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Young people and the private car: a love-hate relationship

Caroline BAYART*; Nathalie HAVET*; Patrick BONNEL**; Louafi BOUZOUINA**

* Laboratory of Actuarial and Financial Sciences – LSAF, Université Claude Bernard – Lyon 1, Université de Lyon, Domaine de Gerland, 50 Avenue Tony Garnier, 69366 Lyon Cedex 07.

** Urban Planning, Economics and Transport Laboratory - LAET, ENTPE, Université de Lyon, CNRS, Rue Maurice Audin, 69 518 Vaux-en-Velin Cedex.

E-mail addresses of authors:

Caroline BAYART: caroline.bayart@univ-lyon1.fr

Nathalie HAVET: nathalie.havet@univ-lyon1.fr

Patrick BONNEL: patrick.bonnel@entpe.fr

Louafi BOUZOUINA: louafi.bouzouina@entpe.fr

Abstract

Urban mobility is one of the main concerns of the public authorities in developed countries. In France, household travel surveys are conducted every ten years in major cities to gather weekday mobility data. They enable decision-makers to better understand travel patterns, their change and their determinants, in order to adapt transport infrastructures to the population's needs. While the automobile has allowed the level of mobility to increase since 1950, an unexpected finding has emerged from recent surveys in most developed countries, namely that there has been a marked decline in car use. Analyses show that this trend is mainly because young adults (18-34 years old) are less likely to acquire a driver's license. This paper tries to better understand the decrease in the rate of driver's license holding among young adults in the Lyon conurbation and to quantify the impact of the main explanatory factors in a temporal perspective. It also aims to analyze the consequences of this trend on private car use as a driver for daily trips. It quantifies the influence of economic, socio-demographic and spatial factors on driver's license holding and car use by considering the responses to the last three household travels surveys conducted in the Lyon conurbation area (1995, 2006 and 2015). The temporal dimension allows us to highlight a change in the relationship between young adults and the private car in the French context.

Key-words: driver's license, car use, young adults, daily mobility

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1. Introduction

Thanks to Nicolas-Joseph Cugnot, who designed and built the first car in 1771, France is often considered as the pioneer of the automobile industry. Nevertheless, it was necessary to wait for the industrial engineering of the American Henry Ford for the automobile to spread throughout the developed world. This has profoundly changed mobility behavior, revolutionizing the relationship not only between humans and space but also between humans and time. Both trade and road infrastructure have massively developed. However, the first downside of increased car use was road accidents. To minimize the risks associated with car use, in particular road deaths, regulations have gradually been implemented in all affected countries. The introduction of the driver's license, an official document authorizing the holder to drive on public roads, was introduced in France in 1922. In the following years, especially after the Second World War, there has been an exponential increase in the number of driver's license holders (41% in 1966 and 83% in 2007) (Roux, 2012). One reason for this is France's adoption of the Marshall Plan, which resulted in massive investments in roads, combined with the mass production of private cars (Dupuy, 1975) and a huge increase in French households' access to private cars between 1950 and 1970 (from 30 % to 60%).

However, from the early 2000s onwards, an unexpected phenomenon emerged in most OECD countries: a simultaneous decline in the holding of driver's licenses (on average by 0.6 % a year (Delbosc and Currie, 2013)) and in car use, especially for daily trips. In several industrialized countries, car traffic has plateaued or decreased (Newman and Kenworthy, 2011; Kuhnimhof et al., 2013). In the Netherlands, peak car use has been observed since 2005, and the same trend has been observed in Germany. In France, the stagnation of individual car use has occurred among all the income groups and in all areas (Grimal et al., 2013): car use for daily trips has dropped by ten percentage points since 1995. This general phenomenon, called "peak car" or "peak travel" (Millard-Ball and Schipper, 2011; Goodwin, 2012) has attracted a lot of interest and debate (Goodwin and Van Dender, 2013). Some authors believe that economic determinants (economic growth, fuel price) are the main drivers of peak car (e.g. Bastian et al., 2016, 2017), while others argue that the observed trends are indications of substantial changes in lifestyles, preferences and attitudes to car travel. For example, individuals may be less willing to use the car because of its negative externalities (congestion, noise, pollution, greenhouse gases, road accidents…). One of the factors hypothesized in the peak car debate up to now is the declining trend in driver's license holding among younger people (Delbosc and Currie, 2013; Kuhnimhof et al., 2012), and some studies go so far as to attribute "peak car" to young adults, especially men (Ward et al., 2013; Kuhnimhof et al., 2013; McDonald, 2015), or at least argue that "peak car" is more marked for this age group. However, research on this subject is fairly recent. Our study aims to better understand the propensity of young adults (18-34 years old) to move away from driver's license holding and car use (Dutzik and Baxandall, 2013; Delbosc and Currie, 2014; Chatterjee et al., 2018). Understanding the changing travel behavior of young adults is important because they appear to be leading the trend (Delbosc and Currie, 2013). Indeed, positions with regard to car use that are established in young adulthood can potentially persist into the future, leading to a significant shift in future car-driving demand.

In this context, our paper focuses on the trends affecting driver's license acquisition and car use among young adults in Lyon (France) over the past 20 years. We have used the three waves of household travel surveys (1995, 2006, and 2015) in the Lyon metropolitan area to estimate econometric models that incorporate a temporal dimension to try to disentangle what is due to changes in socioeconomic and living conditions from what is due to others sources (e.g. changes in behaviors with regard to the car), captured by changes in the impact of these determinants over time. After a literature review on young people's love-hate relationship with the private car (section 2), we will present the design of French household travel surveys and some descriptive statistics on

the trends, between 1995 and 2006 and 2015, that affected driver's license holding and car use for daily trips among young inhabitants of the Lyon metropolitan area (section 3). In section 4, we will develop two different econometric models using these two indicators as dependent variables. First, we will estimate a logistic regression to explain the probability of owning a driver's license. We will then model the proportion of trips made as a driver by means of zero-one inflated beta regression, a methodology that is still rarely used in empirical work and transport economics (see Ospina and Ferrari (2012) for an application to mortality in traffic accidents in Brazil). This specification allows for the fact that different underlying processes could explain non-use of a car (0% of daily trips made as driver), exclusive use of a car (100% of daily trips made as a driver) and the situations in between. Finally, we will discuss some theoretical and economic contributions of our results (section 5).

2. Literature review

In the last few decades, driver's license holding and private car use as a driver have been declining among young adults aged between 18 and 34 years (Dutzik and Baxandall, 2013; Delbosc and Currie, 2014; Chatterjee et al., 2018). After the first cases noticed in Sweden and in Norway, this phenomenon has spread to most developed countries, featuring extensively in the transportation economics literature.

2.1 The sustained decline in license holding and car use among young adults

A growing literature highlights that compared to earlier cohorts, today's young adults have a substantially lower likelihood of having a driver's license, and that this decline is sharper for men than women (e.g. Chatterjee et al., 2018; Vincent-Geslin et al., 2017; Hjorthol, 2016; Vincent et al., 2014; Delbosc and Currie, 2013; Kuhnimhof et al., 2012; Sivak and Schoettle, 2011, 2012). For example, the transnational comparisons of license holding by Kuhnimhof et al. (2012), based on data from twenty household travel surveys, conducted in six industrialized countries (Germany, France, Great Britain, Japan, Norway and the United States) confirm these trends, as do other studies for Canada (Sivak and Schoettle, 2012) or Australia (Delbosc, 2017; Delbocs and Currie, 2014; Raimond and Milthorpe, 2010). In Europe, the greatest reduction in the driver's license rate among young people has been observed in Scandinavian countries. In France, between 1993 and 2008, the rate of driver's license ownership decreased by 2% and 3% for young people aged respectively from 21 to 25 years and 26 to 29 years. This decrease was in order of 4% and 6% if we only consider young men (Demoli, 2017).

A direct and unsurprising consequence of these trends in license holding is that today's young adults across industrialized countries typically drive less than comparable cohorts a few years ago (e.g. Chatterjee et al., 2018; McDonald, 2015; Frändberg and Vilhelmson, 2014; Dutzik and Baxandall, 2013; Waard et al., 2013; Kuhnimhof et al., 2012; Blumenberg et al., 2012). For example, Kuhnimhof et al. (2012) show that car use among 20-29-year-old peaked in the early 2000s in the US, Germany, United Kingdom, Norway and France. Chatterjee et al. (2018) point out that there was a 36% drop in the number of car driver trips per person made by people aged 17-29 between 1995-99 and 2010-14 in UK. This overall trend for each cohort of young people, since the turn of the millennium, to own (Klein and Smart, 2017) and use cars less than the preceding cohort is also strongly present among those with licenses (Kuhnimhof et al., 2013). There is a decoupling between driver's license holding and car access on the one hand, and between car access and daily use on the other. Both contribute to the decline in the car's modal share for daily trips. In fact, several studies show that the phenomenon of plateauing travel demand, known as *peak travel* (Millard-Ball and Schipper, 2011; Goodwin, 2012) and observed in the whole population, was essentially due to the change in the travel of young adults (Ward et al., 2013; Kuhnimhof et al., 2013; McDonald, 2015).

2.2 What are the possible causes of the mobility changes?

Studies seeking to explain why license holding and car use have decreased mainly focus not only on differences in life circumstances (demographics, living situations and socio-economic situations) between today's young adults and previous generations at the same ages, but also on changes in mobility preferences, i.e. the importance that people attach to driving. The evidence indicates that the causes of the changes in young adults' travel behavior lie largely outside transport: the observed trends result from an interaction between multiple factors and their combinations and can differ from one country to another (Millard-Ball and Schipper, 2011; Delbosc and Currie, 2013). We shall now discuss those that may reasonably be applied to the French case.

Changes in the legal conditions for obtaining the driver's license, notably in France, Canada and the United States are one reason given in the recent literature on the decline in the popularity of driver's licenses (see Delbosc and Currie (2013) and Chatterjee et al. (2018) for detailed reviews). Stricter regulations and new requirements (e.g. the introduction of a probationary period in France) may have discouraged young people from enrolling in a driving school (Avrillier et al., 2010; Delbosc and Currie, 2013; Kuhnimhof et al., 2012; Licaj et al., 2012; Raimond and Milthorpe, 2010). However, the literature mainly mentions changes in young people's socio-economic situations (life-cycle stage and affordability) as the causes of the changes in their daily mobility (Delbosc and Currie, 2013; Hjorthol, 2016; Roux, 2012; Demoli, 2017). Firstly, increased participation in higher education and its knock-on effect of later entry into the labor market could be expected to have reduced driver licensing, car ownership and car use among young adults. Young people prefer to devote the time required to take the driving test to their studies. Secondly, the longer average duration of education, the growth in low-end service jobs and the rise of low-waged, uncontracted work among young people - in France, 15-29-year-olds account for half of all precarious employment; 38% of them are employed on precarious contracts (Insee, 2018) – means their disposable income has declined. The costs associated with private car use (driver's license, car purchase, insurance, gasoline, parking) are therefore beyond their limited resources (Demoli, 2017). The cost of motoring is thus often cited by young people as the most important reason for not learning to drive (Chatterjee et al. 2018), particularly by those with lower incomes (including people with part-time jobs and the unemployed). The results presented by Vincent-Geslin et al. (2017), who analyzed the relationship between young adults and the private car in the French context, confirm that socio-economic situations are key contributors to changes in young people's daily mobility, since the most frequent answers that emerged from their qualitative studies are "too busy or not enough time to pass the driving test" and "obtaining a driver's license is very expensive".

Changes in the socio-economic situations of young people are also strongly interrelated with changes in living situations, reinforcing the downward trend. Today's young people are more likely to be in school or unemployed and less likely to be married or parents. The trend for young people to be more likely to postpone leaving the parental home and parenthood also reduces driver licensing and car use. This downward trend may be just a postponement that may be recouped later, although it seems likely that the number of people holding a driver's license will remain lower. Another important change in the living situations of young adults is their residential preference for a highly urbanized environment. More and more young people live in accessible inner-city areas and are therefore less likely to have a driver's license than those living in urban peripheries or rural areas (Hjorthol, 2016; Licaj et al., 2012; Raimond and Milthorpe, 2010; McDonald and Trowbridge, 2009). In densely populated areas, we observe a more marked decrease in the proportion of young adults with a driver's license, since using a private car is perceived as less necessary for daily trips, because of improvements in public transport infrastructure, new mobility services (e.g. self-service bicycles) and the implementation of successful alternatives (paths shared by pedestrians and non-motorized traffic (voies vertes), ride sharing…). Dargay et al. (2007) conclude from an econometric estimation based on mobility surveys from 19 countries that, ignoring the impact of income, the level of urbanization of the place of residence as well as its population density can explain, at least in part, a household's level of vehicle ownership. Oakil et al. (2016) highlight the fact that spatial policies implemented in major European countries discourage young people from using the car for urban

mobility. In Great Britain, Stapelton et al. (2017) show that, instead of changes in income and rising gasoline prices, increased urbanization largely explains the recent reduction in the number of car trips. Melia et al. (2018) confirm the impact of the growing concentration of young adults on driving in the denser areas of larger cities, but at a regional scale the scenario is the same. For example, in London, inhabitants are abandoning the car in favor of public transport (Metz, 2013).

In addition to these changes in economic and living situations, young people seem to have changed their behavior related to car use. Unlike previous generations of young adults, the driver's license and the private car may no longer be the ultimate symbols of freedom, independence and autonomy. Today, smartphones arguably provide as much freedom as the car, offering instantaneous access to information, family or friends (McDonald, 2015). Favorable attitudes towards new technologies are a source of changes in mobility, as they provide great temporal and spatial flexibility for human interactions (Hjorthol, 2016). Numerous opportunities for virtual relationships, online shopping and other remote activities that can be carried out without physically moving, are often also considered to be responsible for the fewer trips made and therefore for the lesser need for a driver's license (Aguilera et al., 2012; Wee, 2015; Hjorthol, 2016). In addition, the use of new technologies can encourage travel on public transport, which provides good Internet access (Lyons et al., 2007). These arguments seem to be supported by the results of Sivak and Schoetlle (2012), who find that the level of Internet use has a negative influence on driver's license holding. However, studies on the impact of new technologies on physical mobility and access to driver's licenses do not always reach the same conclusions (Line et al., 2011; Mokhtarian, 2002; Hjorthol, 2008). Finally, young adults have become aware of the car's externalities and developed eco-friendly behaviors. Environmental concerns combined with the lower social status of the private car could therefore explain their clearer disaffection with driving (the impact of environmental concerns on driver's license holding has been challenged in Le Vine and Polak (2014)). However, Chatterjee et al. (2018) note that "the relative importance of changing values and attitudes in shaping travel behavior is likely to be stronger among middle-class youth with realistic prospects of eventually securing the traditional markers of adulthood".

Research on behavioral changes in young adults' car use is in its infancy. No econometric analysis of French data has been carried out so far on the issue. Our empirical study proposes to address this deficiency through cohort analyses of young adults undertaken with repeated cross-sectional data. We have used the last three household travel surveys conducted in the Lyon conurbation area (1995, 2006, and 2015). Since the surveys were conducted in different years using the same methodology, comparisons over time are possible. By focusing on one specific age group/cohort (18 to 34 years old) in each survey, our study differs from those that seek to distinguish *cohort effects* (variations between groups of people born in different periods) from *age effects* (variations associated with age over time) or *period effects* (variations over time that affect everyone alive at a given time) (McDonald, 2015). Although we do not deny that age and period effects might be at play, our goal is to provide new insights into the cohort effect. Indeed, in the cohort-age-period model (McDonald, 2015), the influence of changing sociodemographic factors is tested through the inclusion of individual and household characteristics (gender, employment, household location, etc.). The associated coefficients are assumed to remain stable over time, except for the age variable, for which an interaction between survey year and age group is included to identify *age effects*. The decline in car use due to lifestyle-related demographic shifts is then calculated by comparing the average car use observed for young people in a given survey with a prediction of what average car use would have been if these young respondents had had similar socio-demographic characteristics to those in the previous survey. However, it is likely that in reality some individual or household characteristics may have a varying influence over time due to changes in behavior related to car use or travel needs. For example, the negative effect of a city center location on car use may be more marked in 2015 than it was in 1995, due to improvements in public transport infrastructure which have made car use in city centers even less necessary. Therefore, the novelty of our study lies in its attempt to discover whether the observed trends in license holding and car use are more due to changes in young

people's characteristics (such as more of them living in the city center) or to changes in the impact of these factors (e.g. place of residence could have more influence on the probability of taking the driver's license in 2015 than in 1995).

3 Data collection

3.1 Survey design

Household travel surveys give a snapshot of a whole population's daily mobility. They provide very rich information at the household and individual levels as well as details concerning all the trips reported during the reference period (the weekday before the survey). French urban household travel surveys are conducted according to a standard methodology designed in the mid-1970's and applicable to the whole country. They are regularly updated and checked by the CEREMA (Center of Studies and Expertise on Risks, the Environment, Mobility and Planning). This methodology makes it possible to compare various indicators at different times and in different French towns and cities (Certu, 2012). Every ten years, a geographically stratified representative sample of the households inside the survey perimeter is interviewed (individuals over five years old). All the trips, as well as the modes used and the purpose at destination, are described. The interviews are conducted either face-to-face in the household's home or by telephone.

The survey perimeter of the household travel surveys conducted in the Lyon conurbation area has gradually expanded (see Figure 1). In order to consider the temporal dimension, without introducing any bias, all our analyses are based on a constant perimeter (that for the 1995 Household Travel Survey). Only the households living in the perimeter used in the 1995 survey, which corresponds approximatively to the area covered by the urban public transport authority, are considered. Moreover, our samples are restricted to the adult population aged 18 to 34 years. The final sample consists of 11,802 individuals (3,901 for 1995, 3,355 for 2006 and 4,546 for 2015) (Table 1) whose characteristics (sociodemographic, economic, spatial, car ownership) are presented in Tables 2 and 3.

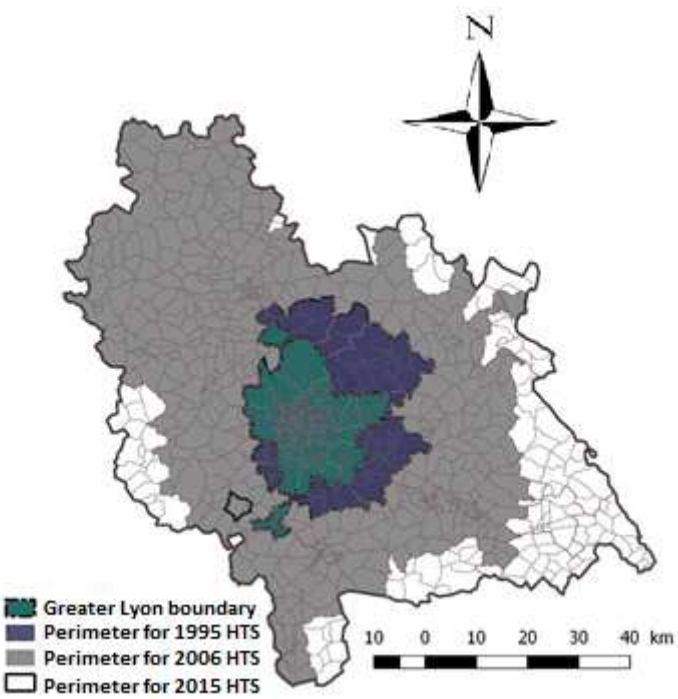

Fig. 1: The boundaries of the urban area and household travel survey perimeters (1995, 2006 & 2015)

3.2 Descriptive statistics on young people and their relationship with the car

Household travel surveys provide indicators that can help us understand the mobility patterns of young adults, and more precisely their relationship with the private car. As seen in the literature review, young adults are currently defined as people from 18 to 34 years old in transport economics. Among this group, we can of course notice different life stages (some students are still living with their parents, while others got their first job and are already in charge of their family). But econometric modelling will take into account these differences by quantifying the specific effect of each explanatory variable, once the effect of the other determinants has been controlled for (reasoning all other things being equal, see section 4).

Table 1 shows that between 1995 and 2015, the daily mobility of young people (18-34-year-old) decreased in the Lyon conurbation (within a constant perimeter). The average number of trips per day decreased from 4.03 to 3.04 over this 20-year period and the proportion of no-trip makers (i.e. those who did not report any trips during the reference period (the weekday before the survey) increased from 9.8% in 1995 to 12.8% in 2006 and 14.2% in 2015. At the same time, we note a marked decrease in the proportion of young adults who hold a driver's license, from 78.4 % in 1995 to 77.1 % in 2006 and then to 69.9 % in 2015. In line with the decreasing trend in driver's license holding, young people use private cars less and less for their daily trips. Indeed, the young adults' car modal share (i.e. the total number of daily car trips made as a driver divided by the total number of trips) decreased from 46.8% in 1995 to 41.5% in 2006 and only 27.4% in 2015. The decline has therefore been greater since the beginning of the millennium. Moreover, among trip makers, the average proportion of daily trips made as a driver (i.e. the mean of the individual proportions) has decreased in a similar way (Table 1).

The change in the main mobility indicators (number of trips per day and proportion of no-trip makers) affects all the age groups. The downward trend in the average number of daily trips also affects older groups: adults aged from 35 to 59 years old reported on average 4.17 trips per day in 1995, vs. only 3.80 in 2006 and 3.13 in 2015 and those over 60 years old reported on average 2.89 trips per day in 1995, vs. only 2.72 in 2006 and 2.45 in 2015. While some mobility patterns have changed, whatever the age group, some trends are specific to young adults. Driver's license holding increased over time for other age groups: from 86.8% in 1995 to 89.1 % in 2015 for 35 to 59 year-olds and from 65.9 % in 1995 to 84.4 % in 2015 for those over 60 years old. The same is true for car modal share, which has been quite stable for 35 to 59 year-olds (from 60.2 % in 1995 to 58.9 % in 2015) and increased among people over 60 years old (from 35.7 % in 1995 to 49.4 % in 2015), who were more likely to have access to a private car. These results indicate that the changes are not due to a period effect, as variations over time in the percentage of driver's license holders and car modal share do not affect all age groups in the same way. Young people's behavior does not change in the same way as that of older groups.

Figure 2 provides some details about the car's lack of popularity among young people. 48.3% of young adults never used a private car for their trips on the surveyed day in 1995. This proportion rose to 53.2% in 2006 and 69.1% in 2015 even though most of the individuals held a driver's license: 57.5% in 1995, 59.7% in 2006 and 57.2% in 2015 among those who never drive a car for their daily trips. On the other hand, the proportion of young adults who used a car for all their daily trips substantially decreased across the surveys (32.0% in 1995, 32.6% in 2006, and 21.3% in 2015). This trend does not seem to be linked to the reduced proportion of driver's license holders. Only a minority of young license-holders in Lyon use the car for all their daily trips.

	1995	2006	2015
Individuals	3,901	3,355	4,546
	(344,384)	*(290,873)*	*(372,759)*
Mobility:			
Total number of trips	15,747	11,614	13,845
	(1,441,504)	*(1,022,901)*	*(1,136,800)*
Average number of trips	4.03	3.46	3.04
	(4.19)	*(3.52)*	*(3.05)*
No-trip makers	9.8%	12.8%	14.2%
	(8.3%)	(11.8%)	(14.3%)
Private car use:			
Driver's license-holding	78.4%	77.1%	69.9%
	(78.6%)	*(78.65%)*	*(70.1%)*
Car modal share	46.8%	41.5%	27.4%
	(45.1%)	*(37.8%)*	*(28.8%)*
Among trip makers:			
Average individual proportion of	42.7%	40.1%	26.3%
daily trips made as a driver	*(37.2%)*	*(32.5%)*	*(22.8%)*

Tab. 1: Survey data: the figures in brackets have been weighed and expanded for the whole conurbation (only adults 18-34 years old)

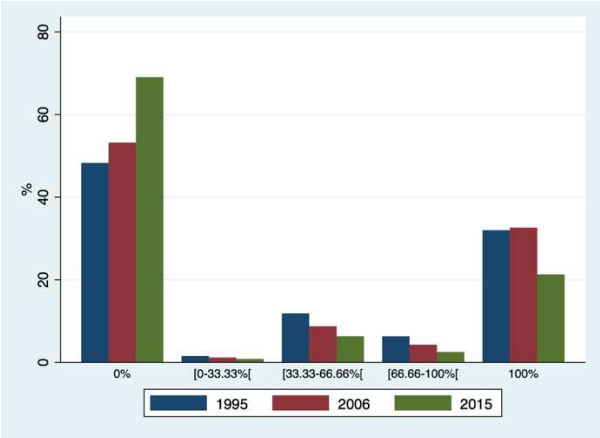

Fig. 2: Distributions of proportion of daily trips made as a driver in 1995, 2006 and 2015 (only adults 18-34 years old)

Changes in transport conditions in Lyon have probably affected the mobility behavior of the whole population, particularly young adults. Recent mobility policies implemented in major urban areas in France and elsewhere (fewer parking spaces, the closure of neighborhoods to vehicles, reduction in the number of lanes for private cars in favor of exclusive public transport lanes, stricter speed limits in cities and on ring roads, etc.), combined with the rising price of gasoline have discouraged many people from using the car for their daily mobility (Oakil et al., 2016). In the Lyon urban area, a proactive policy to reduce car use for urban travel has been implemented since the 2000's. In

particular, it has resulted in major investments in public transport and a wider range of active modes. Indeed, Lyon's public transport network, which is very dense and often considered one of the best in France, has rapidly improved. The metro, created in the 1980s, has undergone continuous extensions, and now reaches the municipalities in suburban areas (extension of metro line A to Vaux-en-Velin in 2007, of metro line B to Oullins in the south-west in 2000 and 2013). Six tramway lines with systematic priority at intersections have been created which result in a significant reduction in capacity reduction for car traffic: 2 such lines were opened in 2001, followed by 3 in 2006, 2009 and 2012, and an express tram line in 2010, the "*Rhône Express*", between the city center and the airport. Since 2011, the bus network has been restructured and given priority at intersections, resulting in a significant increase in the number of kilometers travelled by public transport. In addition, the authorities in the Lyon metropolitan area have supported the introduction of a public bike-sharing scheme (*Velo'v*), car-sharing and carpooling projects (*Citiz, Bluely*), as well as new services to facilitate mobility (*Onlymoov*) and improvements in pedestrian zones ("*les berges du Rhône"*, for example).

The literature review (section 2) indicates that changes in the living and socio-economic situations of young people have led to changes in their mobility behavior. Table 2 shows, for example, that more and more young people live in the city center[1] (41.1% in 1995, 43.4% in 2006 and 56.7% in 2015), where the provision of active modes and public transport is good, which reduces the need for a private car. After several decades of urban sprawl, Lyon has witnessed a relocation of young adults and working people (especially those with a high level of education and in skilled employment) to the city center, due to a policy of increasing population density in the center, coupled with the improvement of the public transport network. Average household size decreased (3.09 in 1995 vs. only 2.63 in 2015) and the proportion of young people aged 18 to 34 years-old living alone increased (15.4% in 1995, 15.6% in 2006 and 24.8% in 2015). These changes may affect mobility levels, as well as purpose at destination and transport mode use (Hjorthol, 2016).

We can assume that changes in access to a private car have been partly driven by these socio-economic situations (increased participation in higher education, decline in disposable income, etc). However, these effects could be moderated by the fact that at the same time, the percentage of young adults in full-time managerial employment has increased, whereas the percentage of blue-collar workers has decreased. This change is in line with the employment structure of the Lyon metropolitan area that has changed profoundly, with a decrease in industrial employment and a gradual increase in highly skilled jobs, in line with other French metropolitan areas (e.g. Paris, Grenoble, Toulouse and Montpellier). As all these explanatory variables are correlated, the real impact of each factor – and their change over time – on the probability of holding a driver's license and using a car as a driver for daily trips can only be accurately evaluated on an "all other things being equal" basis, by means of econometric models.

[1] In this study, the term "city center" refers to Lyon and Villeurbanne, the two main cities in the Lyon metropolitan area. The urban areas that surround Lyon and Villeurbanne belong to the "suburban area" and the more distant ones to the "outskirts".

Variables	Modalities	1995		2006		2015	
		Obs.	%	Obs.	%	Obs.	%
Gender	Female	2017	51.7%	1734	51.68%	2355	51.8%
	Male **(ref)**	1884	48.3%	1621	48.32%	2191	48.2%
Activity status	Employed full time / Entrepreneur	63	1.61%	37	1.10%	53	1.17%
	Employed full time /Managers, intellectual professions	217	5.56%	329	9.81%	584	12.85%
	Employed full time / Clerks, technicians	497	12.74%	503	14.99%	512	11.26%
	Employed full time / Service workers	496	12.71%	393	11.71%	446	9.81%
	Employed full time / Blue-collar workers	486	12.46%	346	10.31%	294	6.47%
	Employed part time	295	7.56%	286	8.52%	387	8.51%
	Student / Secondary	260	6.67%	448	13.35%	358	7.88%
	Student / Post-secondary	950	24.35%	508	15.14%	1249	27.47%
	Other (inactive)	261	6.69%	207	6.17%	204	4.59%
	Unemployed **(ref)**	376	9.64%	297	8.85%	459	10.10%
Family status	Children (living with their parents)	1282	32.9%	1121	33.41%	1125	24.75%
	Other (head of household, spouse, other) **(ref)**	2619	67.1%	2234	66.59%	3421	75.25%
Residence	City center	1603	41.1%	1456	43.40%	2578	56.71%
	Suburban area	1101	28.2%	821	24.47%	1258	27.67%
	Outskirts **(ref)**	1197	30.7%	1078	32.13%	720	15.84%
Reference day	Monday (ref)	911	23.35%	733	21.85%	961	21.14%
	Tuesday	883	22.64%	699	20.83%	949	20.88%
	Wednesday	827	21.20%	753	22.44%	919	20.22%
	Thursday	733	18.79%	639	19.05%	857	18.85%
	Friday	547	14.02%	531	15.83%	860	18.92%

Tab. 2: Descriptive statistics for categorical variables in 1995, 2006 and 2015 (18-34-year-olds)

Variables	1995				2006				2015			
	Mean	S-D	Min	Max	Mean	S-D	Min	Max	Mean	S-D	Min	Max
Age	25.64	4.95	18	34	25.89	5.03	18	34	25.38	4.99	18	34
Nb. of persons	3.09	0.43	1	11	3.05	1.48	1	10	2.63	1.47	1	10
Nb. of children (<18 years)	0.43	0.84	0	7	0.70	0.97	0	7	0.51	0.89	0	6
Nb. cars / Nb. drivers	0.58	0.39	0	3	0.78	0.38	0	2	0.59	0.47	0	4.5

Tab. 3: Descriptive statistics of continuous variables in 1995, 2006 and 2015 (18-34-year-olds)

4. Econometric models

4.1. Econometric Specifications

We have estimated multivariate econometric models in order to explore the possible determinants of having a driver's license and of using a car for daily mobility in 1995, 2006 and 2015. In our analysis, we have considered two dependent variables: first, a dichotomous variable, indicating whether the individual has a driver's license or not; then, just for trip-makers, the proportion of their daily trips they made by car. We have tested the relative influence of socio-demographic (gender, age, number of children), economic (professional activity) and living (living with parents, area of residence) factors and the effect of the household's car ownership (number of available cars per driver's license holder in the household). The econometric models have been estimated on the pooled sample, created with the three waves of the survey, and two dichotomous variables identifying the year of the survey. Interaction terms between explanatory variables and these dichotomous variables were introduced in the two models, to determine whether the determinants of the dependent variables changed over the period (1995, 2006 and 2015). In such specifications, the coefficients associated with the explanatory variables capture the effects of the reference year (1995) – they are called *main effects* – and the interactions terms capture the temporal changes from that reference year. More specifically, if for a given explanatory variable, the associated interaction term for 2006 (respectively 2015) was not statistically significant, this means that the effect of this variable on the dependent variable remained constant between 1995 and 2006 (respectively 2015). If the interaction term was statistically significant and of the same sign as the main effect of the explanatory variable, one can conclude that its effect increased between the two surveys. Conversely, if the interaction term was significant but with the opposite sign to the main effect, one can conclude that the effect of the explanatory variable has decreased.

(i) Driver's license

We have first estimated a logistic regression which explains the probability that a young person will own a driver's license:

$$DL_i = \begin{cases} 1 & if\ DL_i^* = X_i\alpha + u_i > 0 \\ 0 & \text{otherwise} \end{cases} \tag{1}$$

where DL_i is the binary variable indicating if the young person *i* has a driver's license, DL_i^* is a latent variable, X_i is the covariate vector, including interaction terms and u_i is a random term error iid distributed by the standard logistic distribution. The coefficients α associated with the covariates are estimated by maximizing the following likelihood:

$$L(\alpha|X_i) = \prod_{i=1}^{N} \left[\frac{\exp(X_i\alpha)}{1+\exp(X_i\alpha)}\right]^{DL_i} \cdot \left[1 - \frac{\exp(X_i\alpha)}{1+\exp(X_i\alpha)}\right]^{(1-DL_i)} \tag{2}$$

(ii) Proportions of daily trips made as a driver

Many studies in different fields involve data in the form of rates or proportions (Ferrari and Cribari-Neto, 2004). The standard beta regression, an extension of the generalized linear model, is becoming more and more popular in order to model such data. Indeed, linear regression is not appropriate for

regression with a bounded dependent variable and the beta distribution is very flexible, allowing a wide range of different forms (left-skewed, right-skewed, "U", "J", inverted "J", etc.). However, the beta distribution is a continuous probability distribution usually defined on the open unit interval (0,1). In other words, it is not suitable in practical applications where data include zeros and/or ones as in our sample (the proportions of individuals who *never* use a car for their trips or *always* do are significant) (Figure 2). One way to overcome this difficulty is to use recent mixture model theory (more specifically, a three-part model) to compose a new distribution, which incorporates observations with the values of zero and one. In particular, we propose to estimate a general beta regression model that simultaneously estimates probability masses at both zero and one, called a *zero-one-inflated beta regression (ZOIB)* (Ospina and Ferrari, 2012). This three-part model takes account of the fact that different underlying processes could explain non-use of the car (0% of daily trips made as a driver), its exclusive use (100% of daily trips made as driver) and intermediate proportions. It works very much like other multi-part models applied in transport economics, such as the zero-inflated Poisson model or the hurdle model, which are useful modeling count data (Bayart et al., 2018).

The ZOIB model assumes that there are three processes taking place:

- A first process that distinguishes between zeros and non-zeros. There is something qualitatively different about young people who *never* use a private car and those who use one, at least occasionally;
- A second process that distinguishes between ones and non-ones. Again, we assume that there is something qualitatively different between people who use their car *for all their* daily trips and those who use it sometimes or never;
- A third process that determines, among car users, the intensity with which young people use a private car for their daily trips. This models the observations belonging to the open unit interval.

ZOIB regression incorporates the existing beta distribution with degenerate distributions to model the extreme values, thereby allowing for complete modeling of the entire continuous percentage space. The probability density function of this model can be written as follows:

$$f(y_i, X_i, \beta_1, \beta_2, \beta_3, \phi) = \begin{cases} \pi_{0i} & if\ y_i = 0 \\ (1-\pi_{0i})(1-\pi_{1i}) f(y_i, \mu, \phi) & if\ 0 < y_i < 1 \\ \pi_{1i} & if\ y_i = 1 \end{cases} \quad (3)$$

where y_i is the proportion of daily trips that the individual *i* made as a driver, π_{0i} and π_{1i} are respectively the probabilities $P(y_i = 0|X_i)$ and $P(y_i = 1|X_i)$, and $f(y_i, \mu, \phi)$ is the beta distribution with parameters μ and ϕ (0<$\mu < 1$ and $\phi > 0$), whose density function is given by:

$$f(y_i, \mu, \phi) = \frac{\Gamma(\phi)}{\Gamma(\mu\phi)\Gamma((1-\mu)\phi)} {y_i}^{\mu\phi-1} (1-y_i)^{(1-\mu)\phi-1} \quad (4)$$

where $\Gamma(.)$ is the gamma function, μ is the distribution mean and ϕ plays the role of a precision parameter[2].

Formally, the probability parameters, π_{0i} and π_{1i}, and the mean parameters from the beta distribution are linked to observed explanatory variables via link functions. A common choice is to apply logit functions to π_{0i}, π_{1i} and μ. Consequently, $\pi_{0i} = \exp(X_i\beta_1)/[1+\exp(X_i\beta_1)]$ and $\pi_{1i} = \exp(X_i\beta_3)/[1+\exp(X_i\beta_3)]$ such that these two processes are run through well-known logistic regressions. The last process is run through a beta regression after considering $\text{logit}(\mu) = X_i\beta_2$, i.e.

[2] For a fixed value of μ, the greater the value of ϕ, the smaller the variance of y.

$\mu = logit^{-1}(X_i\beta_2) = \exp(X_i\beta_2)\,/[1+\exp(X_i\beta_2)]$. The three processes are also estimated simultaneously by maximizing the likelihood given by:

$$\mathcal{L}(\beta_1,\beta_2,\beta_3,\phi|y_i,X_i) = \prod_{i=1}^{n}(\pi_{0i})^{d_{0i}}.(\pi_{1i})^{d_{1i}}.[(1-\pi_{0i}).(1-\pi_{1i})\,f(y_i,\mu,\phi)]^{(1-d_{0i}-d_{1i})} \quad (5)$$

where d_{0i} and d_{1i} are dichotomous variables respectively indicating whether the individual *i never* uses a car for daily trips and *always* uses one. Here, the covariates used to model the zero and one outcomes and the intermediate proportions are the same (X_i), whereas their impacts, captured by the parameters β_1, β_2 and β_3, may differ.

4.2. Estimation results

Different factors affect the probability of young people obtaining a driver's license and using a car as a driver for their daily trips in the Lyon conurbation area.

4.2.1. The probability of holding a driver's license and its determinants over time

Table 4 displays the results of the logistic regression explaining the probability of obtaining a driver's license. Let us start by examining this issue in 1995 with the first column of Table 4. In accordance with the international literature, we can see that for young people aged between 18 and 34 years in the Lyon conurbation that:

(i) *Having a full-time job or attending higher education* significantly increased the probability of having a driver's license in 1995, compared to being unemployed, being a part-time worker or attending secondary education[3]. Moreover, the probability of holding a driver's license increases with the hierarchical level of full-time employment: entrepreneurs and managers are more likely to hold a license than blue-collar workers and service workers;

(ii) *Age*: the probability of having a driver's license increases with age, but at a decreasing rate;

(iii) *Gender*: women are less likely to have a driver's license than men, all other things being equal;

(iv) *Household composition*: the probability of having a driver's license decreases with the both the number of people and the number of children in the household, but only significantly at 10% (p-values respectively equal to 0.061 and 0.063);

v) *Place of residence*: the probability of having a driver's license is lower for young people who live in the city center and suburban areas close to city center than for those who live in the outskirts of the city.

Most of these differences remained stable between 1995 and 2006 and even in 2015, since the temporal interaction terms are not significant for these variables (columns 2 and 3 of Table 4). However, the difference in driver's license holding between men and women decreased in 2006 compared to 1995 and this trend continued between 2006 and 2015. The reduction in the "gender gap" is apparent over time and the impact of the gender effect on driver's license holding was weaker in 2015. The role of household size has not remained stable: while the number of persons in the household had a negative impact on driver's license holding in 1995, twenty years later young adults belonging to large households had a higher probability of holding a driver's license, all other things being equal, than those in smaller households. Lastly, in 2015, a new explanatory factor emerged. The driver's license rate was lower among young people still living with their parents in 2015, whereas this variable had no significant impact in 1995 and 2006.

	Main effects	**Interaction terms**	**Interaction**

[3] The significance of each of these differences was tested with Wald tests and confirmed at a risk level of 5%.

		(1995)		for 2006 wave		terms for 2015 wave	
		coef.	p-value	coef.	p-value	coef.	p-value
Activity status	Employed full time / Entrepreneur	**2.32**	*(0.023)*	-0.79	*(0.512)*	-1.42	*(0.196)*
	Employed full time / Managers, intellectual professions	**1.62**	*(<0.001)*	0.77	*(0.151)*	0.56	*(0.202)*
	Employed full time / Technicians, clerks	**1.71**	*(<0.001)*	0.38	*(0.302)*	-0.16	*(0.610)*
	Employed full time / Service workers	**0.94**	*(<0.001)*	0.18	*(0.532)*	-0.21	*(0.391)*
	Employed full time / Blue-collar workers	**0.46**	*(0.016)*	0.21	*(0.453)*	0.38	*(0.147)*
	Employed part time	0.29	*(0.126)*	-0.02	*(0.937)*	0.25	*(0.302)*
	Student / Secondary	0.08	*(0.714)*	0.31	*(0.305)*	0.26	*(0.363)*
	Student / Post-secondary	**1.15**	*(<0.001)*	-0.17	*(0.480)*	-0.14	*(0.514)*
	Other (inactive)	**-0.74**	*(<0.001)*	0.46	*(0.116)*	0.33	*(0.217)*
	Unemployed **(ref)**	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
Age	Age	**0.83**	*(<0.001)*	0.16	*(0.386)*	-0.17	*(0.316)*
	Age^2	**-0.01**	*(<0.001)*	0.00	*(0.268)*	0.00	*(0.505)*
Gender	Female	**-0.75**	*(<0.001)*	**0.25**	*(0.008)*	**0.44**	*(0.001)*
	Male **(ref)**	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
Family status	Children (living with their parents)	-0.05	*(0.727)*	-0.19	*(0.362)*	**-0.57**	*(0.002)*
	Other (head of household, spouse, other) **(ref)**	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
Household	Number of persons	-0.09	*(0.061)*	0.08	*(0.297)*	**0.18**	*(0.011)*
	Number of children	-0.14	*(0.063)*	0.16	*(0.161)*	-0.09	*(0.401)*
Residence	City center	**-0.58**	*(<0.001)*	-0.13	*(0.446)*	-0.18	*(0.269)*
	Suburban area	**-0.39**	*(0.001)*	-0.32	*(0.070)*	-0.08	*(0.657)*
	Outskirts **(ref)**	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
	Constant	**-10.7**	*(<0.001)*	-2.0	*(0.421)*	1.8	*(0.410)*
	Number of observations	*11,554*					
	Pseudo R^2	*0.2361*					

Tab. 4: Econometric model explaining the probability of holding a driver's license (logistic regression)

Do these results allow us to understand better the decrease in driver's license ownership between 1995 and 2015, as observed in the descriptive statistics? The answer is "yes". The regression results show that unemployed and part-time workers had a lower probability of holding a driver's license and the proportion of these two occupational categories slightly increased between 1995 and 2015 (from 9.6% to 10.1% for unemployed people and from 7.6% to 8.5% for part-time workers, Table 2). Thus, the decline in driver's license ownership is likely to be due, at least in part, to higher budgetary constraints for some young people. With lower financial resources, some of them can no longer afford a driver's license. The factor that seems most likely to explain a lack of interest among some in the driver's license is their place of residence. Living in the city center significantly and greatly reduces the probability of young people holding a driver's license (it is on average 9 percentage

points lower than for a young person living in the outskirts, with other characteristics that are equivalent[4]), as they do not need a car to get around in the city because they can easily replace it by public transport or active modes. With the densification of urban areas, the proportion of young people living in the center of Lyon sharply increased in our sample, from 41.1% in 1995 to 56.7% in 2015 (Table 2), which may account for the overall decline of driver's license ownership. Changes in socio-economic situations amplify this phenomenon a little, while women's better access to the driver's license slightly moderates it.

In 1995, young people reported on average 4.03 trips per day, but only 3.46 in 2006 and 3.04 in 2015 (Table 1). The lower level of mobility results, in part, from a higher immobility rate. Through a logistic regression, performed to explain whether or not a trip was made[5] during the reference period (the weekday before the survey), we show that the variable "having a driver's license" has a significant influence, even after controlling for the effects of all the other variables. This factor reduced the probability of not making trips by about 5 percentage points between 1995 and 2006, all other things being equal, but had an almost non-existent impact in 2015 (the difference was on average about 0.6 of a percentage point). The decline in driver's license ownership could explain, at least in part, the increased immobility rate among young people between 1995 and 2006, but much less so that in 2015. Moreover, we have shown that there has been a significant decrease in young license holders' mobility, as 8.2% of them were non-trip makers in 1995, vs. 11.5% in 2006 and 13.7% in 2015.

4.2.2. Car use among trip-makers and its determinants over time

Table 5 presents estimation results from the zero-one inflated beta regression on the population of young trip-makers. Part A displays the results for the probability of never using a car for travel, Part B the results for the probability of making all trips by car and Part C the results for the probability of using a private car for some daily trips. Our ZOIB regression is of twofold interest for understanding young people's car use. Firstly, by differentiating between thee three components mentioned above, it shows that economic and living conditions do not influence non-use, partial or exclusive use of the car in the same way. It is not exactly the same variables that are significant in the three parts of our ZOIB model, and some act in opposite directions. For example, in 1995 (first column in Table 5), living in the city center affected the two extreme groups (those who never use or always use a car for daily trips) but not the middle one: young people living in the city center had both a significantly higher probability of never using a private car as a driver (+7 percentage points) than their counterparts living in the suburban areas or outskirts and a lower probability of being exclusive car users (-8 percentage points[6]). Gender only affected the probability of never using a car, but not the proportion of trips made as a driver when a car was used for some or all daily trips[7]. In 1995, there were two very distinct car use profiles among those who lived with their parents, since this variable significantly increased both the probability of making all trips by car and the probability of never using one.

[4] This figure corresponds to the marginal effect of the variable "living in the city center", calculated at the average point from the logistic regression in Table 4.

[5] For reasons of space, this regression has not been reported here, but is available on request from the authors.

[6] These figures correspond to the marginal effects of the variable "living in the city center", calculated at the average point from the ZOIB model in Table 5.

[7] In 2015, a second gender gap emerged: young women were less likely than their male counterparts to use a private car for all daily trips, whereas this gender difference did not exist before.

		Main effects (1995)		Interaction terms for 2006 wave		Interaction terms for 2015 wave	
		Coefficient	p-value	Coefficient	p-value	Coefficient	p-value
Part A: Probability of never using the car for travel							
Activity status	Employed full time / Entrepreneur	-0.40	*(0.394)*	-0.91	*(0.222)*	**-1.67**	*(0.019)*
	Employed full time / Managers, intellectual professions	-0.06	*(0.830)*	**-1.00**	*(0.014)*	**-0.72**	*(0.071)*
	Employed full time / Clerks, technicians	**-0.62**	*(0.006)*	-0.59	*(0.106)*	**-0.68**	*(0.064)*
	Employed full time / Service workers	-0.33	*(0.139)*	-0.11	*(0.765)*	**-0.62**	*(0.092)*
	Employed full time / Blue-collar workers	-0.34	*(0.141)*	-0.61	*(0.115)*	**-0.78**	*(0.049)*
	Employed part time	-0.19	*(0.449)*	-0.23	*(0.570)*	-0.64	*(0.106)*
	Student / Secondary	0.56	*(0.140)*	-0.06	*(0.907)*	-0.24	*(0.678)*
	Student / Post-secondary	-0.14	*(0.542)*	-0.37	*(0.327)*	-0.21	*(0.579)*
	Other (inactive)	**0.53**	*(0.066)*	0.02	*(0.973)*	-0.49	*(0.332)*
	Unemployed **(ref)**	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
Age	Age	**-0.30**	*(0.081)*	-0.44	*(0.097)*	0.13	*(0.609)*
	Age^2	0.004	*(0.205)*	**0.01**	*(0.077)*	-0.00	*(0.605)*
Gender	Female	**0.48**	*(0.000)*	-0.13	*(0.486)*	-0.07	*(0.685)*
	Male **(ref)**	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
Family status	Children (living with their parents)	**0.53**	*(0.005)*	-0.52	*(0.102)*	-0.49	*(0.118)*
	Other **(ref)**	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
Household	Number of children	**-0.19**	*(0.054)*	-0.07	*(0.671)*	0.13	*(0.459)*
	Number of persons	-0.07	*(0.271)*	0.18	*(0.109)*	0.13	*(0.256)*
Residence	City center	**0.46**	*(0.001)*	**0.56**	*(0.011)*	**0.37**	*(0.096)*
	Suburban area	-0.001	*(0.992)*	0.42	*(0.068)*	0.24	*(0.298)*
	Outskirts **(ref)**	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
Reference day	Monday **(ref)**	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
	Tuesday	-0.12	*(0.476)*	0.02	*(0.923)*	0.31	*(0.229)*
	Wednesday	-0.15	*(0.364)*	0.05	*(0.844)*	0.32	*(0.216)*
	Thursday	0.24	*(0.174)*	-0.20	*(0.446)*	-0.21	*(0.426)*
	Friday	**-0.41**	*(0.025)*	0.20	*(0.469)*	0.35	*(0.186)*
	Number cars / Number. drivers	**-2.84**	*(0.000)*	**0.87**	*(0.001)*	**0.79**	*(0.001)*
	Constant	**7.47**	*(0.002)*	5.45	*(0.135)*	-1.09	*(0.752)*
Part B: Probability of making all daily trips by car							
Activity status	Employed full time / Entrepreneur	0.48	*(0.189)*	-0.57	*(0.365)*	-0.90	*(0.137)*
	Employed full time / Managers, intellectual professions	0.24	*(0.348)*	-0.33	*(0.389)*	-0.28	*(0.481)*
	Employed full time / Clerks, technicians	0.22	*(0.302)*	-0.14	*(0.691)*	-0.32	*(0.384)*
	Employed full time / Service workers	**0.42**	*(0.053)*	-0.04	*(0.912)*	**-0.69**	*(0.070)*
	Employed full time / Blue-collar workers	**0.66**	*(0.003)*	-0.23	*(0.533)*	-0.40	*(0.311)*
	Employed part time	0.44	*(0.079)*	-0.20	*(0.620)*	**-0.73**	*(0.074)*
	Student / Secondary	-0.49	*(0.278)*	0.67	*(0.286)*	0.20	*(0.764)*

	Student / Post-secondary	0.03	*(0.895)*	-0.16	*(0.696)*	-0.63	*(0.135)*
	Other (inactive)	0.14	*(0.629)*	-0.43	*(0.393)*	-0.59	*(0.290)*
	Unemployed **(ref)**	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
Age	Age	0.08	*(0.651)*	0.05	*(0.854)*	0.27	*(0.339)*
	Age^2	-0.01	*(0.725)*	-0.00	*(0.870)*	-0.01	*(0.287)*
Gender	Female	0.09	*(0.435)*	-0.28	*(0.102)*	-0.32	*(0.068)*
	Male **(ref)**	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
Family status	Children (living with their parents)	**0.86**	*(0.000)*	**-1.11**	*(0.000)*	**-1.19**	*(0.000)*
	Other **(ref)**	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
Household	Number of children	0.11	*(0.231)*	**-0.44**	*(0.007)*	**-0.51**	*(0.006)*
	Number of persons	0.01	*(0.923)*	0.10	*(0.399)*	**0.38**	*(0.003)*
Residence	City center	**-0.34**	*(0.008)*	**-0.36**	*(0.071)*	-0.03	*(0.876)*
	Suburban area	0.10	*(0.400)*	-0.29	*(0.147)*	-0.22	*(0.299)*
	Outskirts **(ref)**	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
Reference day	Monday **(ref)**	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
	Tuesday	-0.16	*(0.288)*	0.17	*(0.491)*	-0.05	*(0.842)*
	Wednesday	**-0.26**	*(0.091)*	0.33	*(0.164)*	0.08	*(0.768)*
	Thursday	-0.20	*(0.207)*	0.23	*(0.349)*	-0.14	*(0.583)*
	Friday	**-0.43**	*(0.009)*	0.30	*(0.238)*	0.11	*(0.661)*
	Number cars / Number drivers	**0.53**	*(0.005)*	-0.47	*(0.129)*	0.51	*(0.103)*
	Constant	-1.61	*(0.520)*	0.52	*(0.891)*	-3.13	*(0.417)*
Part C: Probability of using partially a private car for daily trips							
Activity status	Employed full time / Entrepreneur	0.20	*(0.275)*	-0.11	*(0.729)*	-0.56	*(0.076)*
	Employed full time / Managers, intellectual professions	0.01	*(0.918)*	-0.19	*(0.322)*	-0.08	*(0.695)*
	Employed full time / Clerks, technicians	0.06	*(0.539)*	**-0.34**	*(0.053)*	-0.09	*(0.647)*
	Employed full time / Services workers	**0.20**	*(0.064)*	**-0.33**	*(0.080)*	-0.29	*(0.148)*
	Employed full time / Blue-collar workers	-0.04	*(0.740)*	-0.10	*(0.611)*	0.08	*(0.692)*
	Employed part time	0.23	*(0.061)*	-0.16	*(0.448)*	-0.23	*(0.295)*
	Student / Secondary	-0.21	*(0.344)*	-0.01	*(0.974)*	-0.10	*(0.773)*
	Student / Post-secondary	-0.07	*(0.592)*	-0.14	*(0.511)*	-0.11	*(0.617*
	Other (inactive)	0.03	*(0.843)*	-0.32	*(0.206)*	0.07	*(0.817)*
	Unemployed **(ref)**	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
Age	Age	**-0.20**	*(0.026)*	**0.34**	*(0.017)*	0.23	*(0.113)*
	Age^2	**0.003**	*(0.030)*	**-0.01**	*(0.031)*	-0.003	*(0.130)*
Gender	Female	-0.07	*(0.192)*	-0.05	*(0.553)*	0.06	*(0.522)*
	Male **(ref)**	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
Family status	Children (living with their parents)	**-0.25**	*(0.011)*	**0.58**	*(0.001)*	0.18	*(0.337)*
	Other **(ref)**	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
Household	Number of children	-0.06	*(0.202)*	0.13	*(0.145)*	-0.04	*(0.720)*
	Number of persons	0.03	*(0.393)*	**-0.14**	*(0.029)*	0.07	*(0.389)*
Residence	City center	-0.10	*(0.126)*	-0.04	*(0.694)*	0.06	*(0.596)*

	Suburban area	0.02	*(0.749)*	-0.17	*(0.125)*	0.08	*(0.477)*
Reference day	Outskirts **(ref)**	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
	Monday **(ref)**	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
	Tuesday	0.11	*(0.162)*	-0.14	*(0.256)*	-0.08	*(0.535)*
	Wednesday	0.09	*(0.262)*	-0.08	*(0.516)*	0.01	*(0.935)*
	Thursday	0.12	*(0.150)*	-0.01	*(0.977)*	-0.05	*(0.698)*
	Friday	0.09	*(0.295)*	0.03	*(0.798)*	-0.08	*(0.557)*
	Number cars/ Number drivers	0.07	*(0.444)*	0.11	*(0.484)*	0.24	*(0.126)*
	Constant	**2.89**	*(0.023)*	**-4.63**	*(0.018)*	**-3.67**	*(0.070)*

Tab. 5: Econometric model explaining the proportion of daily trips made as a driver (zero-one inflated beta regression)

Secondly, our ZOIB regression shows that many of the variables reflecting living and economic conditions changed between 1995 and 2015, suggesting that the decline in car use is partly related to behavior changes. For example, the impact of living in the city center, which positively affected the probability of never using a car and negatively affected that of making all trips by car, observed in 1995, persisted until 2015, with both effects increasing since 2006 (the associated interaction terms are significant). Part of the decline in car use over the period can be attributed to the fact that more and more young people were living in the city center. However, this impact was greater in 2015 than in 1995, with the car being perceived as less and less necessary in the city center.

In the literature, the trend for young people to be more likely to postpone leaving the parental home is expected to play a part in reducing car use. However, our data do not show an increase in the proportion of young people living with their parents over the period 1995-2015 (Table 2). However, this living characteristic has had a varying influence over time. Its impact on the probability of making all daily trips by car has reversed (part B, Table 5): in 2006 and 2015, young people living in the parental home were 9 percentage points less likely to make all their daily trips by car than their counterparts who had left the family nest, while the opposite was observed in 1995. Moreover, the coefficient associated with the variable "Living with their parents" became significant and positive in the equation for intermediate proportions of car use for daily trips, whereas it was negative in 1995 (Part C, Table 5). Young adults who live with their parents opt for partial instead of exclusive use of the private car when they see this mode of transport as an option and the proportion of daily trips made by car decreased among this group between 2006 and 2015. In 2015, living in the parental home decreased the overall probability of using the car for daily trips: this factor increased the probability of being non-car users, decreased the probability of being an exclusive car user and reduced the intensity of use among partial car users. As a result, in 2015, young people living with their parents had a homogeneous profile, corresponding to lower car use, whereas two opposing profiles were observed in 1995. This trend may have contributed to the overall decline observed in descriptive statistics on car use between 1995 and 2015.

Young people aged 18 to 34 years with children were less likely never to use a private car as a driver for daily trips than their counterparts without children, for all the survey waves. However, from 2006, the more children there were in the household, the lower the probability of being an exclusive car user. Children generate many escorting trips, which often involve short distances and for which people use other transport modes (for example, walking or using other active modes to take children to school).

Differences in car use between socio-occupational categories have also changed over time. It is clear that over the three waves of the survey blue-collar workers were always those with the highest probability of being exclusive car users for daily trips, all other things being equal. The proportion of

low-skilled jobs, mainly held by blue-collar workers, in the outskirts increased between 1995 and 2015 during which period public transport services have deteriorated leading to higher car use (Bouzouina et al., 2014). Workers are more likely to have jobs with atypical working hours (rotating shifts, evening, night or weekend work, etc.), for which a private car is needed in view of the level of service provided by public transport. For the same reasons, working part-time increased not only the intensity of car use, in the case of partial use, over the three waves of the survey, but also the probability of making all one's daily trips by car in 1995 and 2006. However, a change was noticeable in 2015: working part-time had a negative impact on the probability of being an exclusive car user. A similar phenomenon can also be observed for the category of full-time service workers. This socio-occupational category had the highest probability of being exclusive car users in 1995 and 2006, after blue-collar workers, but in 2015, it was that with the lowest. Service workers or part-time workers are those who have most clearly changed their mobility patterns, moving strongly away from exclusive use to partial of the car after 2006. Indeed, both service workers and the intermediate professions remained, during all three waves, those employed people with the lowest probabilities of never using the car for daily trips.

5. Discussion and conclusion

Over the last two decades, a sustained decline in driver's license holding and private car use for daily trips has been observed among young people in most Western countries. The literature has highlighted that these trends are partly explained by differences in life circumstances (in terms of demographics, living situation and socio-economic situation). However, these factors do not explain all the observed differences: there are unexplained cohort effects, often put down to changes in values and attitudes (Vincent-Geslin et al., 2017). This article aims to better understand these cohort effects by examining whether, above and beyond structural changes in life circumstances, their impact on license holding and car use for daily trips has changed over time. Such changes can be expected within the young population. Our econometric model allows us to identify to which living or socio-economic situations these changes are most related. Our analysis based on the last three Lyon conurbation household travel surveys (1995, 2006, and 2015) provides some answers in the French context.

Based on several regressions, it appears that the decline in driver's license ownership among 18-34 year olds is primarily due to changes in living and socio-economic characteristics. Indeed, most of the factors studied (age, occupational status, education level, place of residence) had a statistically invariant effect between 1995 and 2015. Consequently, the downward trend observed for driver's license holding may be more related to both a residential preference for the city center and greater affordability constraints. Firstly, in line with previous studies (Hjorthol, 2016; Licaj et al., 2012; Raimond and Milthorpe, 2010; McDonald and Trowbridge, 2009), we have observed that more and more young people in the Lyon conurbation area live in the city center and therefore feel no need to take the formerly much-prized driving test. Two urban form factors can support, at least in part, this hypothesis for the Lyon conurbation area. Between 1995 and 2015, the tram and metro lines were improved and the density of young adults living in the center and near public transport stations increased. Moreover, recent innovations, such as the setting-up of Vélo'v self-service bicycle stations have been immensely successful in the city. Secondly, the proportion of unemployed or part-time workers among young adults increased between 1995 and 2015. More young adults face financial challenges, which probably prevents them from being able to pay for driving lessons. Our results support those of the French qualitative study by Vincent-Geslin et al. (2017) and the national and international literature on affordability (Delbosc and Currie, 2013; Hjorthol, 2016, Roux, 2012; Demoli, 2017). The real behavioral changes with regard to driver's license holding over the 20-year study period seem to be an increase among women, with a reduction, all other things being equal, in the gap between them and their male counterparts, and a decrease among young people living with

their parents, who since 2015 have had fewer driver's licenses than those who have left the family nest.

While the decline in driver's license ownership among young people appears to be little related to changes in their behavior (the determinants of license holding have changed only slightly over time), they seem to play a more important role in the decline in car use. Of course, the relative importance of changing socioeconomic and living conditions in shaping travel behavior is also considerable. Living in the city center has a negative impact on car use. Part of the decline in the number of daily trips made by private car between 1995and 2015 in the Lyon conurbation area can be linked to changes in young people's residential choice. Our results highlight the fact that young people living in the city center have also changed their behavior related to car use. In consecutive surveys, the difference in car use between city center residents and the residents of other areas has widened. We can suspect that young adults living in the city center have to bear substantial and increasing housing costs, which makes private cars less and less of a priority. Moreover, by living in the city center for a long period without using a car, young adults have become more and more familiar with alternative modes and are learning new ways of meeting their daily mobility needs (for example by optimizing their trips on the public transport network, without forgetting ride sharing). With the growth of the collaborative economy, some young adults have foregone private property in favor of sharing. Moreover, changes in behavior related to car use also seem to have affected part-time workers, young people living in the parental home or those who have started a family. All other things being equal, working part-time or living in the parental home increased the probability of making all one's daily trips by car in 1995, but decreased it in 2015. These young people have opted for lower car use and are looking towards alternative modes. Similarly, the impact of the presence of children in the household also changed over the three surveys: while young adults with children still had a higher probability of using a car (a lower probability of never using it for daily trips), since 2006 fewer of them are exclusive car users than young people without children. We can note that similar results are obtained for car use when the sample is restricted to individuals with a driver's license.

In the light of these results, we can ask whether these changes are only transient in the life cycle, i.e. only affect young people, or whether they are more permanent and may also be present among older groups in the future due to generational renewal and cohort effects. Have young adults postponed their decision to obtain a driver's license and use a car on a daily basis until they feel a real need to do so or have they definitively changed their mobility behavior? Although the proportion of those who never use a private car for daily trips has increased since 1995, even among license-holders, analyses distinguishing cohort effects from age and period effects have to be conducted to give a satisfactory answer to this question. Nevertheless, our study suggests that cohort-age-period models will need to take adequate account of changes in behavior related to car use, in addition to changes in living and socioeconomic situations. Moreover, by gathering and analysing some information on individuals' attitudes and preferences regarding car use, it will be possible to correctly distinguish what is due to changes in socioeconomic and living conditions from what is due to changes in preferences and/or attitudes. Lastly, if we highlighted that the decline in car use can be, at least in part, explained by young people's residential choice, nothing is said concerning the causal relationship between the built environment and the travel pattern of inhabitants. As discussed in Naess (2015), it is possible that both influence each other reciprocally. If the built environment of the city center became more attractive to young adults, the latter could develop a more positive attitude towards living in the city center. But young adults living in the city center could also influence the built environment by using certain kinds of transportation modes and urban facilities and supporting politicians according to their urban development program. The combination of quantitative and qualitative methodologies is an avenue for further research, as it allows not only to estimate the impact of socioeconomic characteristics and living conditions on car use, but also to better understand people rationales concerning transportation mode choice for their daily trips.

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