} \quad (6)$$

This expression can then be simplified depending on  $k$  and  $l$  values. The same method is used to obtain  $P(y_{1i} = j | y_{2i} = k, y_{3i} = l)$ , through the bivariate conditional normal law of  $y_{1i}^* | \varepsilon, \eta$ , of expectation  $E(y_{1i}^* | \varepsilon, \eta)$  and variance  $\sigma_{u|\varepsilon, \eta}^2$ , with:

$$E(y_{1i}^* | \varepsilon, \eta) = \alpha_{123} X_i^b + \alpha_{12} X_i^{12} + \alpha_{13} Z_i^2 + \beta_1 y_{2i} + \gamma_1 y_{3i} + \frac{\rho_{u\varepsilon} - \rho_{u\eta} \rho_{\varepsilon\eta}}{1 - \rho_{\varepsilon\eta}^2} \varepsilon + \frac{\rho_{u\eta} - \rho_{u\varepsilon} \rho_{\varepsilon\eta}}{1 - \rho_{\varepsilon\eta}^2} \eta \quad (7)$$

$$\text{And } \sigma_{u|\varepsilon, \eta}^2 = \frac{1 + \rho_{u\varepsilon}^2 + \rho_{u\eta}^2 - \rho_{\varepsilon\eta}(\rho_{\varepsilon\eta} + 2\rho_{u\eta} \rho_{u\varepsilon})}{1 - \rho_{\varepsilon\eta}^2} \quad (8)$$

The resulting expression is again integrated over the validity domain of the conditional law ( $\eta \leq -a_i, \varepsilon \leq -b_i$ ), leading to expressions of the following form,

where  $\varphi_2(\dots)$  and  $\Phi_2(\dots)$  respectively stand for the p.d.f and c.d.f of the bivariate normal law of null expectation and covariance matrix  $\begin{pmatrix} 1 & \rho_{\varepsilon\eta} \\ \rho_{\varepsilon\eta} & 1 \end{pmatrix}$ .

$$P(y_{1i} = 0, y_{2i} = 1, y_{3i} = 1) = \frac{1}{\Phi(b_i) - \Phi(a_i) - \Phi_2(a_i, b_i)} * \iint_{\eta_i > -a_i, \varepsilon_i > -b_i} \left[ 1 - \Phi\left(\frac{E(y_{1i}^* | \varepsilon_i, \eta_i)}{\sigma_{u|\varepsilon, \eta}}\right) \right] \varphi_2(\varepsilon, \eta) d\varepsilon d\eta * \int_{\eta_i > -a_i} \left[ \Phi\left(\frac{E(y_{2i}^* | \eta_i)}{\sigma_{y_{2i}^* | \eta}}\right) \right] \varphi(\eta) d\eta \quad (9)$$

Other expressions are of the same form. The optimization procedure is realized through PROC QLIM with the SAS software package, which proceeds through the GHK simulator to calculate the joint distribution of the dependent variable and endogenous regressors.

#### 5.4 Estimation results

We now come to estimation results, starting from the residential choice model. Among socio-demographic variables, sex has no significant effects on the probability of choosing a central location, which is, by contrast, negatively correlated with family life. Age and generation are also influent, with the probability of choosing a central location increasing across cohorts born after 1965 and over the lifecourse<sup>27</sup>. The probability of choosing a central location is positively associated with socio-professional status. This result might indicate the existence of social competition to access the amenities offered through a central location. The influence of activity status highlights different behaviors between occupied workers and retired, whose probability to live in a city-centre is lower than average, and autonomous students, who are very likely to choose a central location. This choice is likely to be explained by the central location of high-school establishments, the lack of driving license for many students, leading them to choose less car-dependent areas, and the large number of opportunities for leisure and out-of-home activities offered through a central location, in relation with “student life”. Regarding built environment attributes, the choice of an individual house is negatively correlated with centrality, while the attractiveness of a central location also decreases with population density, a consistent result with respect to prior findings from the literature (e.g., Salon, 2009). Finally, the choice to live in a central location is positively associated with the sensitivity to modal alternatives, car externalities and transport efficiency, all concerns for which a central location may look attractive, and negatively associated with pro-car statements and a good image of the bicycle<sup>28</sup>. It is positively correlated with the sensitivity to

<sup>27</sup> The apparent age dependence of the choice of a central location could have several explanations: one of them is an effect of learning experience, as people become more conscious of the monetary, temporal and psychological costs of commuting over time, bringing them to look for closer proximity to work; another is that age captures a significant portion of the income effect, as financial resources usually increase over the lifecourse in relation with professional career and cumulated assets.

<sup>28</sup> Though this result may seem paradoxical, given the facilities offered through a central location for bicycle use (proximity to activities, cycling lanes, free-bike services...), it may be explained by the frequent association of bicycle with leisure practice, even though bicycle use for work is now becoming increasingly popular, especially in large metropolitan areas.

housing, transport, education and employment issues, for which centrality may also offer multiple assets.

Table 5a: Parameter estimates, standard errors and p-values of socio-demographic variables for different models: regular transit use, personal car availability and residential choice (living in a core city)

|                           | Regular transit use |           |        | Personal car availability |           |        | Residential choice |           |        |
|---------------------------|---------------------|-----------|--------|---------------------------|-----------|--------|--------------------|-----------|--------|
|                           | Estimate            | Std-error | P> t   | Estimate                  | Std-error | P> t   | Estimate           | Std-error | P> t   |
| <i>Socio-demographics</i> |                     |           |        |                           |           |        |                    |           |        |
| Intercept                 | NS                  | NS        | 0.57   | NS                        | NS        | 0.66   | 0.63               | 0.29      | 0.03   |
| Age < 20                  | -0.85               | 0.33      | 0.01   | NS                        | NS        | 0.06   | -3.25              | 0.35      | <.0001 |
| Age 20-25                 | NS                  | NS        | 0.08   | NS                        | NS        | 0.73   | -2.98              | 0.35      | <.0001 |
| Age 25-30                 | NS                  | NS        | 0.25   | NS                        | NS        | 0.33   | -2.70              | 0.34      | <.0001 |
| Age 30-35                 | NS                  | NS        | 0.57   | NS                        | NS        | 0.19   | -2.47              | 0.34      | <.0001 |
| Age 35-40                 | NS                  | NS        | 0.82   | NS                        | NS        | 0.18   | -2.23              | 0.34      | <.0001 |
| Age 40-45                 | NS                  | NS        | 0.98   | NS                        | NS        | 0.17   | -2.02              | 0.34      | <.0001 |
| Age 45-50                 | NS                  | NS        | 0.85   | NS                        | NS        | 0.18   | -1.83              | 0.34      | <.0001 |
| Age 50-55                 | NS                  | NS        | 0.71   | NS                        | NS        | 0.23   | -1.62              | 0.34      | <.0001 |
| Age 55-60                 | NS                  | NS        | 0.79   | NS                        | NS        | 0.27   | -1.41              | 0.34      | <.0001 |
| Age 60-65                 | NS                  | NS        | 0.78   | NS                        | NS        | 0.43   | -1.26              | 0.33      | 0.0002 |
| Age 65-70                 | NS                  | NS        | 0.52   | NS                        | NS        | 0.53   | -0.98              | 0.33      | 0.0033 |
| Age 70-75                 | NS                  | NS        | 0.41   | NS                        | NS        | 0.63   | -0.83              | 0.33      | 0.01   |
| Age 75-80                 | NS                  | NS        | 0.38   | NS                        | NS        | 0.70   | NS                 | NS        | 0.08   |
| Age 80-85                 | NS                  | NS        | 0.33   | NS                        | NS        | 0.68   | NS                 | NS        | 0.36   |
| Age 85-90                 | NS                  | NS        | 0.58   | NS                        | NS        | 0.85   | NS                 | NS        | 0.95   |
| Age 90-95                 | NS                  | NS        | 0.44   | NS                        | NS        | 0.41   | NS                 | NS        | 0.32   |
| Born 1915-20              | NS                  | NS        | 0.49   | NS                        | NS        | 0.86   | NS                 | NS        | 0.06   |
| Born 1920-25              | NS                  | NS        | 0.30   | NS                        | NS        | 0.98   | NS                 | NS        | 0.09   |
| Born 1925-30              | NS                  | NS        | 0.44   | NS                        | NS        | 0.89   | NS                 | NS        | 0.26   |
| Born 1930-35              | NS                  | NS        | 0.80   | NS                        | NS        | 0.56   | NS                 | NS        | 0.53   |
| Born 1935-40              | NS                  | NS        | 0.89   | NS                        | NS        | 0.47   | NS                 | NS        | 0.76   |
| Born 1940-45              | NS                  | NS        | 0.87   | NS                        | NS        | 0.37   | NS                 | NS        | 0.99   |
| Born 1945-50              | NS                  | NS        | 0.69   | NS                        | NS        | 0.29   | NS                 | NS        | 0.63   |
| Born 1950-55              | NS                  | NS        | 0.67   | NS                        | NS        | 0.30   | NS                 | NS        | 0.39   |
| Born 1955-60              | NS                  | NS        | 0.59   | NS                        | NS        | 0.35   | NS                 | NS        | 0.21   |
| Born 1960-65              | NS                  | NS        | 0.57   | NS                        | NS        | 0.35   | NS                 | NS        | 0.07   |
| Born 1965-70              | NS                  | NS        | 0.50   | NS                        | NS        | 0.35   | 1.01               | 0.45      | 0.02   |
| Born 1970-75              | NS                  | NS        | 0.48   | NS                        | NS        | 0.44   | 1.24               | 0.45      | 0.005  |
| Born 1975-80              | NS                  | NS        | 0.33   | NS                        | NS        | 0.47   | 1.54               | 0.45      | 0.0006 |
| Born 1980-85              | NS                  | NS        | 0.22   | NS                        | NS        | 0.58   | 1.81               | 0.45      | <.0001 |
| Born 1985-90              | NS                  | NS        | 0.09   | NS                        | NS        | 0.64   | 2.12               | 0.45      | <.0001 |
| Born 1990-95              | 0.93                | 0.42      | 0.03   | NS                        | NS        | 0.80   | 2.34               | 0.45      | <.0001 |
| Born 1995-2000            | 1.17                | 0.42      | 0.01   | NS                        | NS        | 0.92   | 2.62               | 0.45      | <.0001 |
| Occupied worker           | NS                  | NS        | 0.97   | 0.32                      | 0.04      | <.0001 | -0.22              | 0.05      | <.0001 |
| Autonomous student        | 0.22                | 0.04      | <.0001 | 0.55                      | 0.04      | <.0001 | 0.57               | 0.05      | <.0001 |
| Student at parental home  | 0.10                | 0.05      | 0.03   | -0.37                     | 0.04      | <.0001 | NS                 | NS        | 0.12   |
| Unemployed                | 0.16                | 0.04      | <.0001 | NS                        | NS        | 0.67   | NS                 | NS        | 0.27   |
| Retired                   | NS                  | NS        | 0.06   | 0.11                      | 0.04      | 0.007  | -0.25              | 0.05      | <.0001 |
| Other at home             | NS                  | NS        | 0.41   | NS                        | NS        | 0.95   | NS                 | NS        | 0.24   |
| Executive                 | 0.30                | 0.03      | <.0001 | 0.60                      | 0.03      | <.0001 | 0.43               | 0.04      | <.0001 |
| Intermediate              | 0.22                | 0.03      | <.0001 | 0.46                      | 0.03      | <.0001 | 0.24               | 0.04      | <.0001 |
| Employee                  | 0.09                | 0.03      | 0.01   | 0.15                      | 0.02      | <.0001 | 0.12               | 0.04      | 0.0005 |
| Worker                    | NS                  | NS        | NS     | 0.08                      | 0.03      | 0.0014 | 0.08               | 0.04      | 0.0237 |
| Owner                     | 0.08                | 0.01      | <.0001 | 0.27                      | 0.01      | <.0001 | NS                 | NS        | 0.40   |
| Living with a partner     | -0.19               | 0.01      | <.0001 | -0.03                     | 0.01      | 0.0002 | -0.14              | 0.01      | <.0001 |
| Having children           | NS                  | NS        | 0.23   | -0.04                     | 0.01      | <.0001 | -0.16              | 0.01      | <.0001 |
| Sex (female)              | -0.13               | 0.01      | <.0001 | -0.46                     | 0.01      | <.0001 | NS                 | NS        | NS     |

Lecture: Std-error=Standard error; P>|t|=p-value; NS=Non Significant at the 0.05 level; - = parameters not estimated due to variables absent from the model. Most variables are dummies, apart from distances (in km), densities of population (in thousands/km<sup>2</sup>), and travel preferences (see section 4.2 for definition).

Source: French Unified Base of Household Travel Surveys (2009-15)

By contrast with residential choice, the model for car ownership doesn't show any sign of age and generation effects, once many different factors are controlled for. As expected, being a woman is negatively associated with personal car availability. Strangely enough, individual housing and family life are negatively associated with car ownership, as well as distance to the city-centre, possibly because of their relation to income which is unobserved. Indeed, a lower income among middle-class families

living in outer suburbs might lead to the paradox of lower car ownership despite growing car dependence, in a context of growing competition to access the amenities offered through a central location. Signs of such evolutions can be found in the fact that households began to abandon their cars in low-density areas, as they face the persistent effects of the economic crisis (Hubert et al., 2016).

Table 5b: Parameter estimates, standard errors and p-values for different variable sets for different models: regular transit use, personal car availability and residential choice (living in a core city)

|  | Regular transit use  |                     |        | Personal car availability |                     |        | Residential choice |                     |        |
|--|----------------------|---------------------|--------|---------------------------|---------------------|--------|--------------------|---------------------|--------|
|  | Estimate             | Std-error           | P> t   | Estimate                  | Std-error           | P> t   | Estimate           | Std-error           | P> t   |
| <i>Built environment</i>                   |                      |                     |        |                           |                     |        |                    |                     |        |
| Living in a house                          | -0.17                | 0.01                | <.0001 | -0.05                     | 0.01                | 0.0006 | -1.01              | 0.01                | <.0001 |
| Distance to city-centre                    | -2.48 <sup>e-4</sup> | 1.06 <sup>e-4</sup> | 0.02   | -2.13 <sup>e-4</sup>      | 8 <sup>e-5</sup>    | 0.0082 | -                  | -                   | -      |
| Distance to work                           | NS                   | NS                  | NS     | NS                        | NS                  | 0.14   | -                  | -                   | -      |
| Density at homeplace                       | 3.96 <sup>e-2</sup>  | 2.67 <sup>e-3</sup> | <.0001 | -5.78 <sup>e-2</sup>      | 2.32 <sup>e-3</sup> | <.0001 | -                  | -                   | -      |
| Density at workplace                       | 4.36 <sup>e-2</sup>  | 2.5 <sup>e-3</sup>  | <.0001 | -1.97 <sup>e-2</sup>      | 2.12 <sup>e-3</sup> | <.0001 | -                  | -                   | -      |
| Density of city-centre                     | -                    | -                   | -      | -                         | -                   | -      | -0.10              | 2.12 <sup>e-3</sup> | <.0001 |
| <i>Travel-related preferences</i>          |                      |                     |        |                           |                     |        |                    |                     |        |
| Importance of alternatives                 | 0.12                 | 0.02                | <.0001 | -0.11                     | 0.01                | <.0001 | 0.16               | 0.02                | <.0001 |
| Importance of externalities                | -0.12                | 0.02                | <.0001 | -0.04                     | 0.01                | 0.0051 | 0.18               | 0.02                | <.0001 |
| Importance of efficiency                   | 0.11                 | 0.02                | <.0001 | 0.36                      | 0.01                | <.0001 | 0.23               | 0.02                | <.0001 |
| Agreement to pro-car statements            | -0.09                | 0.01                | <.0001 | -0.02                     | 0.01                | 0.02   | -0.13              | 0.01                | <.0001 |
| Agreement to anti-car statements           | 0.06                 | 0.01                | <.0001 | -0.14                     | 0.01                | <.0001 | NS                 | NS                  | 0.07   |
| Image of the car                           | -0.03                | 0.01                | 0.0011 | 0.15                      | 0.01                | <.0001 | -0.24              | 0.01                | <.0001 |
| Image of transit                           | 0.13                 | 0.01                | <.0001 | -0.07                     | 0.01                | <.0001 | NS                 | NS                  | 0.13   |
| Image of the bicycle                       | -0.12                | 0.01                | <.0001 | -0.01                     | 0.01                | 0.0776 | -0.16              | 0.01                | <.0001 |
| <i>Generic preferences (importance of)</i> |                      |                     |        |                           |                     |        |                    |                     |        |
| Leisure                                    | -                    | -                   | -      | 0.04                      | 0.01                | <.0001 | NS                 | NS                  | 0.37   |
| Education                                  | -                    | -                   | -      | NS                        | NS                  | 0.14   | 0.15               | 0.02                | <.0001 |
| Employment                                 | -                    | -                   | -      | -0.04                     | 0.01                | 0.0018 | 0.14               | 0.02                | <.0001 |
| Housing                                    | NS                   | NS                  | 0.61   | -                         | -                   | -      | 0.19               | 0.02                | <.0001 |
| Transport                                  | 0.28                 | 0.01                | <.0001 | -                         | -                   | -      | 0.19               | 0.02                | <.0001 |
| <i>Dummy endogenous regressors</i>         |                      |                     |        |                           |                     |        |                    |                     |        |
| Personal car availability                  | -2.03                | 0.01                | <.0001 | -                         | -                   | -      | -                  | -                   | -      |
| Dummy for living in a city-centre          | 0.07                 | 0.02                | 0.0002 | -0.55                     | 0.03                | <.0001 | -                  | -                   | -      |
| <i>Correlation coefficients</i>            |                      |                     |        |                           |                     |        |                    |                     |        |
| $\rho_{u\varepsilon}$                      | 0.80                 | 4.2 <sup>e-3</sup>  | <.0001 |                           |                     |        |                    |                     |        |
| $\rho_{u\eta}$                             | 0.12                 | 0.01                | <.0001 |                           |                     |        |                    |                     |        |
| $\rho_{\varepsilon\eta}$                   | 0.32                 | 0.02                | <.0001 |                           |                     |        |                    |                     |        |

Lecture: Std-error=Standard error; P>|t|=p-value; NS=Non Significant at the 0.05 level; - = parameters not estimated due to variables absent from the model. Most variables are dummies, apart from distances (in km), densities of population (in thousands/km<sup>2</sup>), and travel preferences (see section 4.2 for definition).

Source: French Unified Base of Household Travel Surveys (2009-15)

Coming to socio-economic variables, car availability is logically found to be greater among occupied workers and autonomous students, in relation with travel needs induced by activity/studies and opportunities for students living at parental home to use their parent's vehicles. Personal car availability is also positively associated with socio-professional status. Among built environment attributes, distance to the workplace has no significant effect, while car availability is negatively associated with population densities at home/workplace. However, the influence of built environment attributes is weak, once travel preferences are controlled for, suggesting that their apparent effect is largely an artefact of residential self-selection<sup>29</sup>. By

<sup>29</sup> However, estimated effects might be partially inconsistent because the choice of a residential place is endogenous to financial resources, which are unfortunately unobserved and can only be approached through imperfect *proxies*.

contrast, most attitudinal constructs are significantly associated with car availability, providing evidence of travel-related self-selection. Sensitivity to transport efficiency and a good image of the car are positively associated with car availability, while importance of car alternatives, agreement to anti-car statements and a good image of transit have the opposite effect. Paradoxically, agreement to pro-car statements is negatively associated to car availability - though the effect is hardly significant - possibly because non-motorized individuals may feel its absence and become more conscious of its assets. Interestingly, sensitivity to car externalities has no significant link to car availability, a result which is consistent with prior findings that environmental awareness has little relation with real-world practice. By contrast, the influence of generic opinions is weak but significant: car ownership is positively associated with an interest in leisure, and negatively associated with sensitivity to employment. Finally, the direct influence of a central location is negative and substantial, in relation with the proximity to activities, the existence of efficient alternatives to the car, along with traffic and parking difficulties.

We now come to the regular transit use model. As for car ownership, age and generation effects stop being significant once a large number of factors are controlled for. Family life and being a woman are negatively associated with regular transit use, a result which might be explained partially through the distribution of child escorting trips, but also by different safety concerns between men and women. With respect to activity status, autonomous students and unemployed are those using transit the most. Transit use also increases with socio-professional status, as does car ownership, possibly because high income groups are likely to be more mobile by all modes and not only by car, indicating an opposition between intensive travellers and low-mobility patterns in relation with income. When it comes to built environment factors, transit use is decreasing with lower densities and a higher distance to the city-centre, while distance to work/studying place is non-significant. Travel preferences exert a direct influence on transit use, but of lower amplitude than for car availability: sensitivity to modal alternatives and transport efficiency, a good image of transit, agreement to anti-car statements, are positively associated with regular transit use, while agreement to pro-car statements, a good image of the car or the bicycle, have the opposite effect. The negative association between transit use and sensitivity to car externalities may come from a mismatch between travel behaviors and attitudes, in relation to income: educated people, for instance, might be more sensitive to environmental issues, while at the same time owning more cars and travelling more, thanks to a higher income. Finally, personal car availability has a very strong negative effect on transit use, while the effect of a central location is positive but weak, once car availability is controlled for.

In the end, we come to analyze the model correlation coefficients. A very strong correlation is found between the error terms of the regular transit use and personal car models, estimated to  $\rho_{u\epsilon} = 0.80$ , meaning that unobserved factors exert a joint positive influence on car ownership and transit use. Again, we suspect that it is essentially a matter of income: a shadow dimension of travel patterns might be indirectly revealed, opposing highly mobile individuals to rather sedentary patterns in relation with either income or desired lifestyles. A positive correlation  $\rho_{u\eta} = 0.12$  is

also found between the error terms of the residential choice and transit use models. These choices might be particular expressions of an urban lifestyle, combining the choice of a central location, transit as the main travel mode and the participation to many out-of-home activities. Finally, there are also unobserved factors jointly affecting car availability and residential choice, manifested through the correlation coefficient  $\rho_{\varepsilon\eta} = 0.31$  between the corresponding error terms. Again, income is a good candidate for explanation, given the social filtering which operates through residential competition.

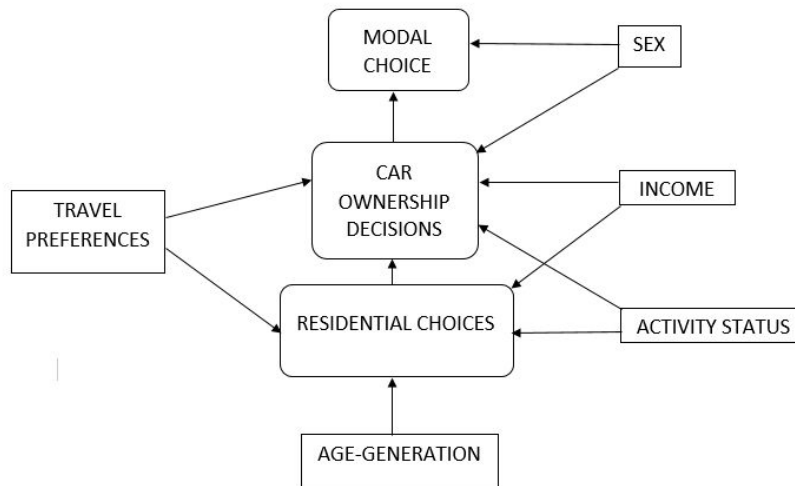


Figure 5. Conceptual scheme for the main relations between different dimensions of life choices – residential choice, car ownership decisions and regular travel habits – and their main determinants

If we try to synthesize these results through a figure, retaining only the main directions of causality, the general outcome is that travel patterns are influenced mostly by socio-demographic factors and travel attitudes/desired lifestyles, while the association between travel behaviors and the built environment would be mainly caused by residential self-selection. By contrast, the direct influence of car ownership on travel patterns remains very strong, even when controlling for self-selection. Finally, residential location exerts an influence on transit use mostly in an indirect manner, through its effect on personal car availability.

## 5. DISCUSSION

The generation born between 1980 and 2000, sometimes designed as “the millennials”, shows off a shift in their travel patterns, with decreasing car ownership and use, to the benefit of alternative transport modes. Researchers and experts have imagined different explanations to these trends which, despite their diversity, can be split in two major families: the first one assumes a transformation of attitudes, aspirations and lifestyles, potentially resulting in durable outcomes for travel demand (e.g., Kalinowska et al., 2012; Hopkins, 2016; Vincent-Geslin et al., 2017), while the second postulates a delay, given a longer transition towards adulthood (Kim, 2014; Garikapati et al., 2016), possibly aggravated by economic conditions (Licaj et al., 2012; Demoli, 2017). We bring a new contribution to this debate in the French context. First, our research confirms that travel behaviors of French millennials differ

substantially from their elders, showing off an important shift from driving to transit, along with a decline in personal car availability, with an acceleration in cohorts born after 1985. Yet, French millennials tend to pass driving license exams as much as their elders, suggesting that behaviors could have become more opportunistic, with driving license still being perceived as an insurance for mobility, but driving being delayed until it is really needed. In parallel, the millennials experience a transformation in their living conditions. In particular, lower university standards have resulted in increasing the number of students, thus delaying entrance into the workforce, especially in cohorts born after 1985. In addition, cohabitation patterns have evolved, with family foundation being delayed. Finally, the proportion of central city dwellers has increased across cohorts. By contrast, travel attitudes among the millennials do not differ substantially from their elders.

By jointly modelling the choice to live in a central city, personal car availability and regular transit use, we show that age and generation effects on car ownership and transit use disappear once a large number of socio-demographic and built environment attributes are controlled for. This result tends to confirm the assumption that age and generation effects are mainly caused by structural factors (Blundell et al., 1994). There is also significant evidence of self-selection caused by travel attitudes, either for residential choices or car ownership decisions. As a result, the influence of attitudes on travel patterns is mostly indirect, with travel choices being anticipated well-in-advance, from the steps of residential choice and car ownership decisions. When controlling for residential self-selection, the built environment has limited effects, apart from that of a central location on personal car availability, which transmits to travel choices, as car ownership remains a very important determinant of travel decisions.

Behaviors among autonomous students differ from working people mostly through their preference for a central location, which has indirect effects on car ownership and transit use. Student's residential choices are explained through the centrality of high-school establishments and the large number of opportunities for leisure and out-of-home activities offered through a central location, of which students are usually fond of. However, several factors could have contributed to strengthen these trends across generations. Age cohort analysis reveals the existence of generation effects in residential choices, with a growing inclination to live in a central place in cohorts born after 1965. Metropolization might have increased the spatial concentration of high-school establishments and highly-qualified jobs in the largest urban areas. In parallel, longer studies among the millennials, in relation with a less selective scholar system, has resulted in delaying entrance into the workforce, and therefore the need for a car. Finally, new residential patterns tend to persist beyond the studying period, possibly because of delayed family foundation, increasing work pressure and reduced travel speeds resulting in longer travel times, representing as many incentives to look for closer proximity to work and maintain an urban way of life longer. However, they could also reflect a shift in residential attitudes and desired lifestyles. Further research will be required to sort between these potential explanations. In the end, living conditions should explain much of new travel patterns, thus disclaiming the regular statement of the millennials being less car-oriented. The access to car-based mobility

could simply be delayed, putting into perspectives expectations about new generations to help reducing car use. However, to deal more in-depth with this issue, we identified complementary research tracks that would require further attention:

- A deeper comprehension of the economic conditions experienced by the youth, to determine their contribution to the decline of the car. They should contribute to explain why low car ownership/driving persists at an advanced stage of the lifecourse, in relation with a lower income, job uncertainty and increasing housing costs. In this case, the environmental benefits that would result from less car use would represent some kind of « Pyrrhic victory »<sup>30</sup>, obtained only at the price of social cohesion. In order to explore this issue, solutions will have to be found to overcome the absence of income in local travel surveys, which is an important limitation. By the way, it could also help limiting endogeneity in model estimation;
- Another subject is about establishing causality links with more certainty. In particular, some results suggest that, beyond a possible influence of opinions on travel patterns, a reverse direction of causality may also exist, where transport-related attitudes are shaped by travel experience. The classical hierarchy of choices that was retained is also questionable, as car availability might have effects on residential choices<sup>31</sup>;
- The third issue is about getting a better knowledge of attitudes and travel patterns among young countrymen and suburban adults, in relation with issues of social and territorial equity, which have become critical in the French context, following the Yellow Vest movement triggered by unpopular tax reforms<sup>32</sup>. Metropolization, along with changes in the economy, might generate contradictory injunctions between the discourse on adopting an environmentally-friendly way of life and the impossibility to access a residential location where one can do without a car, thus forcing young adults from working and middle classes to cope with the costs of car dependence, despite lower resources.

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<sup>30</sup> Pyrrhus was an old king of Epirus, whose army defeated the Romans at the battle of Heraclea. However, this apparent victory was obtained at the price of such damage in its own forces that it could hardly still be considered a real win. [https://en.wikipedia.org/wiki/Pyrrhic\\_victory](https://en.wikipedia.org/wiki/Pyrrhic_victory)

<sup>31</sup> For instance, the lack of a vehicle might orientate individuals towards a central location where one is less dependent from the car.

<sup>32</sup> Notably fuel price increases resulting from the implementation of a carbon tax.

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