*Where sustainable transport and social exclusion meet: households without cars and car dependence in Great Britain*

GIULIO MATTIOLI[1]

**ABSTRACT**

A secondary analysis of the British National Travel Survey for the years 2002-2010 shows that the composition of the group of carless households is a good indicator for the level of car dependence in a local area: indeed, while non-car ownership in peripheral and rural areas very often corresponds to a marginal socio-demographic situation and a lack of autonomous travel, this is less and less true as one moves towards larger urban areas. This is consistent with the recent wave of studies on transport and social exclusion, arguing that, in some types of local area, the car is essential for participation in society. This conclusion is challenging for environmental policy, as it highlights the tensions and trade-offs between social and environmental goals in the domain of transport, and thus the difficulty of achieving the latter. The same analysis also shows that socio-demographic characteristics are the most important determinant of household car ownership: this means that there are limits to what spatial planning interventions, such as carfree developments, can achieve, and points to the need for environmental policies informed by research on car dependent social practices.

**KEYWORDS**: car ownership, households without cars, social exclusion, sustainable transport, car dependence, car-free developments

## 1. The carless: environment and social inequality

Current trends in surface passenger transport are unsustainable: historical trends towards increasing travel distances, car use and ownership over the course of the 20th century have made transport one of the main contributors to greenhouse gas (GHG) emissions (Schäfer, Heywood, Jacoby, & Waitz, 2009). On top of that, the remarkable resistance to change demonstrated by transport systems makes them one of the most challenging aspects of the climate change agenda. In this context, official policy documents generally assume that technological innovation and a modal shift away from private car use (i.e. increasing multimodality) will be enough to bring about emission reductions at a sufficient scale and speed (see for example European Commission, 2011). Accordingly, policy makers usually avoid highlighting the need for a reduction in travel distances and motorisation rates.

However, transport research generally acknowledges that car ownership is a crucial determinant of modal choice and travel behaviour, both at the individual (Van Acker & Witlox, 2010) and aggregate level (Kwon & Preston, 2005). This is worrying because the number of

[1] Centre for Transport Research, School of Geosciences, University of Aberdeen, Aberdeen, UK. Email: giulio.mattioli@abdn.ac.uk; giulio.mattioli@gmail.com

cars and vans worldwide is increasing rapidly and, if current trends continue, is expected to reach one or two billion within a couple of decades (Schäfer et al., 2009; Sperling & Gordon, 2009). Although growth is more rapid in developing countries, this trend calls European societies, where motorisation is approaching saturation, into question as well (Dargay, Gately, & Sommer, 2007). As a matter of fact, if the rest of the world were to reach the motorisation rates of the EU, this would put too much strain on oil reserves and the atmosphere's capacity to absorb GHG emissions. Therefore, a trend reversal in the demand for cars is arguably necessary and an increase in the number of households without cars in industrialised countries is desirable.

This idea has underpinned the recent interest in "carfree developments", defined as "residential or mixed use developments which normally provide a traffic free immediate environment, offer no parking or limited parking separated from the residence, and are *designed to enable residents to live without owning a car*" (Melia, Parkhurst, & Barton, 2010, p.28, emphasis added). Research on carfree developments has generally noted that residents tend to be relatively young, educated, environmentally aware households who are not necessarily poor, but are both willing and able to live without a car (Melia et al., 2010; Ornetzeder, Hertwich, Hubacek, Korytarova, & Haas, 2008). This is not surprising as these developments are generally quite recent and located in dense urban areas, where transport alternatives are widely available. Broadly speaking, research into carfree developments often addresses the question of whether or not there is demand for them and which groups should be targeted: in this context, concepts of attitudes and lifestyle are often brought to the fore (Melia, 2010).

The way in which households without cars are discussed in research literature on transport and social exclusion could not be more diverse. Indeed, in recent years a growing number of academic and policy studies have tackled the links between transport, accessibility and social exclusion, especially in the UK (Lucas, 2012). In this context, it is noted that in industrialised countries the lack of a car is often the consequence of economic or other constraints and/or the cause of difficulties in accessing services and opportunities. This transport disadvantage can in turn lead to (further) social exclusion and is thus problematic from a social equity perspective. The focus here is often on disadvantaged or marginal groups such as low income households, ethnic minorities, the unemployed and older people, and on how the lack of a car impacts on their life chances. In terms of policy implications, researchers sometimes conclude that it is necessary to increase the motorisation of these groups, to allow them to participate in society (Lucas, 2004).

In short, then, the issue of autolessness is at the peculiar intersection of two contradicting policy goals: while environmental concerns invite us to promote *carfree* living, it seems that the number of *carless* households has to be reduced, if we want to promote equality of opportunity in the domain of transport. However, studies on sustainable transport focus on a type of carless that is quite different from that considered by research into transport and social exclusion: an inadvertent outcome of this situation is that the overall view of the sheer variety of situations that cause people to live without cars is lost. By contrast, I argue in this article that there is a need to focus on the composition of the carless group as a whole, and on how it varies across different types of area. Indeed, it is reasonable to assume that in dense urban areas, where services and opportunities can be accessed relatively easily with alternative modes, the carless group will be larger, more diverse and relatively more mobile, and it will include a substantial share of households for whom carfree living is a matter of lifestyle. By contrast, in peripheral and rural areas, where the car is often an essential tool for social

inclusion, households without cars are more likely to be concentrated among the poor and the elderly, and to be relatively less mobile.

Accordingly, I argue that the composition of the carless group can be considered an indicator for the level of car dependence in a local area. The notion of car dependence is used in a variety of ways in transport literature, with the main division running between a micro-social understanding of the term (where it is an attribute of the individual) and macro-social one (where it refers to a local society's reliance on the automobile). In this second meaning, two points are crucial: firstly, the concept conveys the idea of resistance to change, whereby curbing car use and ownership is more difficult where dependence is high. Secondly, higher levels of car dependence imply greater disadvantage for the carless, as compared to the situation of car drivers (Dupuy, 1999; Mattioli, in press).

In this article, I show how the composition of the carless group changes across different types of area. In order to do that, I present the results of a secondary analysis of the British National Travel Survey (NTS) for the years 2002-2010. The paper is structured as follows: in the next section, I focus on the data source and on methodological issues. In the third and fourth section, I illustrate the main empirical findings. Finally, I discuss the implications of the study for environmental policy and planning in the field of transport.

## 2. Data and methodology

The British National Travel Survey is one of the oldest of its kind, having begun in 1972/1973. Since 1988, it has been carried out on a continuous basis and since 2002 the sample has been increased to about 9,000 households per year. All household members, children included, have to complete a one week travel diary, if necessary by proxy. Beside travel behaviour, a range of household and individual characteristics are assessed in the questionnaire. The survey is representative for Great Britain (Northern Ireland is excluded).

For most analyses in this article, I have used pooled data from the NTS 2002-2010 database[2] (Department for Transport, 2012). This allows me to work with a larger sample size: this is crucial since the carless are only a small subset of the total sample, accounting for about 25% of households and 19% of individuals (20,416 households, 36,064 individuals and 316,325 trips). Accordingly, pooling the data allows for more disaggregate analysis and more robust estimates than would be possible for individual years. On the other hand, of course, this obscures any differences between years: however, the share of households without cars is remarkably stable at around 25-26% across the reference period, even though there are small changes in the composition of the group across the years. In the next sections, for the sake of brevity, I will not comment on these differences.

Finally, as far as definitions are concerned, it must be acknowledged that living in a household without cars is not the only way of being carless: in fact, non-drivers in car-owning households are to a certain extent excluded from the mobility and flexibility that the automobile provides. Furthermore, car deficient households (where there are less cars than licensed drivers) are regularly confronted with the question of which household member is entitled to use the vehicle; this process of allocation can result in considerable inequality in car availability, notably along gender lines (Scheiner & Holz-Rau, 2012). Therefore, focusing on households

[2] The NTS 2002-2010 has been conducted by the National Centre for Social Research on behalf of the Department for Transport, which owns the data. The dataset is kindly provided by the Economic and Social Data Service (ESDS) through the UK Data Archive at the University of Essex, Colchester.

who do not own cars (as I do in this work) obscures possible differences in access to vehicles *within* households. However, it allows me to assess the existence of differences *between* households, as well as the extent to which individuals in non-car owning households make use of the automobile.

## 3. The carless group across different types of area

As noted above, 25% of households in the pooled sample (corresponding to 19% of individuals) do not own cars. The size of the carless group is quite stable across the period – marking the first time this has happened after decades of steady decline (Department for Transport, 2011).

| | | Households without cars | Population |
|---|---|---|---|
| **Single-person units** | | 57 | 29 |
| **No member under 16** | | 83 | 73 |
| **Female HRP** | | 60 | 37 |
| **Age of HRP** | **16-29** | 15 | 10 |
| | **30-59** | 36 | 56 |
| | **60+** | 49 | 34 |
| **HRP not in employment** | | 70 | 39 |
| **Income quintile** | **Lowest** | 41 | 20 |
| | **Second** | 29 | 20 |
| | **Third or higher** | 30 | 60 |

**Tab. 1 – Composition of the carless households group, for key socio-demographic characteristics, as compared to the sample as a whole (percentage values). Data source: NTS 2002-2010.**

In terms of socio-demographic profile, descriptive statistics (Tab.1) show that singles, households without members under sixteen and family units with a household reference person (HRP) that is either female or not employed are overrepresented among carless households[3]. In terms of age, both younger and older households are overrepresented; finally, non–car ownership is also disproportionately concentrated amongst low-income households, with approximately 70% of carless households in the two lowest quintiles. Overall, these results confirm expectations, as previous research on the determinants of non-car ownership has shown it to be negatively associated with income, household size and employment, while it has a curvilinear relationship with age (Karlaftis & Golias, 2002; Preisendörfer & Rinn, 2003).

[3] In the NTS, the HRP is defined as "the householder with the highest income, or their spouse or partner" who answered the household questionnaire (Rofique, Humphrey, Pickering, & Tipping, 2011, p. 16).

| | | London Boroughs | Metropolitan built-up areas | Other urban over 250k | Urban over 25k to 250k | Urban over 10k to 25k | Urban over 3k to 10k | Rural |
|---|---|---|---|---|---|---|---|---|
| **Households without cars** | | 41 | 33 | 25 | 25 | 23 | 19 | 10 |
| ***As percentage of households without cars*** | **Single-person units** | 49 | 54 | 58 | 59 | 64 | 66 | 68 |
| | **No member under 16** | 82 | 82 | 83 | 82 | 84 | 87 | 88 |
| | **Female HRP** | 53 | 59 | 60 | 61 | 65 | 67 | 65 |
| | **Age of HRP: 60+** | 33 | 47 | 48 | 52 | 61 | 65 | 72 |
| | **HRP not in employment** | 49 | 67 | 67 | 70 | 76 | 80 | 81 |
| | **Two lowest income quintiles** | 55 | 76 | 70 | 73 | 75 | 77 | 76 |
| | **Four characteristics or more** | 41 | 57 | 57 | 61 | 68 | 72 | 76 |

**Tab. 2– Size and composition of the carless households group in different types of area (percentage values). Data source: NTS 2002-2010.**

The incidence of non-car ownership is obviously very uneven across different types of area (Tab.2): while 41% of family units in London Boroughs do not own cars, this figure is as low as 10% in rural areas. The descriptive statistics illustrated in Tab.2 also provide a first piece of evidence to show that the socio-demographic profile of carless households becomes less diverse as the degree of urbanisation decreases. For example, only 33% of carless households in London are over 60 years old, a figure which is as high as 72% in rural areas. The same pattern is apparent for all six key socio-demographic characteristics listed in Tab.2, even though for some, such as the absence of young children, the increase is only moderate (but statistically significant). The last row shows how the percentage of carless households that accumulate four or more of the characteristics listed above (such as, for example, a household composed of a single woman over 60) varies across different types of area: an increasing trend is apparent in this case too, with households with a marginal socio-demographic profile accounting for 76% of households without cars in rural areas, but for less than half of the group (41%) in London.

| | London Boroughs | Metropolitan built-up areas | Other urban over 250k | Urban over 25k to 250k | Urban over 10k to 25k | Urban over 3k to 10k | Rural |
|---|---|---|---|---|---|---|---|
| **Single-person units** | 3.9 | 5.6 | 5.8 | 6.6 | 8.3 | 9.1 | 10.5 |
| **No member under 16** | 2.1 | 2.2 | 2.1 | 2.0 | 2.4 | 2.7 | 2.9 |
| **Female HRP** | 2.4 | 3.4 | 3.6 | 3.8 | 4.8 | 5.2 | 5.4 |
| **Age of HRP: 60+** | 1.6 | 2.5 | 2.6 | 2.9 | 3.6 | 3.6 | 4.9 |
| **HRP not in employment** | 4.4 | 7.1 | 7.4 | 8.2 | 9.2 | 11.6 | 12.1 |
| **Two lowest income quintiles** | 3.6 | 6.3 | 5.8 | 6.4 | 6.7 | 8.3 | 8.0 |

**Tab. 1 – Odds ratios of not owning a car for key socio-demographic characteristics, by type of area. Data source: NTS 2002-2010.**

However, these trends might be (at least in part) the by-product of socio-demographic differences between different types of area. Tab.3, which shows odds ratios for the same six key socio-demographic variables across different types of area, controls for this confounding effect. For every variable and every area, the odds ratio is defined as the odds of not owning a car (rather than owning it) for households who have the characteristic in question, divided by those same odds for other households. So for example the first row shows that, in London, the odds of not having a car (rather than having one) are 3.9 times more for single-person households compared to family units with two or more members. This figure increases steadily as one moves towards less urban areas, to reach a staggering 10.5 in rural areas. The same trend is apparent for all other variables, although the increase is less pronounced for most of them – and notably is almost absent for the variable assessing the presence of young children. The increasing values of the odds ratios indicate that the positive association between the six key socio-demographic variables and non-car ownership is substantially greater in peripheral and rural areas. This confirms that the carless are significantly more concentrated among households with a marginal social profile where the degree of urbanity is lower.

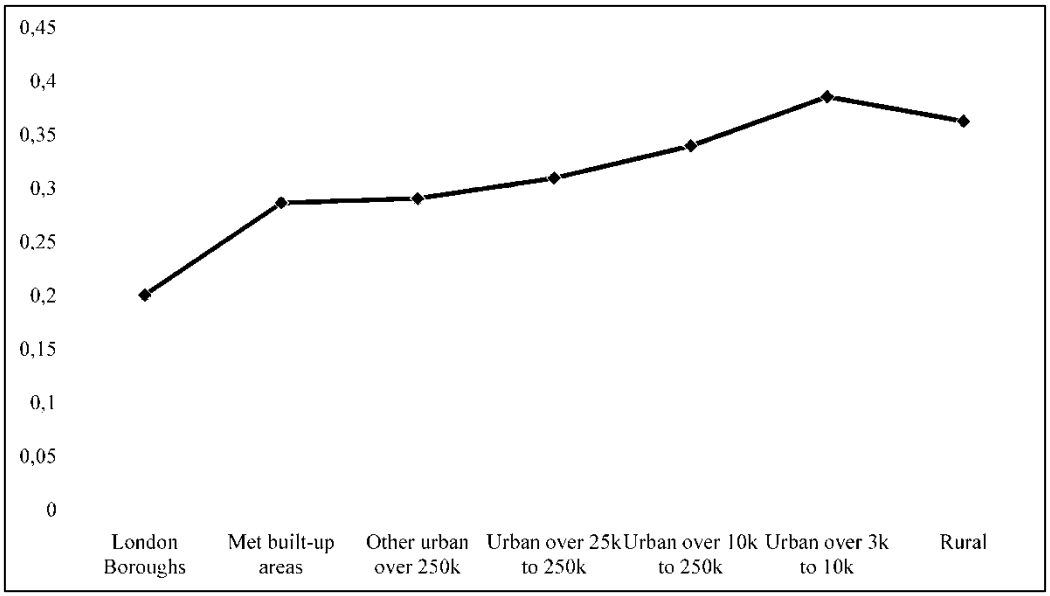


**Fig. 1 – Values of McFadden's pseudo-$R^2$ for logistic regression models including only socio-demographic predictors, fitted separately for the different types of area. Data source: NTS 2002-2010.**

This conclusion is further supported by more formal analyses: Fig.1 shows the values of McFadden's pseudo $R^2$ (a goodness of fit statistic) for a series of logistic regression models including only socio-demographic predictors that have been fitted separately for the different types of area[4]. As the graph clearly shows, the values increase significantly as we move from London to less urbanised areas, from 0.2 to 0.39 (in small urban municipalities) before declining slightly for rural areas. As McFadden (1979, p. 307)suggested that values comprised between 0.2 and 0.4 indicate an excellent fit, the fit of the model in the more peripheral areas should be considered very good, especially if one acknowledges that it deliberately excludes any independent variable related to the area of residence (such as public transport access and the like), which could arguably increase the predictive power even further. This result can be interpreted as follows: predicting which households do not own cars on the basis of socio-demographic variables is much easier in sparser areas than in cities. This confirms that the profile of carless households in large urban areas is much less one-sided, predictable and marginal than in other areas.

[4]The detailed results for the models are not reported here for the sake of brevity. The independent variables included are the same reported in the regression model illustrated in Tab.4 below, with the exception of territorial variables, but including the survey year.

| Functional set of variables | | | Coefficient | Robust Std. Error |
|---|---|---|---|---|
| Socio-demographic variables | **No. HH members** | | -1.331*** | (0.0377) |
| | **No. HH members (squared)** | | 0.135*** | (0.00595) |
| | **No. minors in HH (under 16)** | | 0.0324 | (0.0301) |
| | **HRP female (dummy)** | | 0.816*** | (0.0247) |
| | **Age band of HRP** (vs. grand mean) | 16 – 19 years | 1.737*** | (0.1965) |
| | | 20 – 29 years | 0.438*** | (0.0490) |
| | | 30 – 39 years | -0.239*** | (0.0460) |
| | | 40 – 49 years | -0.410*** | (0.0448) |
| | | 50 – 59 years | -0.609*** | (0.0441) |
| | | 60 – 69 years | -0.859*** | (0.0449) |
| | | 70 + years | -0.0572 | (0.0426) |
| | **No. HH members in employment** | | -0.427*** | (0.0248) |
| | **HRP non-white (dummy)** | | 0.241*** | (0.0544) |
| | **Real household income equivalent quintile** | | | |
| | | (ref.cat.: Lowest):Second | -0.419*** | (0.0315) |
| | | Third | -1.134*** | (0.0374) |
| | | Fourth | -1.693*** | (0.0453) |
| | | Highest | -2.143*** | (0.0509) |
| Territorial variables | **Region** (ref. cat.: England) | Wales | 0.288*** | (0.0589) |
| | | Scotland | 0.517*** | (0.0441) |
| | **Type of area**(ref. cat.: London Boroughs) | | | |
| | | Metropolitan built-up areas | 0.272*** | (0.0636) |
| | | Other urban over 250k | 0.0509 | (0.0667) |
| | | Urban over 25k to 250k | 0.208** | (0.0694) |
| | | Urban over 10k to 25k | 0.326*** | (0.0810) |
| | | Urban over 3k to 10k | 0.238** | (0.0858) |
| | | Rural | -0.267** | (0.0868) |
| | **Population density – Local Authority (persons / hectare)** | | 0.0142*** | (0.00132) |
| | **Population density - Primary Sampling Unit (persons / hectare)** | | 0.00900*** | (0.000845) |
| | **Walk time to bus stop: 7 minutes or more (dummy)** | | -0.0755* | (0.0349) |
| | **Frequency of bus service: Less than 1 every half hour (dummy)** | | -0.330*** | (0.0341) |
| | **Time to railway station (by quickest mode)** | | | |
| | | (ref. cat.: 13 minutes or less): 14-26 minutes | -0.0924** | (0.0295) |
| | | 27 minutes or longer | -0.192*** | (0.0348) |
| | **Type of railway station: Frequent service rush hour only or less (dummy)** | | -0.118** | (0.0434) |
| | **Rail/metro/tram stop not closer than railway (dummy)** | | -0.300*** | (0.0533) |
| Survey Year | **Survey year** | | -0.0231*** | (0.00678) |
| | **(constant)** | | 2.129*** | (0.143) |
| | ***N*** | | 62503 | |
| | ***McFadden's pseudo $R^2$*** | | 0.335 | |

$^{*}p< 0.05$, $^{**}p< 0.01$, $^{***}p< 0.001$

**Tab. 4 - Logistic regression model for the probability of not owning household cars: logit coefficients and robust standard errors. Data source: NTS 2002-2008.**

At this point, the evidence provided should suffice to show that in the NTS 2002-2010 sample the socio-demographic composition of the carless group varies systematically with the degree of urbanisation of the local area. In order to understand in detail how this happens, it is necessary to further examine the results of a single logistic regression model for household non-car ownership (Tab.4). The model includes all the six key socio-demographic variables discussed above (plus a quadratic term for household size), as well as a dummy to assess

whether the HRP is not white. Additionally, it includes several territorial variables besides the type of area, such as region, population density (both at the primary sampling unit and at the local authority level), and five predictors measuring access to public transport. The model is based on pooled data for the years 2002-2008, since population density variables are not available for the years 2009-2010. In order to control for differences between individual years, it includes a 'survey year' predictor. Since the goodness of fit is high (pseudo-$R^2$=0.34), the model can be considered a good representation of the data. Overall, the values of the logits reported in Tab.4 generally confirm theoretical expectations, with two exceptions: the lack of a significant effect concerning the number of minors and the non-linear effect of the type of area. In both cases, this is due to the fact that other collinear variables are controlled for (household size and population density respectively).

A common data-analysis strategy in multiple regression or correlation is hierarchical regression, which allows for the answering of questions about the relative importance of different functional sets of independent variables in accounting for the outcome (Cohen, Cohen, West, & Aiken, 2003, p. 158-163). In the context of this article, it is interesting to assess the relative importance of socio-demographic variables and territorial variables in accounting for non-car ownership. This can be done in the following way: the two sets are entered cumulatively, and upon the addition of each set the pseudo-$R^2$ is determined, as well as the increase thereof. In this framework, the increase in the pseudo-$R^2$ that follows the entering of an additional set can be interpreted as the gain in prediction associated with this group of variables (p. 508). The results of hierarchical regression clearly show that socio-demographic factors (pseudo-$R^2$=0.28) are a much more important determinant of non-car ownership than the functional set of territorial variables[5] (accounting for just 0.05). On a substantive level, these findings show that not having a household car is mainly a question of socio-demographics and income, while the spatial features of the residential area (such as population density and access to public transport) only play a secondary role. However, this very broad conclusion needs to be integrated with a more in-depth look at the model results.

The detailed interpretation of a logistic regression model can be challenging, as interpretations based on logits and odds ratios often run the risk of being misleading and deceptive (Freese & Long, 2001). While I report the values of the logits in Tab.4, in the following table I will discuss the predicted probabilities generated by the model, showing their values for a series of ideal-typical cases. The goal is to directly convey the substantive results that the model offers, as well as to find a plausible interpretation for the changing socio-demographic composition of the carless group across different types of area.

[5] The hierarchical order for entry of the two sets is determined on the basis of considerations of causal priority and the removal of confounding or spurious relationships (Cohen et al., p. 158): accordingly, in my analysis, the set of socio-demographic variables precedes the set of territorial variables. However, the alternative entering order does not change the conclusions, with socio-demographics still accounting for 0.28 and territorial variables for 0.06 of the pseudo $R^2$.

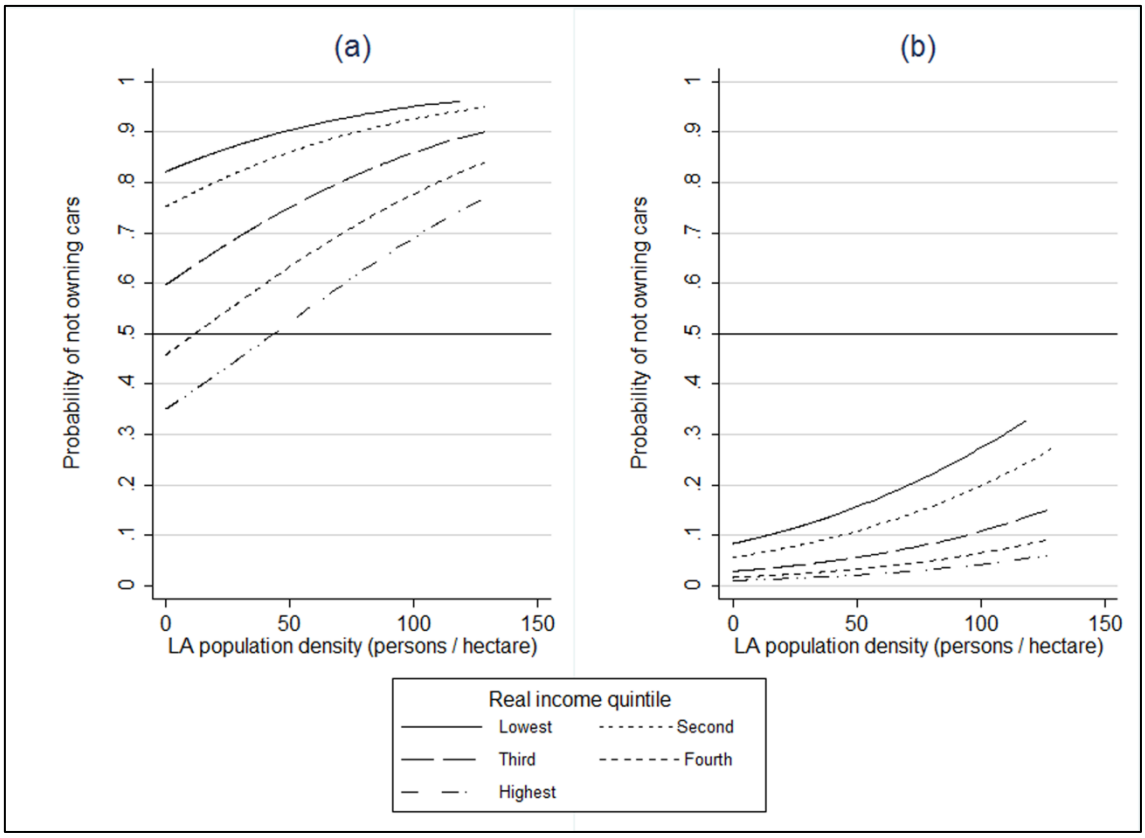


**Fig. 2 – Predicted probabilities of not owning a car by income quintile and LA population density, for two ideal-typical socio-demographic profiles. Data source: NTS 2002-2008.**

Fig.2 shows how the predicted probability of not owning a car varies according to population density in the Local Authority (LA) and to income quintile, for two ideal-typical socio-demographic profiles. All predictors not represented in the graph which are not fixed to specific values in order to build the profile are held constant at their mean (or mode for categorical variables). Fig. 2a refers to a first ideal-type of household: a single woman over 70 years old, not employed. The graph clearly shows that, in this case, the two predictors have a considerable impact on the likelihood of not owning cars: indeed, the predicted probability of being carless for a single old woman in the middle income quintile goes from 0.6 to 0.9 as the population density in the LA increases from zero to its maximum sample value. Similarly, in very sparsely populated areas, the predicted probabilities vary from just above 0.3 to approximately 0.8, depending on the level of income. In short then, it seems that for retired ladies, population density in the local area and available income make quite a difference in terms of non-car ownership, even when all other factors are held constant.

By contrast, Fig.2b refers to a household including two working adults in the age band 40-49 and two children under 16. As expected, the likelihood of not owning cars is here considerably lower; moreover, the probability curves are much closer to each other, with values ranging from virtually zero to just above 0.3. In other words, the probability of being carless is not only lower, but also much less sensitive to changes in population density and/or income. In short then, it appears that for working couples with children owning a car is almost an obligation – no matter where they live or how poor they are.

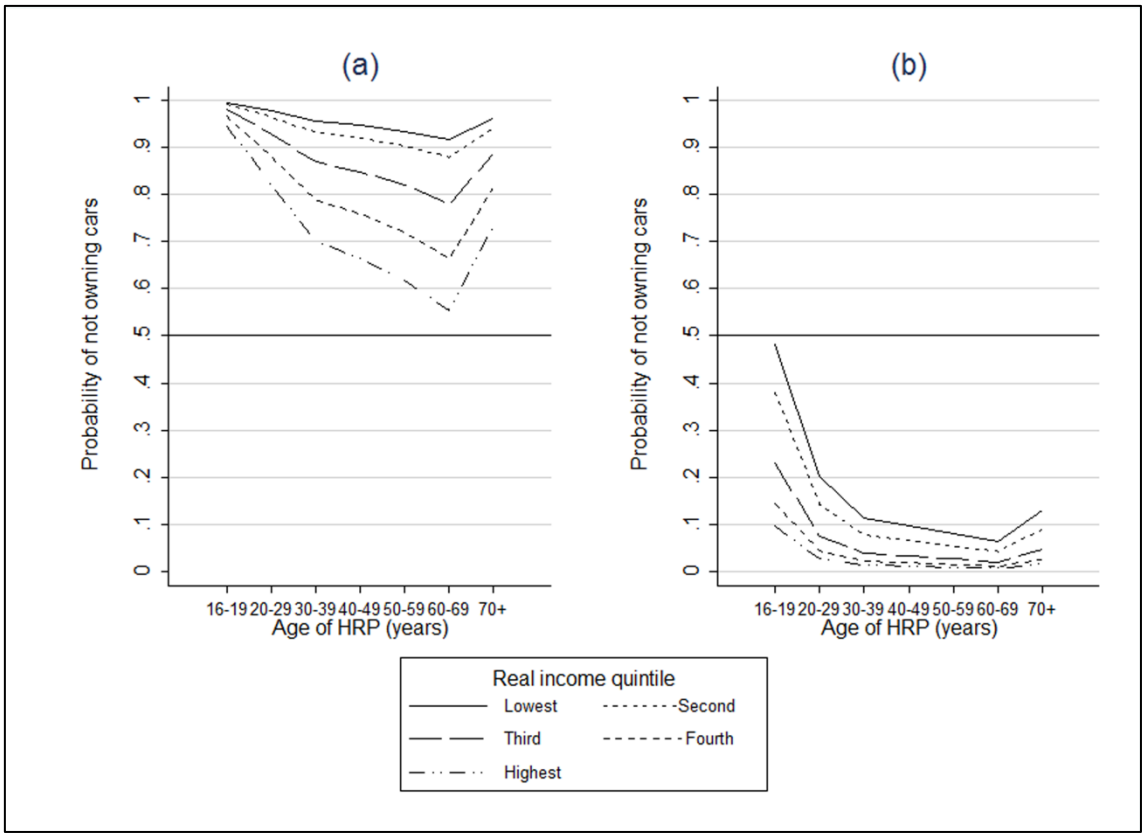


**Fig. 3 - Predicted probabilities of not owning a car by income quintile and age of the HRP, for two opposite ideal-types of residential area. Data source: NTS 2002-2008.**

Fig.3 shows how the predicted probability of not owning cars varies according to the age of the HRP and household income in two opposite ideal-types of residential area. Fig.3a refers to a scenario of maximum density and public transport accessibility: here both population density variables included in the model are fixed to their maximum value in the sample, all public transport access variables are fixed to the value corresponding to maximum accessibility, while all other variables are held constant at their mean or modal value. The graph clearly shows that, despite predicted probabilities never dropping below 0.5, age and income have quite an impact on the likelihood of not owning cars, notably for households in the middle range of the age distribution. In substantive terms, this means that even in a scenario combining very high densities and ideal public transport service, age and income make a substantial difference to car ownership.

By contrast, Fig.3b refers to a minimum density and accessibility scenario, where density variables are held constant at their minimum values and public transport accessibility indicators at their worst value. In this graph, the probability curves are not only lower, but also much closer to one another, with values ranging from 0.0 to 0.2. The exceptions here are households with an HRP under 20, who, however, account for only 0.4% of households in the sample and are very unlikely to include a licensed driver. In a nutshell, it appears that when population density is very low and access to public transport very difficult, not owning a car is virtually not an option – no matter how old or poor you are.

Yet the results of the descriptive analysis illustrated above clearly show that even in rural areas a non-negligible percentage of households are carless – and their socio-demographic profile is characterised by old age, non-participation in the labour market, low income, etc. How to explain this apparent paradox? My argument here is that there exist two main conditions that make it virtually impossible for households to live without cars: firstly, living in areas where population density is low and access to public transport is difficult; in these cases, the effect of socio-demographic conditions which are usually associated with a higher propensity to be carless (such as old age and low income) is almost non-existent, as shown in Fig.3b. Secondly, there are also socio-demographic situations which make it very difficult to get by without a car: this is true for example for working couples with young children. For these households, on average, the spatial characteristics of the residential area and the quality of public transport service are unlikely to make a difference to their propensity to join the ranks of the carless, as shown in Fig.2b. *It is the interweaving of these two impeding conditions, one related to geography, the other to social practices, that explains the changing socio-demographic profile of carless households across different types of area*. Indeed, each of these impeding circumstances can only be overcome if several other factors positively associated with non-car ownership are simultaneously present: for example, in order to be carless in rural areas, being either 'old' or 'poor' or 'single' is not enough – only when several of these factors are combined does the probability of not owning a car increase significantly. This explains why the socio-demographical profile of carless households in peripheral and rural areas is characterised by the simultaneous presence of low income, old age and the like. Similarly, for working households with children, simply living in a densely populated area is not reason enough to give up the car; in fact, it is only when density, urban location and good quality of public transport are simultaneously present that the probability of living without a vehicle is substantially greater. This kind of process potentially explains the greater diversity of household without cars that is observed in British metropolitan areas.

While studying how the determinants of non-car ownership intersect is crucial to understanding the changing composition of the carless group across areas, it tells us nothing about how this relates to differences in travel behaviour. This issue will be dealt with in the following section.

## 4. The travel behaviour of carless individuals

As stated above, the NTS questionnaire includes a one week travel diary that is completed for every household member. Therefore, while the unit of analysis in the previous section was the household, here I will focus on the travel behaviour of individuals living in carless households.

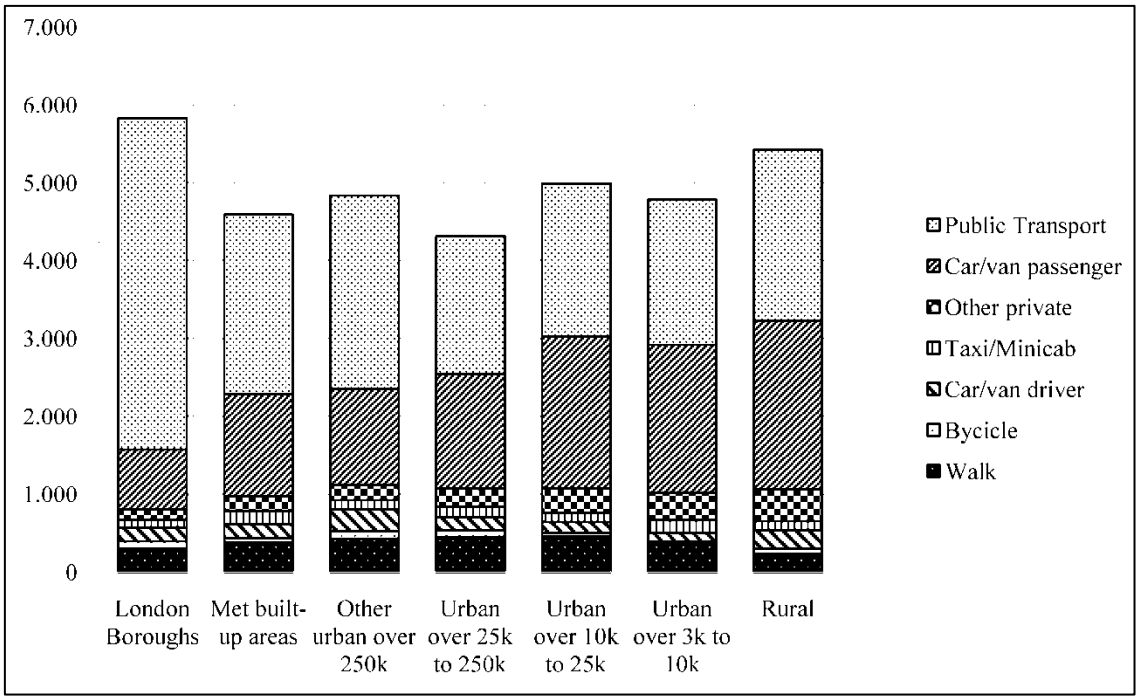


**Fig. 4 – Total annual distance per person (km), by transport mode and type of area, for carless individuals. Data source: NTS 2002-2010.**

Fig.4 shows, for individuals living in households without cars, the average annual travel distance by transport mode, across different types of area. Overall, it appears that the degree of urbanity does not make much difference to travel distance: this stands in stark contrast with corresponding figures for members of car-owning households (not reported here for the sake of brevity) showing that London residents travel on average much less (approximately 10,000 km per year) than their rural counterparts (approximately 17,000 km). However, this stability for carless individuals is the result of two diverging trends: indeed, while the distance covered as a car passenger increases steadily as the degree of urbanity decreases in Fig.4; the opposite is true for public transport. As a result, the modal split is very different across types of area, with London carless individuals covering 73% of their travel distance by public transport and only 13% as car passengers, while the corresponding figures in rural areas are 41% and 40%. This pattern might be explained by the better provision of public transport in larger cities; yet, the changing composition of the carless group across different types of area illustrated in the previous section is probably not unconnected to these differences in modal behaviour.

To test this hypothesis, in this section I present the results of a cluster analysis conducted on the subset of carless individuals, on the basis of travel behaviour variables. Two groups have been excluded from the analysis: children under the age of 16, because they are often accompanied by their parents, and adults who did not report travel during the survey week, due to missing information. The input variables used for the cluster analysis were: weekly travel distance; average speed of travel; the share of total distance travelled by car (either as

driver or passenger), taxi or other private motorised transport means; the share of trips made for work or education related purposes[6].

| | | SL | CR | PTC | IM | LDW | Carless adults | NTS sample |
|---|---|---|---|---|---|---|---|---|
| **Cluster size** | ***%*** | 40 | 23 | 23 | 8 | 6 | 100 | |
| ***Travel week*** | | | | | | | | |
| **Trips** | ***mean*** | 16.7 | 11.8 | 17.3 | 0 | 16.3 | 14.4 | 19.8 |
| **Distance travelled (km)** | ***mean*** | 64 | 79 | 105 | 0 | 551 | 100 | 237 |
| **Journey time (h:min)** | ***mean*** | 6:32 | 4:02 | 8:26 | 0 | 12:23 | 6:15 | 7:39 |
| **Average length of trips (km)** | ***mean*** | 3.8 | 6.6 | 6.1 | - | 33.8 | 7.0 | 12.0 |
| ***Modal split (basis: distance)*** | | | | | | | | |
| **Walking** | ***%*** | 16 | 4 | 8 | - | 1 | 7 | 2 |
| **Cycling** | | 2 | 1 | 3 | - | 0 | 2 | 1 |
| **Car/van driver** | | 0 | 5 | 2 | - | 9 | 4 | 58 |
| **Car/van passenger** | | 7 | 63 | 12 | - | 29 | 25 | 21 |
| **Public Transport** | | 72 | 12 | 70 | - | 53 | 55 | 15 |
| **Taxi/minicab** | | 2 | 6 | 3 | - | 1 | 3 | 1 |
| **Other private** | | 0 | 9 | 2 | - | 7 | 4 | 2 |
| **Share of trips for work or education** | % | 8 | 9 | 66 | - | 27 | 28 | 36 |

**Tab. 5 – Typology of carless adults: clusters size and descriptive statistics for selected travel behaviour variables. Data source: NTS 2002-2010.**

For the sake of brevity, the values of the centroids for the four-cluster solution retained are not reported here in detail. Instead, Tab.5 shows how the clusters differ in size and some key travel behaviour variables, which in turn are strongly related to the input variables. To allow comparison, corresponding values for carless adults as a whole and for the NTS sample are reported in the rightmost columns.

The table also shows results for a fifth cluster, labelled *Immobile* (IM, 8%), consisting of those respondents who were excluded from the cluster analysis because they did not travel at all during the survey week. While this group was not obtained by clustering methods, it is arguably characterised by very peculiar travel behaviour, and is thus an integral part of the typology put forward here. Another small group (6%), labelled *Long Distance Week* (LDW), has the highest values on all indicators of overall travel, apart from the number of trips. Accordingly, it probably includes adults who made at least one long distance journey during the survey week (probably not representative of their ordinary travel behaviour): for this reason, I will ignore this cluster in the following. The *Car Reliant* cluster (CR), accounts for approximately one quarter of the subset and is characterised mainly by the high modal share of the car as passenger (63%) – motorised private means of transport and taxis taken together account for a staggering 86% of the distance travelled. Accordingly, individuals in this group are those that spend less time travelling, despite covering considerable distances, as they rely on faster travel modes. Moreover, people in this cluster virtually do not travel for work or education reasons, something which suggests low participation in employment and education. In a nutshell, people in this group, despite being carless, rely on car lifts, taxis and the like for

[6] The clustering was conducted using k-means algorithm, Euclidean distance as dissimilarity measure and standardized input variables. A four cluster solution was retained, representing the most distinct clustering, as attested by the maximum value of the Calinski/Harabasz pseudo-F statistic.

most of their travel. The *Public Transport Commuters* cluster (PTC) also accounts for 23% of the carless, but it could not be more different: the distance travelled here is higher, but the speed lower, as public transport is clearly the dominant transport mode (70% of travel distance). Moreover, 66% of the trips made by individuals in this group are for work or education purposes. In short then, about a quarter of carless individuals are reliant on public transport in order to reach their work or study place. Finally, the biggest cluster (41% of individuals) shows a profile that is intermediate between the two previous: virtually no trips for work or education, but also no reliance on the car, which accounts for only 11% of the distance travelled. In contrast with both previous groups, this is the cluster with by far the lowest travel distance and speed, as it relies mostly on walking and public transport in order to travel short distances: accordingly, I have labelled it *Slow and Local* (SL).

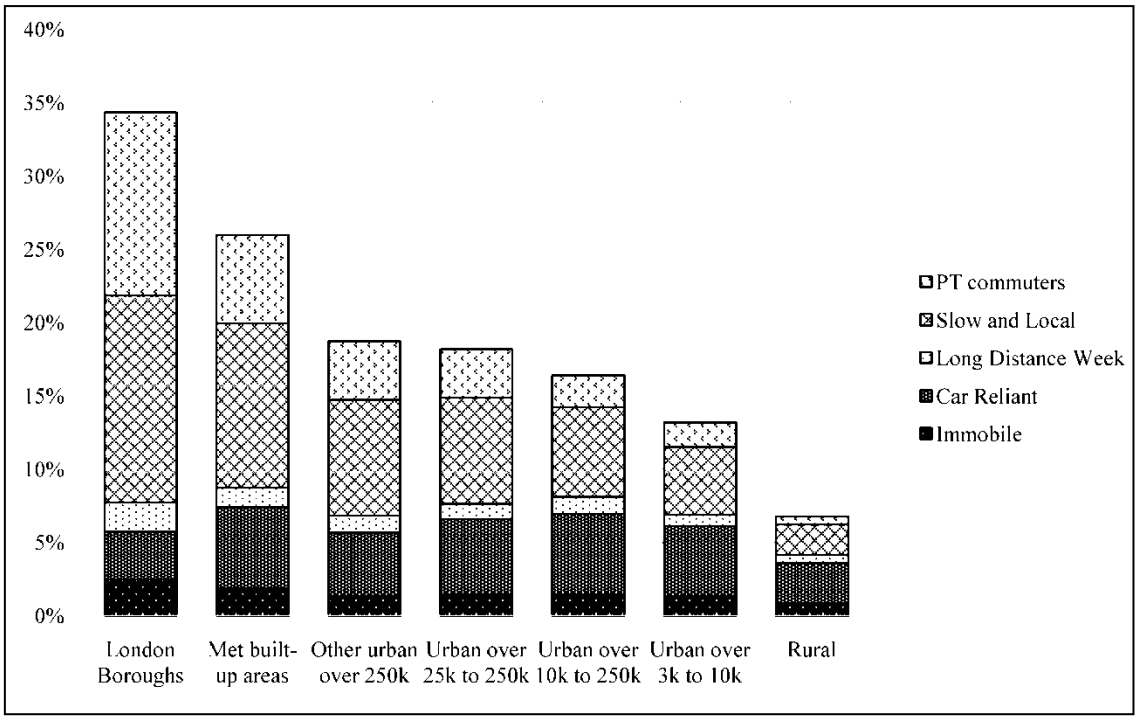


**Fig. 5 - Size and composition of the group of carless adults across different types of area, by travel behaviour type. Data source: NTS 2002-2010.**

Fig.5 depicts how the size of the groups varies across types of area: it can be observed that, while the CR and IM clusters (depicted with black background patterns) do not account for a much larger share of the total population in London than they do in rural areas, the size is much more variable for the SL and the PTC groups (white background patterns). As a result, while in rural areas approximately half of carless adults are either *immobile* or *car reliant*, but only 8% *commuters*, in London the latter group accounts for 36%, as compared to 10% for the CR cluster. Accordingly, most of the increase in the share of carless households that can be observed between the different areas is attributable to variations in clusters characterised by an intensive use of public transport. To sum up then, evidence from travel-diary data shows that in more urban areas the carless group is more diverse in terms of travel behaviour, with the large majority of individuals able to travel autonomously. This stands in stark contrast with

peripheral and rural areas, where more often than not the lack of a car corresponds either to immobility or dependence on others for lifts.

This is not the only point where clusters differ: descriptive statistics (not reported here in detail for the sake of brevity) show that the over 60s constitute the large majority (over 60%) of both the CR and the IM group. By contrast, the elderly account for just less than half of SL, and less than 4% of PTC. Other socio-demographic characteristics also show a stark contrast between CR and IM on the one hand – mostly composed of retired people and even more concentrated among the poor than the carless group average – and PTC on the other, where other household types (including families with children), middle-upper classes, but also non-whites are more represented. The SL group has a socio-demographic profile that is somewhat intermediate between the two, except that is even more concentrated among the poor (48% in the lowest income quintile). The same dividing line is also observed in other respects: so for example while individuals in the PTC cluster have a larger mobility capital in every respect (ownership of transport means, public transport tickets and driving licences, access to public transport networks, ability to move around without difficulty), about 50% of CR and IM individuals report mobility difficulties of some kind. In addition, both SL and PTC households enjoy better accessibility to basic services and opportunities in the local area – although this is to some extent due to the fact that they are more concentrated in urban and dense areas than the CL and IM groups. Finally, Tab.5 shows that SL and PTC individuals are much more mobile – at least in terms of number of trips and time spent travelling: PTC individuals even spend approximately eight and a half hours per week travelling – one hour more than the average for the total population.

To sum up then, there appear to be two main contrasting models of non-car ownership. The first (clusters CR and IM) is associated mainly with old age, illness and retirement: the carless of this kind have low levels of mobility capital and tend to make fewer trips; accordingly they either rely on others for car lifts, or they have extremely low levels of mobility (not detectable with a one-week travel diary). This macro-group is best conceived as the hardcore of the carless and represents approximately the same share of the total population across types of area. It is an interesting case in that it shows how non-drivers (more than 60% do not have a driving licence) can also be very dependent on the automobile for their daily activities: the crucial point here is that the sum of these two factors makes them dependent on others for travel. Accordingly, in terms of transport disadvantage, individuals in this group might well be at risk of social exclusion, given their apparent lack of autonomous mobility. The second type of non-car ownership (clusters PTC and SL) is relatively younger and more diverse in terms of socio-demographics, and it is mainly characterised by the ability to undertake autonomous travel, be it on foot in the local area or by public transport for longer distances. It also includes a minority of adults who are able to participate in employment or education, despite the lack of a vehicle. Accordingly, figures for travel time and number of trips are here higher than the carless average. The size of these clusters is extremely variable depending on the spatial characteristics of the local area, as they are disproportionately concentrated in large cities and metropolitan areas. From the perspective of transport and social exclusion, although they might seem better off than other carless clusters, it would be unwise to conclude that they are not at any kind of disadvantage: the vast amount of time that individuals in the PTC group spend travelling and the fact that they do not seem to travel much for reasons other than work or education, for example, both suggest that the lack of a household car for these individuals might lead to them missing out on activities that are essential for participation in society, and thus to social exclusion – although further research is probably required to explore this point.

## 5. Discussion

The relationship between travel and the built environment is one of the most thoroughly researched topics in urban planning, where a wealth of studies have tried to assess the potential of densification strategies in contributing to more sustainable transport. Even though scholars disagree on the details of this relationship and on policy prescriptions, there is no doubt that levels of car ownership and use are regularly higher in low-density suburban and rural areas (Ewing & Cervero, 2010). Scholars of transport and social exclusion, for their part, often argue that in these areas car ownership is essential for social inclusion (Gray, Farrington, Shaw, Martin, & Roberts, 2001). The argument that in these areas the car is perceived as a necessity is supported by empirical studies relying on a diversity of methods, ranging from econometrics (Dargay, 2002) to focus groups (Smith, Hirsch, & Davis, 2012).

The empirical work presented in this article adds new evidence in support of this conclusion, by showing that the carless group in rural areas consists in large part of households with a marginal social profile, who are often dependent on other motorised households for travel. By contrast, as one moves towards denser urban areas, the composition of the carless group becomes progressively less one-sided, both in terms of socio-demographics and travel behaviour. In large metropolitan areas, a large majority of carless households is capable of autonomous travel with transport means other than the car, and a sizeable minority is even able to participate in work and employment. In a nutshell then, while in peripheral areas the lack of a car corresponds mostly to a lack of autonomous travel and non-participation in employment or education, this is less and less true as one moves towards large cities: therefore, I put forward the argument that *the composition of the group of households without cars is a good indicator for the level of car dependence in a local area*.

The fact that in many contexts the car appears to be an essential prerequisite for social inclusion is considerably challenging for environmental policy and planning. In fact, when this is true, policy measures to discourage car use and ownership are criticised for being inequitable, as they run the risk of pushing people into social exclusion (Cucca & Tacchi, 2012; Lucas, Grosvenor, & Simpson, 2001): this is particularly true for green taxes and charges, which are often the object of controversy, not only in the field of transport (Ekins & Dresner, 2004). While 'pull' measures such as public transport improvements and densification strategies do not threaten social equity (at least in principle), they are unlikely to be sufficient alone – one of the reasons why it is generally believed that there is a need for integrated sets of policies, including 'push' measures such as pricing, if environmentally sustainable transport is to be achieved (Banister, 2005). This dilemma may lead to a 'transport policy stalemate' for policy makers interested in both social equity and environmental sustainability, whereby no serious attempt will be made to reduce car use and all hopes will be concentrated on a 'technological fix' to eventually solve all problems, without having to raise any social equity issue (Mattioli, in press). Recently, in the UK, even government reports have acknowledged the existence of this tension: the Sustainable Development Commission, for example, has published a report titled 'Fairness in a car dependent society' (2011) that puts forward a 'sustainable transport hierarchy' meant to reconcile social and environmental goals.

While the challenge posed by this tension is crucial for sustainable transport policy at large, it is arguably more serious in peripheral and rural areas. Overall, what we have here is a lose-lose situation with respect to sustainable transport and transport-related social exclusion: on one hand, the environmental impact of travel is at its maximum, as illustrated by the fact that even carless households members here have more polluting travel behaviour (Fig.4). On the other hand, social exclusion concerns are also serious: not only is the travel disadvantage suffered by

the carless here worse, but there is arguably also a considerable amount of people who are 'forced' into car ownership and use, even though their life conditions (in terms for example of income or age) make this problematic (Motte-Baumvol, Massot, & Byrd, 2010). Moreover, in prospective terms, the findings of the present study could be taken to confirm that reducing motorisation in these areas is extremely difficult: since the lack of a car often means the impossibility of autonomous travel, households are likely to be reluctant to give up their vehicles, and every attempt to restrain car use is likely to be met with opposition on the grounds of inequity. In a nutshell, in these areas environmental and social goals are traded-off against each other, making it difficult for policy-makers to intervene. Accordingly, the scope for increasing the percentage of households without cars is here very limited.

By contrast, compact cities with good public transport networks arguably provide more scope for win-win policies that reconcile environmental and social goals in transport. As a matter of fact, not only are there more carless households here, but their travel behaviour is also less environmentally detrimental (Fig.4). Besides, the fact that a sizeable minority of households is able to manage employment or education without a car could be taken to mean that the lack of a vehicle does not necessarily preclude autonomous travel or participation in mainstream society. To put it simply, the bar of non-car ownership is set lower here, and living without a vehicle is an option for a wider range of households: this also includes people who in other areas struggle with 'forced' car ownership (for age, financial or other reasons), yet here are more free to give up their car – even if this might well entail other problems such as long travel times. From a policy perspective, there is a lesser trade-off between environmental protection and social equity; therefore measures aimed at reducing car ownership are likely to encounter less resistance. Accordingly, in prospective terms, it can be posited that an increase in the share of household without cars is a possibility for compact cities where comprehensive packages of sustainable transport policies are pursued.

To sum up then, the percentage of carless households is likely to decrease (or remain stable) in peripheral and rural areas, but to increase in large cities. This diverging trend is already apparent in the NTS 2002-2010 data: indeed, a slight decline trend over the period is detectable only in rural areas and small urban municipalities (under 25,000 inhabitants), while there are no significant differences between individual years in other types of area; in London, for example, car ownership has remained relatively stable over the last 15 years (Whelan, Crockett, & Vitouladiti, 2010), while it has increased at a national level.

While the results of this study could be taken to mean that 'space matters', this should not be overstated. In fact, the results of hierarchical regression clearly show that the predictive power of socio-demographic characteristics is much greater than that of the spatial location of households. To put it simply, this means that, at the household level, *who you are* is significantly more important than *where you live* when it comes to the likelihood of being carless. Indeed, in-depth analysis shows that for some types of household (such as working couples with children) living without a car is virtually not an option, regardless of the built environment. If this is true, it follows that there are serious limits to what spatial planning measures (such as carfree developments) can achieve, if the goal is to increase the number of households living without cars.

Broadly speaking, the findings illustrated in the previous sections show that two principal types of impeding condition exist when it comes to living without cars: *spatial* conditions and *socio-demographic* conditions. Interestingly this conclusion, which is the outcome of a quantitative secondary analysis, is in accordance with the results of recent studies with a very different methodological approach: indeed, researchers working on the definition of a minimum income

standard for the UK have shown that there are only two types of households who in focus groups agree that the car is part of a minimum acceptable living standard: rural households (Smith et al., 2012) and families with children (Davis, Hirsch, Smith, Beckhelling, & Padley, 2012).

Despite empirical evidence showing that both spatial and socio-demographic conditions can be virtually insurmountable obstacles to living without a car, the first aspect has attracted considerably more attention. This is probably due to the fact that the theoretical tools needed to grasp why different type of households have varying propensity to non-car ownership are still insufficiently developed. Indeed, as argued by Shove(2010), much research on environmentally relevant behaviour and social change has been driven by the 'ABC' paradigm whereby "social change is thought to depend upon values and attitudes (the A), which are believed to drive the kinds of behaviour (the B) that individuals choose (the C) to adopt" (p.1274). Unsatisfied with this approach, as an alternative Shove proposes drawing on theories of social practice. While the concept of 'social practice' has a long history and a variety of approaches exist (Reckwitz, 2002), an essential common feature is that they all turn the assumptions of behaviourist approaches on their head: while in the latter the individual is the main object of study, in the former practices are the primary unit of analysis, while "individuals feature as carriers or hosts of a practice" (Shove, Pantzar, & Watson, 2012, p. 7). Applying this approach to the subject of this paper, one could argue that the reason that socio-demographic characteristics are so relevant for non-car ownership is that they correspond to different patterns of activities; in other words, it is not so much *who you are* that matters, but rather *what you do* – e.g. the practices that you are committed to.

Indeed, many scholars have suggested that a concept such as "car dependent trips" might exist, defined by Stradling as "the type of trips that is seems it would be the most difficult to transfer away from the car"(2003, p. 102). Similarly, Gorham puts forward the concept of "circumstantial car dependence", meaning a situation where "the nature of the activities in which a household regularly engages renders it dependent on the car" (2002, p. 110). In this approach, car dependence is defined as an attribute of certain practices (and the related trips) rather than of individuals or society. In this context it is often pointed out that, regardless of attitudes and residential location, activities such as shopping trips and getting around with children are considerably car dependent. Accordingly, the fact that working couples with children are more often engaged in these activities than other types of household might explain why they are very reluctant to live without cars.

This observation invites us to further explore how some practices have become so dependent on the automobile, and if and how this can be changed. In this context, it might be helpful to draw on the simple framework recently put forward by Shove et al. (2012) for the study of practices, whereby they consist of three kinds of elements – materials, competences and meanings – that are integrated when practices are performed. From this perspective, a hypothetical 'social practices' approach to car dependence would imply the study of practices where the car has become an essential element, on the material side of the integration. Relevant questions in this context might be, for example: how has shopping come to depend so much on the availability of a vehicle? How have the materials, competences and meanings once involved in the daily shop changed in this transition? Is it possible to encourage a new transition, in order to break the links between the car and the other elements of shopping as an integrated practice? While the concept of environmental policy informed by social practice research is still very much in its infancy (Shove et al., 2012), this is an intriguing direction, and one which could help make carless living a more realistic option for a wider range of

households. For the time being however, it seems that current trends are going in the opposite direction: indeed, the piece of research by Davis et al. (2012) cited above shows that British families with children in 2012 consider the car part of a minimum living standard, while they did not do so in 2008. This might be the sign of an evolution of practices towards increasing car dependence, which would, in turn, be very bad news for environmentally sustainable transport and for transport inclusion, as it would make it all the more difficult to reconcile these two policy goals.

**References**:


Banister, D. (2005). *Unsustainable transport. City transport in the new century.* Abingdon: Routledge.

Cohen, J., Cohen, P., West, S. G., & Aiken, L. S. (2003). *Applied multiple regression / correlation analysis for the behavioural sciences. Third edition.* Mahwah, NJ: Lawrence Erlbaum.

Cucca, R., & Tacchi, E. M. (2012). Tradeoffs and entanglements among sustainability dimensions: the case of accessibility as a missing pillar of sustainable mobility policies in Italy. *Sustainability: Science, Practice, & Policy, 8* (1), 70-81. http://sspp.proquest.com

Dargay, J. (2002). Determinants of car ownership in rural and urban areas: a pseudo-panel analysis. *Transportation Research E, 38*, 351-366. doi:10.1016/S1366-5545(01)00019-9

Dargay, J., Gately, D., & Sommer, M. (2007). Vehicle ownership and income growh, worldwide: 1960-2030. *Energy Journal, 28* (4), 163-190. doi:10.5547/ISSN0195-6574-EJ-Vol28-No4-7

Davis, A., Hirsch, D., Smith, N., Beckhelling, J., & Padley, M. (2012). *A minimum income standard for the UK in 2012. Keeping up in hard times.* Retrieved from Joseph Rowentree Foundation website: http://www.jrf.org.uk/sites/files/jrf/minimum-income-standards-2012-full.pdf

Department for Transport. (2011). *Statistical Release - National Travel Survey 2010.* Retrieved from: http://assets.dft.gov.uk/statistics/releases/national-travel-survey-2010/nts2010-01.pdf

Department for Transport. (2012) National Travel Survey, 2002-2010 [computer file]. 7th Edition. Colchester, Essex: UK Data Archive [distributor]. SN: 5340. doi:10.5255/UKDA-SN-5340-3

Dupuy, G. (1999). From the "magic circle" to "automobile dependence" : measurements and political implications. *Transport Policy, 6*, 1-17. doi:10.1016/S0967-070X(98)00028-6

Ekins, P., & Dresner, S. (2004). *Green taxes and charges. Reducing their impact on low-income households.* Retrieved from Joseph Rowentree Foundation website: http://www.jrf.org.uk/sites/files/jrf/1859352472.pdf

European Commission. (2011). *White paper: Roadmap to a single transport area - Towards a competitive and resource efficient transport system.* Retrieved from: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2011:0144:FIN:EN:PDF

Ewing, R., & Cervero, R. (2010). Travel and the built environment. A meta-analysis. *Journal of the American Planning Association, 76*, 265-294. doi:10.1080/01944361003766766

Freese, J., & Long, J. S. (2001). *Regression models for categorical dependent variables using Stata.*College Station, TX: Stata Press.

Gorham, R. (2002). Car dependence as a social problem. A critical essay on the existing literature and future needs. In W. R. Black& P. Nijkamp (Eds.), *Social change and sustainable transport* (pp. 107-115). Bloomington: Indiana University Press.

Gray, D., Farrington, J., Shaw, J., Martin, S., & Roberts, D. (2001). Car dependence in rural Scotland: transport policy, devolution and the impact of the fuel duty escalator. *Journal of Rural Studies, 17*, 113-125. doi:10.1016/S0743-0167(00)00035-8

Karlaftis, M., & Golias, J. (2002). Automobile ownership, households without automobiles, and urban traffic parameters: are they related? *Transportation Research Record: Journal of the Transportation Research Board, 1792*, 29-35. doi:10.3141/1792-04

Kwon, T.-H., & Preston, J. (2005). Driving forces behind the growth of per-capita driving distance in the UK, 1970-2000. *Transport Reviews, 25*, 467-490. doi:10.1080/0144164052000336489

Lucas, K. (2004). Towards a 'social welfare' approach to transport. In K. Lucas (Ed.), *Running on empty. Transport, social exclusion and environmental justice* (pp. 291-298). Bristol: The Policy Press.

Lucas, K. (2012). Transport and social exclusion: Where are we now? *Transport Policy, 20*, 105-113. doi:10.1016/j.tranpol.2012.01.013

Lucas, K., Grosvenor, T., & Simpson, R. (2001). *Transport, the environment and social exclusion.* Retrieved from Joseph Rowntree Foundation website: http://www.jrf.org.uk/sites/files/jrf/1859352936.pdf

Mattioli, G. (in press). Car dependence, sustainability and the transport policy stalemate: the potential trade-offs between intra- and intergenerational equity. *The International Journal of Sustainability Policy and Practice*.

McFadden, D. (1979). Quantitative methods for analysing travel behaviour of individuals: some recent developments. In D. A. Hensher & P. R. Stopher (Eds.), *Behavioural travel modelling* (pp. 279-318). London: Croom Helm.

Melia, S. (2010). Potential for carfree development in the UK. Paper presented at the 42nd Universities Transport Study Group Conference, Plymouth.

Melia, S., Parkhurst, G., & Barton, H. (2010). Carfree, low-car – what's the difference? *World Transport Policy & Practice, 16* (2), 24-38. http://www.eco-logica.co.uk/worldtransport.html

Motte-Baumvol, B., Massot, M.-H., & Byrd, A. M. (2010). Escaping car dependence in the outer suburbs of Paris. *Urban studies, 47*, 604-619. doi:10.1177/0042098009349773

Ornetzeder, M., Hertwich, E. G., Hubacek, K., Korytarova, K., & Haas, W. (2008). The environmental effect of car-free housing: a case in Vienna. *Ecological Economics, 65,* 516-530. doi:10.1016/j.ecolecon.2007.07.022

Preisendörfer, P., & Rinn, M. (2003). *Haushalte ohne Auto. Eine empirische Untersuchung zum Sozialprofil, zur Lebenslage und zur Mobilität autofreier Haushalte.* Opladen: Leske + Budrik.

Reckwitz, A. (2002). Toward a theory of social practices: a development in culturalist theorizing. *European Journal of Social Theory, 5*, 243-263. doi: 10.1177/13684310222225432

Rofique, J., Humphrey, A., Pickering, K., & Tipping, S. (2011). *National Travel Survey 2010 - Technical Report.* Retrieved from Department for Transport website: http://assets.dft.gov.uk/statistics/series/national-travel-survey/nts2010-technical.pdf

Schäfer, A., Heywood, J. B., Jacoby, H. D., & Waitz, I. A. (2009). *Transportation in a climate-constrained world.* Cambridge, Massachusetts: The MIT Press.

Scheiner, J., & Holz-Rau, C. (2012). Gendered travel mode choice: a focus on car-deficient households. *Journal of Transport Geography, 24*, 250-261. doi:10.1016/j.jtrangeo.2012.02.011

Shove, E. (2010). Beyond the ABC: climate change policy and theories of social change. *Environment and Planning A, 42*, 1273-1285. doi:10.1068/a42282

Shove, E., Pantzar, M., & Watson, M. (2012). *The dynamics of social practice. Everyday life and how it changes.* London: Sage.

Smith, N., Hirsch, D., & Davis, A. (2012). Accessibility and capability: the minimum transport needs and costs of rural household. *Journal of Transport Geography, 21*, 93-101. doi:10.1016/j.jtrangeo.2012.01.004

Sperling, D., & Gordon, D. (2009). *Two billion cars. Driving towards sustainability.* New York: Oxford University Press.

Stradling, S. G. (2003). Reducing car dependence. In J. Hine& J. Preston (Eds.), *Integrated futures and transport choices. UK transport policy beyond the 1998 White Paper and Transport Acts.* Aldershot: Ashgate.

Sustainable Development Commission. (2011). *Fairness in a car dependent society.* Retrieved from: http://www.sd-commission.org.uk/data/files/publications/fairness_car_dependant.pdf

Van Acker, V., & Witlox, F. (2010). Car ownership as a mediating variable in car travel behaviour research using a structural equation modelling approach to identify its dual relationship. *Journal of Transport Geography, 18*, 65-74. doi:10.1016/j.jtrangeo.2009.05.006

Whelan, G., Crockett, J., & Vitouladiti, S. (2010). A new model of car ownership in London: geo-spatial analysis of policy interventions. Paper presented at the European Transport Conference 2010, Glasgow.