UNIVERSITA' DEGLI STUDI DI MILANO – BICOCCA

Scuola di Dottorato in Scienze Sociali (SCISS)

Where sustainable transport and social exclusion meet
Households without cars and car dependence in Germany and Great Britain

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A dissertation for the European Doctoral Programme in Urban and Local European Studies (URBEUR)

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May 2013

Acknowledgements

Someone said that writing a PhD thesis is a lonely process. It is, and I sometimes felt like it was especially so for me. Therefore, I bear the sole responsibility for the mistakes, the inconsistencies, the confusion and the few good ideas that are found in the next 400 something pages. However, a few good people have helped along the way, and I much obliged to them.

Ever since we first met in 2008, Matteo Colleoni has encouraged me to devote myself to research. With his pioneering work about mobility and accessibility in Italy, he created a space for transport studies at the Department of Sociology and Social Research at the University of Milan-Bicocca. Without him paving the way, none of this would have been possible. During the last three years, Matteo has provided me with feedback about my work, and has accepted me for the 'non-typical' PhD student that I allegedly am (he said that!). Notably, he supported me when I struggled with PhD 'depression', taking the time to talk to me via Skype or international phone calls. *Grazie*.

Prof. Serena Vicari, in her capacity of head and coordinator of the URBEUR doctoral programme, has been an important point of reference for me in the last three years. Notably, she was of great help when I had to organize my visiting period in Berlin. *Grazie*. Anna Casaglia, in her capacity as 'tutora' has helped and encouraged me and my colleagues during the first phases of our research projects. Much obliged.

Prof. Christine Ahrend and Dr. Oliver Schwedes at the Fachgebiet Integrierte Verkehrsplannung at the Technische Universität Berlin have hosted me as a visiting PhD student at their chair from June 2011 to February 2012. For a few months, I was able to use one of their offices at Salzufer 17-19: much of this thesis has been written there. I am very grateful for these opportunities. In five occasions between June 2011 and May 2013 I have had the chance to present my work to Prof. Ahrend, Dr. Schwedes and other PhD candidates (including Uwe Böhme, Stefan Daubitz, Jörg Leben, Melanie Herget and Holger Jansen) in the context of a two-hour *Doktorandenseminar*. Their criticism was *hart aber gerecht* and – what matters the most – always very useful. Notably, Dr. Oliver Schwedes has taken the trouble to read early versions of my research project, and to comment on them. To all of them a big *Danke*.

I am very grateful to Elizabeth Shove for inviting me to be a visiting PhD student at Lancaster University. The three months that I spent there (February-May 2012) were probably the most fruitful time of my PhD. The by-weekly meetings that I had with Elizabeth were extremely useful, and led me to develop a lot of ideas. Some of them ended up in this thesis. I am also obliged to Prof. Colin Pooley at Lancaster University for taking the time to discuss my work with me and inviting me to present my work at the CeMoRe Annual Research Day 2012.

I am of course indebted to the institutions that have granted me use of the data sets. The MiD 2008 and MiD 2002 data sets of the German Federal Ministry of Transport, Building and Urban Development were kindly provided by the Clearing House of Transport Data at the DLR Institute of Transport Research in Berlin. Additional geographical variables were kindly provided by the German Federal Ministry of Transport, Building and Urban Development. The NTS 2002-2010, NTS 2002-2008 and NTS 1995-2001 data sets of the British Department for Transport were kindly provided by the Economic and Social Data Service (ESDS) through the UK Data Archive at the University of Essex, Colchester.

Dr. Karen Lucas and Dr. Gordon Stokes of the University of Oxford took two hours of their time to meet me in Oxford and answer my questions about transport and social exclusion. I was impressed by their kindness, and their advice has been very helpful. Thank you so much.

Gianluca Argentin has provided me with informal advice about quantitative data analysis techniques, and he did it out of sheer generosity. My dear friend Giovanni Abbiati also took interest in my data analysis problems, helping me when he could. *Grazie*.

I am also obliged to Prof. Allan McCutcheon, who taught me latent class analysis at the 44th Essex Summer School in Social Science Data Analysis, for taking the time to give me early advice on my latent class models.

This thesis greatly benefited from the criticism of three anonymous reviewers of an article on the same topic submitted to the Journal of Environmental Policy & Planning in 2012, as well as from the observations of the anonymous reviewer of a book chapter for the soon to appear book "*Mobilitäten und Immobilitäten*", published by the Technische Universität Dortmund.

For a few months I shared a co-working space with the guys at *120 läuft* in Berlin (Tim Werremeyer, Simon Schnepp, Morgane Renou, Sebastian Kretz, David Schelp, Simon Hufeisen, Jan Schaefer and Mounia Meiborg). I am very grateful to them for this opportunity that saved me from the work-from-home blues. I am much obliged to my dear friend Sebastian Kretz for making this possible.

My father Mauro Mattioli is one of the few people on this earth who read this thesis in its entirety.. and certainly the only one who did for the fun of it (although I suspect that parental pride might have played a role). I hope it helped him to kill time. It certainly made me feel less lonely.

Last but not least: Romy Fischer is probably the single most important reason why I chose to go down this path in 2009. Three and half years later, I am not sure whether I made the right choice, but I would probably do it again.

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PART II – COUNTRIES

PART III – EMPIRICAL STUDY

Introduction

This thesis focuses on households without cars in Germany and Great Britain – but not only. Admittedly, the conceptual structure of this thesis is quite complex: in this section, I briefly illustrate the interrelationships between its various elements. Fig. Intro.1 depicts this structure graphically.

Typically, research develops in response to and in conjunction with some kind of problem. By problem, I mean a process with problematic consequences for human life. The problem that constitutes the background for this thesis is the dramatic growth in travel demand that has taken place in developed countries in the last decades, and is gathering speed at the global level. This goes in hand in hand with a dramatic increase in motorisation and car use. This phenomenon is the object of Chapter 1.

Increasing mobility and motorisation has raised two kinds of concerns, corresponding to two research fields. Concerns for the environmental consequences of transport are behind the concept of environmentally sustainable transport. Transport contributes to both climate change emissions and oil depletion, arguably two of the most important environmental challenges of the 21st century. However, as mobility grows, society (and urban structure) adapts itself: the result is that being able to cover great distances at sufficient speed has become paramount. In other words, mobility and accessibility have become key factors for social inclusion, resulting in new forms of social inequality and/or reinforcing existing ones.

In the theoretical part of this thesis (Part I), these two fields of research are reviewed. Chapter 1 discusses the environmental consequences of increasing motorisation, as well as policies for environmentally sustainable transport. Also, different approaches to the study of increasing motorisation (car ownership modelling, the 'travel and the built environment' debate and the concept of car dependence) are reviewed. Chapter 2 introduces the field of transport and social exclusion research, and reviews policies to tackle transport disadvantage.

Interestingly, these two fields of research have remained quite separate until very recently. Arguably, this is a problem, for at least three reasons: firstly both concerns arise from a common problem, i.e. the increasing demand for (car) travel; secondly, the leading policy concept of 'sustainable transport' includes both environmental and social goals (as well as economic ones); finally, literature in both fields provides numerous examples of instances where there is a trade-off or a *latent tension* between environmental and social goals (as discussed in Chapter 2). This in turn is arguably a strong barrier to the implementation of sustainable transport policies.

At the theoretical level, the goal of this thesis is to put forward an integrated framework to conceptualise the social and environmental consequences of increasing motorisation, and their interrelationships. To do this, I use the concept of car dependence. Since it has mostly been used in studies concerned with the environmental consequences of increasing motorisation, the notion is introduced in Chapter 1. In Chapter 2, I put forward a typology of forms of *car-related* transport disadvantage, and illustrate how they arise from the process of increasing car dependence. In Chapter 3, I put forward an original working definition of car dependence, aimed at reconciling the two concerns and highlighting the role that the different forms of car-related transport disadvantage play in the self-reinforcing cycle of increasing motorisation.

All throughout the theoretical chapters, the emphasis is on the *spatial dimension* of car dependence: urban structure and the built environment adapt to increasing motorisation, and this results in further motorisation, thus creating a self-reinforcing cycle with both environmental and social consequences.

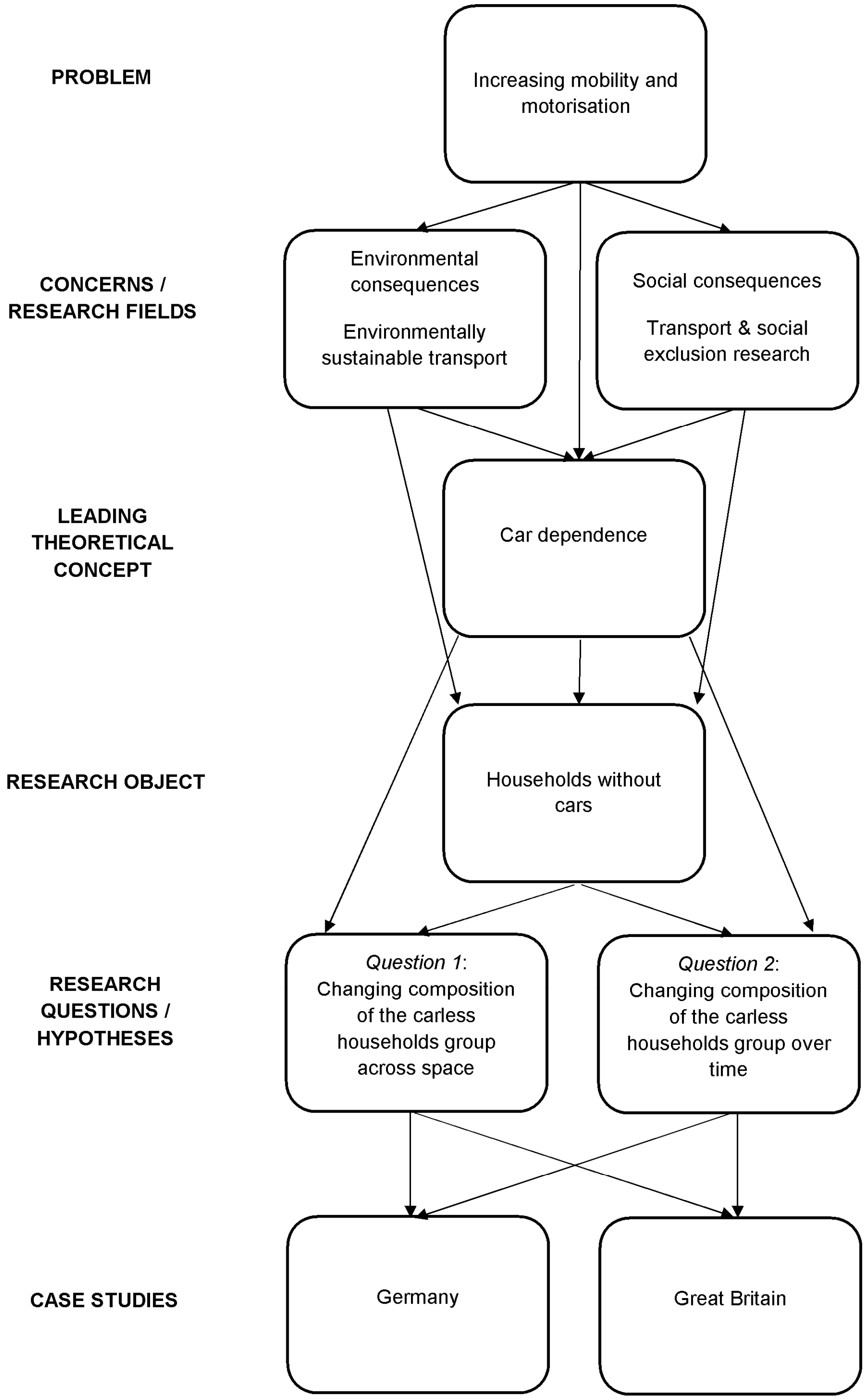

Fig. Intro.1 – Conceptual structure of the thesis. Source: own elaboration.

The research object of this thesis is households without cars. There are two main reasons for this. Firstly, it is located at the intersection of the two research fields. From an environmental perspective, carless households have been studied as examples of environmentally sustainable behaviour. Notably, existing research has sought to identify households who *choose* to live without cars, exploring their motivations and trying to understand how to encourage *carfree* living. By contrast, in transport and social exclusion research, lack of car access has been considered as the most important form of transport disadvantage in developed societies. Accordingly, studies have focused on the exclusionary consequences of living without cars. Overall, studies on environmentally 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 thesis that there is a need to focus on the *composition* of the carless group as a whole, and on how it varies over time and space. The empirical work illustrated in Part III of this thesis is organized around two research questions, and both deal with the composition of the carless households group. Notably, the research questions are derived from the 'car dependence' theoretical framework, as illustrated in Chapter 3. In a nutshell, the idea behind both research questions is that there is a relationship between the degree of car dependence of a given (local) society and the composition of the carless households group. This reflects the conviction that, as Lucas and Le Vine argue, "one of the most effective and immediate ways in which to identify the benefits of transport in general and car ownership in particular, is to look (at) what happens when people in predominantly car-based societies do not have regular access to a private motor vehicle" (2009, pp. 8-9).

The two research questions adopt different approaches to explore the relationship between car dependence and the composition of the carless households group. Question 1 adopts a *synchronic* perspective, by comparing types of area with different levels of car dependence at the same moment in time. Differences in the composition of the carless group across different types of area are explored, with reference to the following four areas: socio-demographics, reasons for not owning cars, travel behaviour and accessibility to services and opportunities. Based on the results of previous research, the different types of area are assumed to correspond to different degrees of car dependence. Question 2 adopts a *diachronic* perspective by comparing the composition of the carless households group at different moments in time. The assumption is that, given the continuing process of increasing motorisation, car dependence is higher at a later moment in time. In this case, only the socio-demographic composition of the carless household group has been explored.

In a nutshell, both questions explore the same basic question (the relationship between car dependence and the composition of the carless households group), but 'take different roads to get there'. The empirical results suggest that the approach adopted for Question 1 has been more successful in bringing to light significant relationships between the two constructs. With hindsight, several limitations to the approach adopted for Question 2 are apparent: these are discussed in the conclusions.

In accordance with the tradition of the Doctoral Programme in Urban and Local European Studies at the University of Milan-Bicocca, the empirical work has focused on two case studies: Germany and Great Britain. Information about the countries (with reference to transport and spatial planning policies and previous research on car ownership trends and households without cars) is provided in Part II (chapters 4 and 5). Both research questions have been explored for both case studies, and the empirical results are illustrated in Chapter 6 and Chapter 7. The research strategy adopted is quantitative secondary analysis of national travel surveys (*Mobilität in Deutschland* and *National Travel Survey*). For the *synchronic* analysis, I used data from the 2008 wave of MiD and a pooled sample (2002-2010) for NTS. For the *diachronic* analysis, I compared data from the 2002 and 2008 waves of MiD, and single waves of the continuous NTS survey over the period 2002-2010.

While the empirical work was conducted for two case studies, no research question adopted a *comparative* approach in the strict sense of the word. The reason for this is that travel surveys have not yet been harmonized at the European level. The approach adopted here is rather to explore the same research questions for the two countries. Replication of the empirical research has allowed me to provide stronger evidence in support of my hypotheses (when corroborated) and to explore a wider range of topics than would have been possible with a single case study.

The data analysis techniques employed include, beside descriptive analysis, (multinomial) logistic regression, cluster analysis and latent class analysis. All techniques are described in detail in Appendix A in Part V. Appendix B and C report the details of the data analysis for both case studies, as well as technical details for both national travel surveys.

Part IV consists of a single concluding chapter, including two sections. Firstly, the empirical evidence for the two case studies is brought together and discussed in light of the research questions and hypotheses. Secondly, the empirical results are discussed in light of the theoretical and policy debates outlined in Part I and II.

To sum up, with this thesis I hope to demonstrate two things. First, it is possible to conceptualize the environmental and the social consequences of transport within a single framework, and to conduct empirical studies that take into account both sides. The key link between the two concerns is the *need* to own and drive cars. Second, focusing on those who do not own cars is a powerful way to understand better what makes people so reluctant to give up theirs.

PART I – THEORY

1. Motorisation as a relevant object of study for the Urban and Social Sciences

1.1. Mobility and motorisation

1.1.1. A dramatic growth in travel

Academic disciplines develop in response to and in conjunction with processes that are relevant for human life: for instance, Sociology was born with modernity – and the study of the ongoing process of modernization has always been one of its main tasks; Urban Studies are of course related to the process of urbanization – which in turn can be conceptualised as one component of modernization. Similarly, the transport sciences can be seen as a product of the dramatic increase in travel that has accompanied the social and geographical restructuring of societies in the last two hundred years. Just as there are strong interrelations between the three processes mentioned above, so there is a great potential for exchange and cooperation between the aforementioned disciplines.

In order to set the context for the main topic of this thesis, it is first essential to discuss more in depth the third process, i.e. the dramatic increase in travel over the last two centuries, that has particularly accelerated in the second half of the 20th century. However, when talking about growth in travel it is important to be precise: indeed, while some aspects of travel have undergone rapid change, others have barely changed at all. This intertwining of growth and stability has crucial consequences for the nature and meaning of those trends. In detail, the increase has involved (Knowles, 2006; Metz, 2008; 2010; Schäfer et al., 2009; Scheiner, 2010; Banister, 2011):

- the distance travelled (in terms of aggregate travel distance, per capita travel distance and average trip distance)
- the speed of travel, as a consequence of the increasing modal share of faster modes of travel (such as the automobile)
- the affordability of all transport modes, which has increased "despite significant improvements in speed, comfort, and reliability of transport systems" (Schäfer et al., 2009, p.24-25); moreover, this has happened during a period when per capita income has grown significantly

By contrast, there has been a remarkable stability in other aspects of travel (Metz, 2008; 2010; Schäfer, 2000; Schäfer et al., 2009; Scheiner, 2010):

- per capita trip rates
- the average time spent on daily travel – a fact that has prompted considerable research work and debate over the concept of a constant "travel time budget" (Zahavi & Ryan, 1980; Zahavi, 1982; Marchetti, 1994; Schäfer, 2000; Mokhtarian & Chen, 2004)
- the average percentage of income dedicated to travel

Figures from national travel surveys illustrate these trends clearly (DfT, 2010b; Banister, 2011, p. 956): for instance in Great Britain, in 1972/73, the average distance travelled per year was 4.476 miles, a figure which has increased to 6.775 in 2009. In the meantime, however the time taken to cover this distance has remained quite stable at around one hour per day (353 hours per year in 1973/73, 372 in 2009). Similarly, while the average trip length has almost doubled in the last forty years (4,7 miles in 1972/73, 7 in 2009), the average trip time is virtually identical at around 22-23 minutes. This corresponds to an increase in speed of 44%[1] (DfT, 2010b; Banister, 2011, p. 956).

In sum then, we seem to travel *on average* further and at greater speed than our parents and grandparents did when they were our age. However, we do not seem to carry out much more trips, nor to spend more time travelling than they did. Similarly, we tend to spend (on average) a similar share of our income on travel – even though this corresponds to a greater sum in absolute terms, because income per capita has increased significantly[2].

As argued by Knowles (2006), the direct cause of these changes is a succession of transport innovations over the last two centuries that have brought about mechanised and motorised transport. New surface transport modes have appeared (train, car, etc.) which make it possible to travel at greater levels of speed and reliability, while at the same time the units costs of transport have reduced as a result of technological improvements and availability of cheaper energy sources. As a consequence, Knowles argues, "the *frictional impact of distance has generally declined* over time with cheaper and faster transport, and created (..) time/space and cost/space convergence" (p. 407, emphasis added). As people have on average continued to invest the same amount of time (and an increasing amount of money) in cheaper and faster travel, the outcome is an increase in distance travelled – and a dramatic expansion of their activity spaces (Scheiner, 2010).

One of the main factors responsible for the processes described above is thus the diffusion of the motor car, i.e. the process of motorisation.

1.1.2. The role of motorisation

The most striking feature of motorisation is the impressive scale and speed of its development. As Dupuy wrote in 1995: "at the turn of the last century there were practically no cars: by the next century there will be half a billion cars driving around the planet" (1995a, p. 24). Actually, the number of light-duty vehicles worldwide in the year 2000 was 611 million (Schäfer et al., 2009, p.3), and "if nothing changes" it is expected to reach 1 or 2 billion within a couple of decades, depending on the estimates (Dennis & Urry, 2009; Schäfer et al., 2009, p. 4; Sperling & Gordon, 2009; Dargay et al., 2007).

Fig. 1.1 depicts the historical growth of the world light-duty vehicle fleet (including automobiles as well as other light-duty vehicles such as vans and SUVs) since the beginning of the 20th century. It shows clearly three phases: up to the 1950s, motorisation is essentially an American phenomenon (Jones, 2008); from that moment on, other industrialised countries start to catch up, soon joined by other, "developing" countries. The aggregate outcome of these trends at the global level is an exponential growth in the world light-duty fleet. Projections of these trends into the future show that most of this growth is likely to take place in the developing world, notably in fast-growing countries such as China and India where motorisation rates are still low, but increasing rapidly (Dargay et al., 2007; Wright & Fulton, 2005): in that sense, on a global level, "the largest wave of motorisation is yet to come" (Schäfer et al., 2009, p.3). The astronomic potential for car growth in developing countries is increasingly seen as problematic since, "if people in these areas (..) demand 'western' levels of private car ownership, this will place enormous strain upon domestic transport infrastructures, road safety, global world fuel resources and the future climate" (Dennis & Urry, 2009, p. 44). In developed countries, car ownership has grown less rapidly in the last years, as it is closer to saturation levels (§1.3.3).

[1] Similar trends for the last forty years are described for Germany by Scheiner (2010) and for Sweden by Frändberg and Vhilelmson (2011).

[2] It has to be kept in mind that the stability of travel time, trip rates and expenditure over time does not preclude the possibility of great variation in individual travel behaviour, as a function of factors such as socio-demographics and geographical location. As argued by Metz (2010), "travel using the transport system of modern societies is evidently a complex system where a wide range of individual behaviours aggregate. Average travel time and trip rate can be regarded as *emergent parameters* which hold constant over long durations and *which are properties of the whole system*" (p.664, emphasis added).

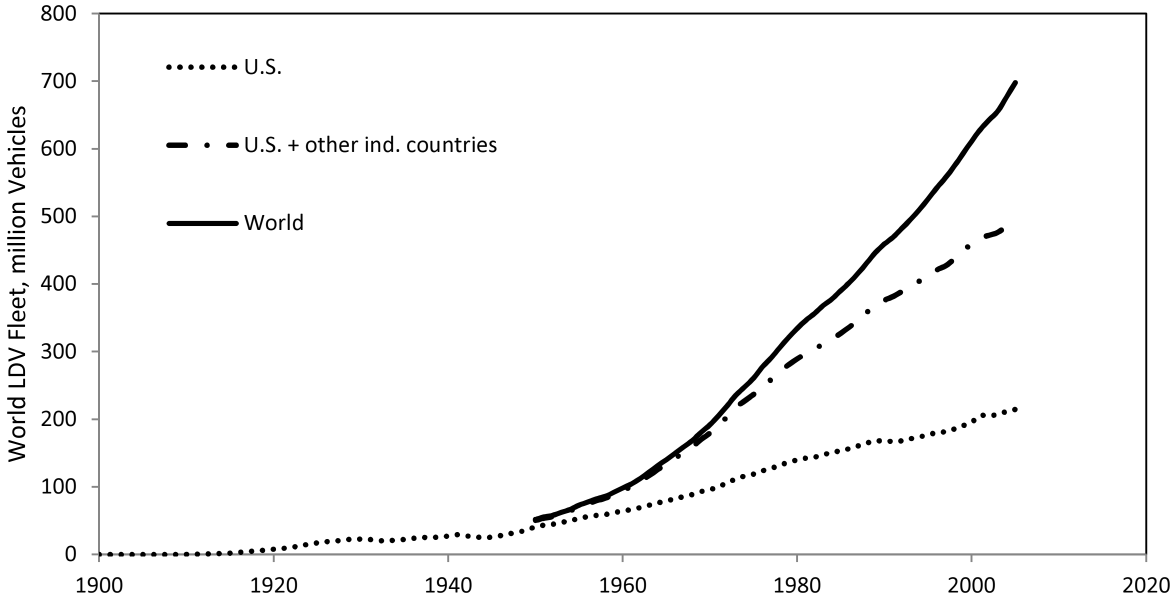

Fig. 1.1 – Historical growth of the world light-duty vehicle fleet, Schäfer et al. (2009). Data retrieved from www.transportandclimate.com

The growth in car ownership has obviously been accompanied everywhere by huge increases in car use: in Great Britain for example, between 1975/76 and 1999/2001, car use increased by 67%, much to the detriment of the modal share of walking, cycling and bus (Knowles, 2006, p. 411). In the meantime, car ownership also increased enormously: there were 2,6 million vehicles in Britain in 1951, and more than ten times as many (27 million) in 2001, with the share of households without cars also decreasing from 86% to 26% during the same period (Whelan, 2007, p. 41). The research literature on car use has shown time and again that car ownership is a crucial determinant of modal choice and travel behaviour (Simma & Axhausen, 2001; Kwon & Preston, 2005; Scheiner, 2009a; Van Acker & Witlox, 2010), confirming the common sense observation that "more vehicles means more vehicle use" (Sperling & Gordon, 2009, p. 1). It is thus apparent how the historical trend towards greater mobility (in terms of distance and speed) is strongly associated with the process of motorisation. The continuation of these trends into the future, however, is less than certain – at least for developed countries.

1.1.3. Future trends

Schäfer et al. (2009) have studied passenger travel at the global level for the period 1950-2005. According to their model, in the second half of the 20th century the main determinants of aggregate travel demand have been the growth in per capita income and population and the increasing affordability of all modes of transport. These trends have resulted in rising in passenger kilometres travelled (PKT) and in a shift to faster modes, that has allowed increase in PKT in spite of constant aggregate travel-time budget. Based on the same model, the authors have projected the trends of world passenger travel from 1950 to 2005 into the next five decades (2050), under the assumption that "economic motivations and impediments, technological advances, environmental influences (..) and other drivers of change are largely consistent with those of the past" (p. 23-24). On this basis, the authors estimate a substantial increase in transport mobility in 2050, that is likely to be made possible by an increasing relative importance of faster modes of transport such as car and air travel. By contrast the share of low-speed public transport modes would have to continue its historically decline and ultimately tend to zero in the long term (p. 46). As a result, "globally, automobiles are projected to continue to satisfy the largest share of mobility demand in 2050, followed closely by high-speed transportation; low-speed public transport modes would supply only a small share of world mobility" (p. 48-49).

Even if this Schäfer et al. purposely omit several potential limiting factors (such as congestion, lack of technological opportunities and operational strategies to increase the mean vehicle speed, limited supply and asymmetric distribution of oil deposits, global warming policies and potential catastrophic events, see Schäfer et al., 2009, p. 51-65), it is a very useful tool for understanding the fundamental dynamics underlying the evolution of travel demand as of today. As Shove puts it: “exercises of this kind are immensely influential not, or not only, for the results they produce but for the questions they cast, and the shadows these throw”. (2003, p. 5). In that sense, business-as-usual transport scenarios such as this (Annema & de Jong, 2011) highlight how the continuation of current transport trends into the future would lead to substantial increases in travel demand in the 21st century – provided that there is no dramatic change in the conditions that have allowed such increases to take place in the past. Framed in this way, the claim by Schäfer et al. that “only radical policies to reduce greenhouse gases emissions or a strenuous response to the risk of oil disruptions might cause future travel demand to grow less than we project” (2009, p. 67) sounds worrying, notably if the role of transport itself in causing global warming and oil depletion is taken into account (see §1.2).

For some developed countries, however, such trends might already to have come to halt. Given that the present thesis focuses on two western European countries, I expand on these recent developments in the next section.

1.1.4. A turning point for developed countries?

Studies carried out in Britain show that in recent years, the historical trends towards more car ownership, car use and distance travelled have slowed down and even come to a halt. Kwon and Preston (2005) show how the growth rates of car trip and car driving distance have slowed considerably in Great Britain in the 1990s, even though car ownership kept increasing. Similarly, Le Vine and colleagues (2009) find out that, while car ownership and use have grown steadilliy in Britain in the second half of the 20th century, there is increasing evidence of a stabilisation in car use. As the British economy has kept growing during the period of study, these findings suggests the possibility of an unprecented “decoupling” between GDP and car use growth, that have historically been strongly correlated (OECD, 2006). All in all, these trends prompt Levine et al. (2009) to ask whether the historical growth in car use has come to an end in Great Britain. Metz (2010) goes even further, showing how the average distance travelled in Britain (by all modes) has stabilized at about 7.000 miles per person per year in the first decade of the 21st century – the first time such a levelling off is observed since the beginning of the records in the early 1970s. Accordingly, he argues that we are witnessing an unprecedented “saturation of demand for daily travel” with far reaching consequences for transport policy.

International research work seems to suggest the generalizability of these trends to other developed countries: in the US, Puentes & Tomer (2008) show how vehicle-miles travelled per capita, which grew steadily during the 20th century, have stabilized after 2000 and started dropping after 2005 – the largest decline since World War II; they also predict that “amid the current recession and declining gas prices, drops in driving should continue, creating dramatic impacts in the realms of transportation finance, environmental emissions, and development patterns” (p. 1). Analyzing travel data for eight high-income OECD countries (including Germany and the UK), Millard-Ball and Schipper (2011) observe that since 2003 total per capita travel has stabilized or even dropped in most countries, even though both GDP and car ownership have generally increased (albeit the latter at slower pace than in the past). Interestingly, it is the first time that such a levelling-off is experienced across so many countries and, as Schipper (2011) notes, the combination of such a plateau in car use with improvements in fuel economy has resulted in stable levels of fuel consumption per capita over the last few years. These facts prompt Millard-Ball and Schipper (2011) to suggest the possibility that industrialized countries are reaching “peak travel” – with a decline in passenger travel expected for the coming years, partly as a result of increasing fuel prices and economic recession. The possibility that we are witnessing a “peak car” has also been discussed (Goodwin, 2012). Similarly, Litman (2006) argues that the factors that caused the tremendous growth of motorized mobility in the 20th century are unlikely to continue in the next future, and predicts a decline in travelled distance per capita and vehicle ownership in developed countries. Furthermore, the world economic crisis started in 2008 is likely to have important consequences for the transport sector, possibly bringing about further reductions in travel (Rothengatter, 2011).

Regardless of current economic developments, there thus seem to be increasing evidence to suggest that the historical trends towards increasing car use and travelled distance might have halted in a number of developed countries, and that there might be a "decoupling" between economic growth and car use growth[3]. This evidence is not conclusive, however, and notably the reasons for this change are widely debated. Notably, the following explanations have been put forward:

- it might be a by-product of methodological shortcomings in travel surveys (Le Vine et al., 2009; Metz, 2010). As people become more internationally mobile (notably travelling by air), national travel surveys, which generally do not record international travel, tend to increasingly underestimate passenger travel per capita. This "unobserved mobility", if taken into account, might reveal a scenario where increasing international and air travel offset the current levelling-off of car travel, in accordance with the historical shift from slower to faster modes of travel (Schäfer et al., 2009)
- the sustained rise in oil prices since 2002 might explain at least in part the levelling-off of travel, even though it is unlikely to be the sole reason for it (Millard-Ball & Schipper, 2011)
- historically, increasing demand for car travel has gone hand in hand with increasing supply of road infrastructure. This has changed in recent years in a number of countries, partly as a result of limited public budgets, partly in a deliberate attempt not to foster further growth in car use (see §5.2.2 on the British case). The resulting capacity constraints and increasing congestion on the road networks, as well as other policy measures deliberately meant to constrain car use, such as parking restrictions, might have had the effect of reducing the competitive advantage of the car over other transport modes in terms of speed (Le Vine et al., 2009; Chlond, 2006; Chlond & Kuhnimhof, 2007).
- Metz (2010) argues that a more fundamental process is at work: the desire for more access and choice has historically been the main driver behind the increase in travel distance and speed; however, even access and choice are subject to the principle of diminishing marginal utility, and are thus expected to eventually reach saturation. This is happening now, and we are thus witnessing an historical turning point in travel trends, corresponding to a "saturation of demand for daily travel" in which "daily personal travel has (..) ceased to grow because our need for routine access and choice has largely been met" (p. 667).

1.1.5. Travel demand and demographic change

According to Metz (2012), if the stabilization of per capita demand for daily travel is going to continue, it follows that, in developed countries, "demographic change (..) will be the main determinant of future travel demand and traffic levels" (p. 20). Notably, two developments will be particularly relevant: population growth and ageing. The impacts of increasing life expectancy and the ageing of the population is particularly relevant in the context of this thesis, as it brings about two partially contradictory trends:

- for several reasons, older people travel on average less than the rest of the population, and are also less likely to own a car and drive (Metz, 2000; 2003; Schwanen & Páez, 2010). As a result, an increase of the share of old people on the total of the population is expected to reduce the average levels of mobility, as well as to increase the numbers of those who, mainly for reasons of health, have to give up driving (or have mobility difficulties more in general).
- more importantly, however, new cohorts of older people tend to be more mobile than previous ones, and this is reflected also in higher driving licence rates and car use (Rosenbloom, 2001; Hjorthol et al., 2010). Moreover, the travel behaviour of women is gradually converging with that of men in new

[3] It is important to emphasise that there is no contradiction between the trends forecasted by Schäfer et al. (2009) discussed in §1.1.3 and the research findings discussed in §1.1.4, for at least two reasons. Firstly, while Schäfer et al. (2009) refer to the *global* level, the studies suggesting a leveling-off of travel trends refer to *developed* countries only. Secondly, while Schäfer et al. discuss *forecasts* based on the assumption that the impact of past determinants of increasing travel demand (such as rising income) continue unperturbed into the future, the authors reviewed in §1.1.4 elaborate on *recent trends* suggesting that there might be a change in the relationship between travel demand and its determinants (such as the possibility of a decoupling between economic growth and increasing traffic).

cohorts of elderly, thus bringing about a further increase in travel distances and car use (Donaghy et al., 2004)

The net outcome of these contradictory trends is complex to ascertain, as it is the cumulative product of cohort, age and period effects, as well as of the distribution of different cohorts on the territory. It seems unlikely, however, that the ageing of the population will result in diminishing levels of travel and car use in the next future (Dejoux et al., 2010; Hjorthol et al., 2010). As a result, it is often concluded that "this demographic force behind car ownership growth can be expected to remain important in Western Europe for another couple of decades" (de Jong et al., 2004). At the same time, however, the increase in the number of people who might be exposed to mobility difficulties and/or transport disadvantage because of old age has caught increasing attention in recent years (see §2.1.5), for it has great transport policy implications (Metz, 2003; OECD, 2001), notably if the role of mobility for well-being and quality of life among the elderly is taken into consideration (Metz, 2000; Banister & Bowling, 2004).

However, it has to be kept in mind that population ageing is not the only demographic development with impacts on travel demand, as decreasing household size, increasing female participation in the workforce and the like also play a major role (Giuliano, 1997), even though for the sake of brevity they will not be expanded upon here. For the purpose of this thesis, however, one recent trend is worth highlighting: both in Germany and Great Britain (see §4.2.1, §5.2.1), recent travel data show that, among young adults, car ownership and use as well as licence ownership have reduced or stagnated in the last few years, showing a trend that is exactly opposite to that illustrated for older people (Lucas & Jones, 2009; Infas, 2010; Kuhnimhof et al., 2011; Kuhnimhof, Armoogum et al., 2012; Kuhnimhof, Buehler et al., 2012). While the reasons for this development are still unclear (and under-researched), they are likely to be related to the costs of motoring and the postponement of adulthood among younger cohorts[4] (Metz, 2012, p. 24; Kuhnimhof, Buehler et al., 2012; Le Vine & Jones, 2012).

The findings of the research work carried out for this thesis allow me to explore if and how such trends (increasing share of old drivers, decreasing share of young drivers) impacts on the changing composition of the subset of households without cars over time (research question 2, §3.3.3). Also, the findings for research question 1 provide some clues about the possible reasons for decreasing car ownership among young adults in Germany (see §8.2.8).

1.1.6. Two kinds of concerns

Even though the possible levelling-off of travel distances pro-capita and current demographic trends will be crucial to interpret future trends in mobility demand in developed countries, the sheer force of population growth is likely to determine an increase in total travel even in the industrialized world. Furthermore, while the historical trend towards more car ownership and use might have slowed down in these states, it is gaining pace in many developing countries. As a result, trends *at the global level* are likely to be more in line with the projections of Schäfer et al. (2009) than with the saturation of daily travel demand observed by Metz for the UK (2010).

But why should this matter? And why should travel figures, traditionally the bread and butter of transport scholars, be of any interest to the urban and social sciences? The answer has to do with the fact that *these trends have problematic consequences*, in at least two respects: first on the environment, since most motorised transport is based on the burning of oil, which is both a finite natural resource and a major contributor to global warming. I deal with these implications in more detail in the next section (§1.2). Second, the increase in travel and car ownership has profound implications for the dynamics of social inequality: in a more mobile world, the ability to cover greater distances and the access to motorised means of transport (such as the automobile) arguably becomes a crucial factor for social inclusion, social status and quality of life.

[4] This topic is developed further in the case-study chapters (§4, §5).

Knowles (2006) illustrates this latter point brilliantly: even though in the last two centuries cheaper and faster transport have brought about what geographers call time/space and cost/space convergence, reducing the "frictional impact of distance" this should not be taken as proof of a "uniform spatial collapse in the time and costs of travel" (p. 407). Indeed, these processes are inherently unequal – in Knowles' words: "the differential collapse in time/space, (..) has always been very uneven spatially, economically and socially (and) this has created a misshapen world in terms of travel time, accessibility and personal mobility" (p. 408). As a matter of fact, as time/space convergence has gone hand in hand with an increasing dispersal of activity sites on the territory (see §1.5), transport improvements have never been equally distributed: as a result, "geographical differences remain" and "location remains all important" – and so do the approaches that focus first and foremost on differences across space. In that sense, it is true that "as the world shrinks in time/space and cost/space, economies and societies become more intermeshed and interdependent" (a process that has been studied by Sociology under the name of modernization), but the downside of this is that "whilst many people are moving closer together in time/space, others are moving farther apart" (p. 408).

The unequal access to transport networks (and accordingly to services and opportunities), however, does not depend only on location in space, but also varies greatly according to socio-demographic characteristics, economic resources, disability and the like. Accordingly, as passenger travel has increased enormously in the 20th century, the significance of transport and the related patterns of inequality for social inclusion has hugely increased, catching the attention of both scholars and policy makers. Given the complexity of the subject, this research field will be the focus of a whole chapter in this thesis (§2).

1.2. Motorisation as an environmental problem

1.2.1. Motorisation and its criticism: from local to global

Motorisation has always been the target of criticism, and the concerns surrounding it have gradually moved from the local, to the regional and then to the global level (Schäfer et al., 2009). The introduction of the automobile in U.S. cities for example, even if greeted with enthusiasm by many, led to battles over the use of street space and the reduction of traffic accidents, which ultimately resulted in broad anti-automobile campaigns and in the isolation of roads from pedestrians, mainly for safety reasons (Norton, 2008). These first externalities of the automobile could be managed at a local scale, because they affected mainly drivers and pedestrians (Jones, 2008, p. 202). By contrast, the problems of congestion have gradually moved from city centres to a larger geographic scale, now typically affecting entire metropolitan areas and their residents (Schäfer et al., 2009, p. 4). A similar increase in geographical scale has been observed for air pollution, as scientist have exposed the effects that automotive emissions (such as NOx, SO_2, ROG, CO and PM) have on health at the regional level. Today vehicles are considered as a major source of air pollution in metropolitan regions (Schweitzer & Valenzuela, 2004).

More recently, increasing concern has been expressed about the negative impacts of motorisation at the global scale in relation to major global concerns such as climate change and possible oil depletion. These concerns are in turn at the basis of the notion of sustainable development (World Commission on Environment and Development, 1989), and are likely to be of the utmost importance in the present century. These problems are compounded by the fact that, as illustrated above, the global demand for passenger travel is on a constant rise, as motorisation is sky-rocketing in several fast-developing countries: this poses fundamental threats to sustainability, because it threatens to absorb any fuel or emission savings that could be provided in the future by technological improvements (see Schäfer et al., 2009, §1.2.4).

Both of these global issues (oil depletion and climate change) represent a "perfect moral storm" (Gardiner, 2008) that urges scholars to take into account the problematic issue of intergenerational equity. Indeed, as Vanderheiden (2008b) argues, global climate change is major problem for politics and society, since it is best defined as a "massive negative environmental externality created by the world's affluent to be disproportionately borne by those least responsible for it among the poor and future generations" (p. xiv-xv).

In that sense, the negative effects of current emissions are likely to fall mainly on posterity, whereas benefits are primarily felt by the present generation, mostly in form of cheap energy (*ibidem*). Global problems such as climate change and possible oil depletion thus entail a social equity dimension that, however, is often not recognised as such but hidden behind the label of “environmental problems"[5].

1.2.2. “The end of cheap oil”

A heated debate surrounds the possible depletion of oil resources in the twenty first century. Many scholars and institutions are in fact increasingly worried that oil production may eventually not meet demand in the course of the present century, bringing about price rises with potentially serious consequences for social life. Others argue by contrast that these forecasts are too pessimistic and ignore the regulatory role of the market mechanism, that will bring about the incentives necessary to find new (unconventional) oil reserves and develop alternative fuels and technologies.

First, it has to be stated that “because fossil oil deposits are a finite resource, there is no question that the world oil production rate will peak and then go into decline. What is not known with certainty is the year (..) and what rate of decline” (Krumdieck et al., 2010, p. 308). According to exponents of the peak oil theory (Campbell & Laherrère, 1998; Deffeyes, 2005), first formulated by Hubbert in the 1950s and 1960s (1956), the extracting of oil reserves typically follows a bell-shaped curve, since the ability to produce oil is seen as depending almost exclusively on the unproduced fraction, and not so much on oil price (Deffeyes, 2005, p. 35-42). This implies that when approximately half of the existing reserves have been extracted, the production reaches maximum output, and subsequently declines. Thus “peak oil” is defined as “the calendar year in which global conventional oil production reaches a historical high point and there-after declines” (Krumdieck et al., 2010, p. 308). This is likely to bring about, in a context of soaring world population and economic growth, “a growing gap between expanding petroleum demand and a gradually declining oil supply” (Dodson & Sipe, 2007, p. 40). In that sense, “the threat to sustainability is not so much “running out” of oil, but the increasing costs, environmental and economic, of its use” (Wegener & Greene, 2002, p. 37). Krumdieck et al. (2010) have proposed a probabilistic approach to identify the likelihood of peak oil occurring in a given year, that takes into consideration all the different projections produced by experts (petroleum geologists, oil companies, etc.) so far. The resulting probability distribution (representing expert consensus) shows that “peak oil predictions cluster around 2010, and all are before 2030”, the year when the cumulative probability of occurrence reaches 100% (Krumdieck et al., 2010, p. 310). According to Deffeyes, this is an “unprecedented problem” since, “for the first time since the industrial revolution, the geological supply of an essential resource will not meet the demand” (2005, p. xi). Moreover, he argues, past peak oil there will probably be “enormous price volatility”, with bigger and bigger oscillations (p. 31). This is likely to be very problematic for various sectors of human life, and especially for transport, given that “current transport systems around the world rely nearly completely on a single form of energy – petroleum” (Fulton, 2004, p. 189).

However, not all scholars share this point of view: others point out that all projections of “oil-peakers” up until the present have proved to be incorrect, and argue that, since oil reserves are defined as “the quantity of oil that can be *profitably* extracted with existing technology at prevailing market conditions”, their quantity may actually increase over time, as technology improves and prices change (Schäfer et al., 2009, p. 60, emphasis added). In that sense, they accuse oil peakers of not taking enough into consideration factors other than geological estimates, such as political and economic factors. Schäfer et al. argue for example that “the principle of demand and supply mandates that the world will never run out of oil. Rising demand causes the price of oil to rise, which, in turn accelerates the search for alternatives, including unconventional oils (..), (that) will become ever more profitable” (2009, p. 62). Thus, when the global production of conventional oil will eventually start to decline, alternative fuels and new technologies will be able to “fill the gap” between supply and demand.

[5] Importantly, they also entail a normative dimension (Walker, 2012).

Still, many are concerned that the transition may not be as smooth as implied by economic theory. According to Robinson & Powrie, for example "there isn't anything conceivable that could replace conventional oil, in the same quantities or energy densities, at any meaningful price" (2004, p. 7; see also Trainer, 2007). This might be especially relevant for the transport sector, that has a dependency on oil of 98 per cent (Fulton, 2004), representing approximately 50 per cent of all global oil consumption and about 20 per cent of all energy consumption (Dennis & Urry, 2009, p. 17), and where alternative fuels are unlikely to have a substantial impact in the short-medium term. Indeed, "most of the increase in global oil use over the past 30 years has been for the transport sector" (Fulton, 2004, p. 190) and the International Energy Agency expects a continued growth in demand for transport fuels worldwide over the next 30 years (IEA , 2007). Even the most optimistic forecasts concede that "the demand for petroleum products, especially for transportation fuels (will) continue to grow (..) on a global scale" (Schäfer et al., 2009, p. 10) and that "oil prices hikes (..) cannot be excluded from happening over the next fifty years" (p. 64).

As Schäfer et al. (2009) argue "the global fuel market is already in transition" (p. 219), and in the transport sector various alternatives are already under development (biofuels, unconventional oils, natural gas, hybrid vehicles, electric batteries, hydrogen). However, as Dennis and Urry (2009) argue "each alternative is fraught with conflict and uncertainties" (p. 65). In fact, as illustrated by Schäfer et al. (2009), oil products have many favourable transport-related characteristics, that are not easily reproducible: they are liquid at atmospheric temperature and pressure, lend themselves to rapid and simple fuelling processes and easy storage, have outstanding weight-volume characteristics necessary for long-vehicle range, store the largest amount of energy per unit weight of all liquid fuels, and have the highest energy content per unit of fuel volume (p. 164,165). Moreover, a century and a half of investments in oil production "has resulted in a transportation fuel supply system of enormous scale" that gives a clear advantage to any alternative fuel that is compatible with the existing infrastructure, such as biofuels (p. 166). For these reasons, the transition to alternative fuels in the transport sector is likely to be slow and gradual, and to experiment great difficulties and time lags: Schäfer et al. have estimated that only few alternative fuels could achieve 25% of the fuel market by 2030 (2009, p. 215). Moreover, some alternative fuels have other undesirable effects, either environmental (unconventional oil) or social (biofuels), that might significantly hamper their effective introduction (Schäfer et al., 2009). For these reasons, "price rise can be on a much shorter time scale than the response of the market with alternative fuels and vehicles" (Krumdieck et al., 2010, p. 307). On the other hand, according to some authors "even if energy markets were able to adjust quickly to much higher oil prices, our production and distribution systems are unlikely to be so responsive" (Dodson & Sipe, 2007, p. 59). This has prompted some analyst to state that "the most likely alternative for our current cheap plentiful of oil will also be oil, but much more expensive and less plentiful oil" (Robinson & Powrie, 2004, p. 9).

Arguably, these forecasts are worrying from an inter-generational perspective because continued oil consumption at this level will have severe consequences on future generations, who will find themselves dependent on a resource that will be both increasingly scarce and expensive. Accordingly, scholars all around the world and across disciplinary boundaries are beginning to focus on the economic, social and spatial impacts of possible substantial rises in oil prices, with a special concern for urban areas and transport (Gilbert & Perl, 2008; Newman et al., 2009; Dodson & Sipe, 2009; Urry, 2013), especially since the end of the 1990s, when oil prices started to rise significantly (Fig. 1.2). Urban scholars Dodson and Sipe (2007), for example, considering that "it is imperative for social scientists to contemplating the risk that either a rising oil price or oil peak scenario might pose for urban economic and social systems" (p. 40), have tried to assess "how the impact of recent and future oil prices rises might be distributed across urban areas and which social groups and localities would be most adversely affected" (p. 38). In the next chapter, I will discuss a selection of findings from this research strand in more detail, focusing in particular on how rising oil prices might cause new patterns of transport-related social exclusion in the next future (see §2.2.4).

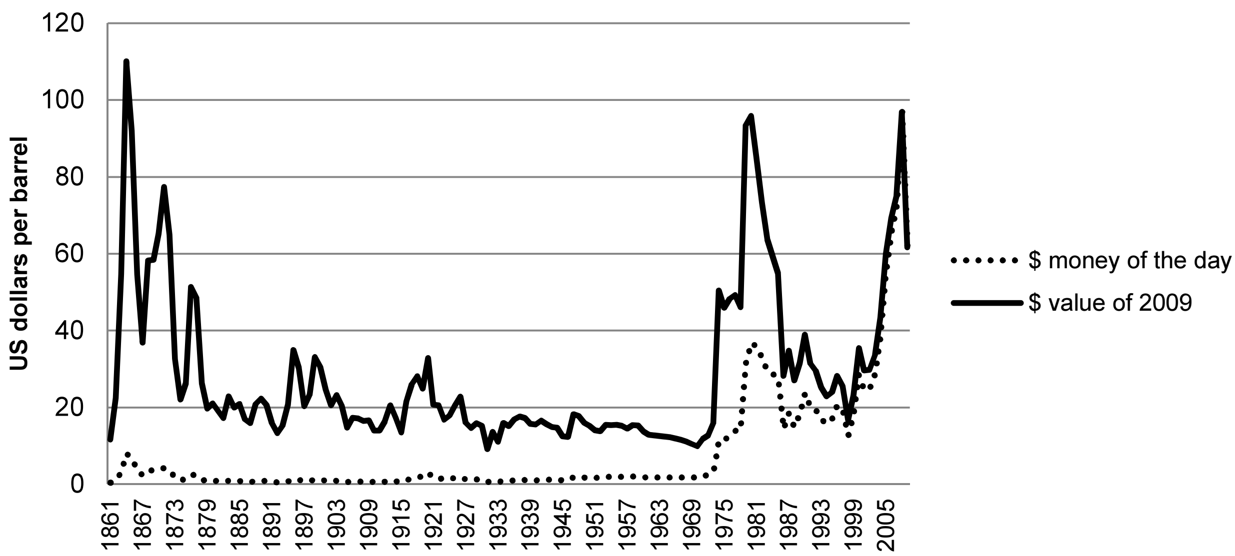

Fig. 1.2 – Historical crude oil prices, 1861 to present. Source: BP (2010)

1.2.3. Climate change

After the United Nations Intergovernmental Panel on Climate Change 2007 report (IPCC, 2007) said that global warming is "unequivocal" and that human activity is "very likely" to be its cause, the issue of climate change is high on the global and the academic agenda. Carbon dioxide (CO_2) is the most important of the anthropogenetic greenhouse gases (GHG) that are instrumental in the warming of the earth, and is produced by many human activities, including transport. According to the IPCC "unmitigated climate change would, in the long term, be likely to exceed the capacity of natural, managed, and human systems to adapt" (IPCC, 2007, quoted in Vanderheiden, 2008b, p. xi) and thus constitutes the "world's major threat to human life and social organization" (Dennis & Urry, 2009, p. 4). In that sense, as stated by Dennis & Urry, "climate change is no longer simply an environmental issue" (p.137), since its overall consequences, if not reduced, "will very substantially reduce the standard of living and the capabilities of life around the world". On the other hand, they argue that "the nature of 'social life' is central to the causes, the consequences and the possible 'mitigations' involved in global heating" (p. 8), and thus even attempts to mitigate climate change "are likely to involve dramatic changes in social organization" (Szerszynski & Urry, 2010, p. 1, see also Urry, 2011). These latter would have to be important, since climate change imperatives suggest reductions in greenhouse gases of at least 50 percent by 2050.

In this context, the transport sector is a major contributor to GHG emissions: it currently accounts for about 23 percent of the world's CO_2 (Schäfer et al., 2009, p. 64), and within this sector, "the motor car is the second biggest contributor (..) (behind road freight)" (Chapman, 2007, p. 357). Moreover, the reason why it is seen as the most difficult and worrying part of the climate change agenda is that – unlike other sectors – its impact is likely to increase rather than diminish in the next few decades (Chapman, 2007; Johansson, 2009); transportation is today the fastest-growing source of energy-related GHG emissions, and thus its relative importance is likely to increase at such a rate that it will be difficult to reverse for technological improvements alone (see §1.4.2, Schäfer et al., 2009, p.vii).

Failure to contain increases in the global temperatures would result in massive environmental externalities (such as strong storm patterns, and warmer ocean temperatures) that will probably weigh disproportionately on the most disadvantaged and on future generations (that is, on the most disadvantaged among future generations). According to the IPCC, in fact, impacts "will fall disproportionately upon developing countries and the poor persons within all countries, and thereby exacerbate inequities in health status and access to adequate food, clean water, and other resources" (IPCC, 2007, quoted in Vanderheiden, 2008b, p. xiii).

However, most GHG emissions are currently originated in the rich countries of the West, especially on a per capita basis (Schäfer et al., 2009, p. 13,14).

1.2.4. The need for reductions in car use

As illustrated, current transport trends at the global level point at a significant growth in PKM, car ownership and car use (§1.1). Given that most motorized transport relies on combustion of fossil fuels (mostly oil), transport is a major contributor to the twin issues of oil depletion and climate change (§1.2.2, §1.2.3), that in turn raise serious concerns because of their inter-generational and global implications. On the other hand, this implies that the climate change agenda partially overlaps with the oil agenda, since they both point at the need to burn less (non-renewable) carbon-containing fuel (Newman et al., 2009, p. 32). For this reason, they are often subsumed under the label “environmental sustainability”.

Accordingly, in theory it would be possible to solve these problems by intervening only on the technological side of the equation: if it was possible to use alternative fuels (renewable and non-polluting), or to improve indefinitely the energy efficiency of existing transport means, the future development of travel trends would not be of any concern. Unfortunately, this is not the case. Schäfer and colleagues (2009, p. 19-20) provide a simple way to conceptualize this conundrum for transport and climate and change, using the following algebraic statement:

$$\mathrm{GCE} = \frac{\mathrm{CGE}}{\mathrm{E}} * \frac{\mathrm{E}}{\mathrm{PKT}} * \mathrm{PKT}$$

In short, the equation shows how passenger travel greenhouse gas emissions (GCE) can be conceptualized as the product of three factors: first, the type of fuel, “characterized by the amount of GHG emissions (CGE) per unit of energy consumed (E)” (*ibidem*). Second, passenger travel energy intensity, defined as the amount of energy (E) required to cover a certain distance (PKT); this depends mostly on the technological characteristics of the travel modes, but also on other “non-technological” factors (such as the occupancy rate of vehicles). Finally, passenger travel demand, here represented in terms of passenger-kilometres travelled. In more lay terms (Fulton, 2004, p. 190) passenger transport GHG emissions can be thought of as the product of: “how much travel occurs” (PKT, “largely a behavioral issue”); “how it occurs” (by which mode) and “how energy intensive it is” (here conflated in E/PKT, which is a combination of both technical and behavioural issues); the coefficient of carbon emissions per unit fuel use, by contrast, can be considered as a purely technical issue.

As this simple equation shows then, in the pursuit of environmentally sustainable transport there is a trade-off between the three components. Given that the goal is to reduce transport-related GHG emissions, two “successful” scenarios are imaginable:

- a simultaneous reduction in all three factors (less overall travel, more energy efficient travel, less polluting fuels)
- an increase in one or two factors, offset by a more than proportional decrease in the other(s)

All alternative scenarios (an increase in all factors, an increase in one or two factors that is not offset by a more than proportional decrease in the others) obviously result in an increasing amount of emissions. It is apparent then that the rapid increase in travel distances (PKT) and the historical shift towards faster and more polluting modes such as the automobile (implying an increase in E/PKT) bring about an enormous technological challenge: indeed, if these trends were to continue, this would require a more than proportional increase both in the share of travel propelled by alternative, less polluting fuels (CGE/E) and in the energy efficiency of travel (also a part of E/PKT), in terms of modal split and/or energy efficiency of vehicles.

In other words, *even if various technological improvements could enhance the energy efficiency of the various components of contemporary transportation, thus reducing our need for oil in the transportation sector, they are likely to be offset by other non-technology related factors*, such as (Schäfer et al., p. 68-87): shift to faster, more energy-intense modes of transport (automobiles and airplanes), increasing share of urban driving, shift to ever larger and powerful vehicles, declining occupancy rates (all increasing E/PKT) as well as by the dramatic increase in PKT. This is not just speculation: this is what has actually happened in recent decades. Schäfer and colleagues (2009) have proven that “human factors” have actually offset technological improvements in the period 1950-2005 in the USA: as a result, even passenger travel energy intensity (E/PKT) has remained roughly constant or grown throughout the second half of the twentieth century. This kind of trend is not peculiar to the transport sector (Rosenfeld et al., 2004): while in the 20^{th} century the efficiency of energy use has constantly improved, the increase in primary energy use (both in terms of per capita energy consumption and population growth) has more than offset these gains. As a result energy demand and related CO_2 emissions have increased steadily throughout the century.

As far as the future of transport is concerned, Schäfer and colleagues (2009) estimate that, in a scenario without any technological advances relative to today’s vehicle, current trends will lead globally to a passenger travel energy intensity to be about 5-20 percent over current levels in 2050, which, multiplied by the projected growth in travel demand (see §1.1.3) yields a projected increase in passenger travel CO_2 between roughly three and five times today’s level - assuming that oil products will continue to fuel nearly the entire transportation system (p. 98,99). In that sense, the growth in passenger travel demand and other “human” factors seriously threatens to offset any efficiency gain that could be attained with improved technologies and/or alternative fuels. A shift to transportation fuels with lower carbon-to-hydrogen ratio is highly desirable, but it is likely to be a slow and difficult process and it will require supporting government policy measures or incentives such as instituting higher gasoline prices (p. 211). However, the authors estimate that even in a maximum technology scenario, because of strong growth in travel demand in developing countries, global-mobility related GHG emissions are likely to continue to increase “at least through midcentury”, even under the most stringent GHG-emission-reduction policies (p. 260-266). Similarly Fulton, based on IEA forecasts, predicts that “even in Europe and Japan, improvements in fuel economy probably will not be enough to offset the expected growth in travel activity” and that transport related CO_2 emissions will double from 2000 to 2030 (2004, p. 192).

These challenges are compounded by the peculiar nature of environmental issues: while social problems are generally studied and defined in relative terms (for instance: child mortality rate as an indicator of child wellbeing, crime rates as an indicator for criminality, etc.), what ultimately matters for environmental problems is *absolute* levels. This is because they deal by definition with the finiteness of the earth resources: in this case oil reserves and the absorptive capacity of the atmosphere. Accordingly, *relative improvements*, such as a reduction in per capita PKM (or energy use in general), are not enough in themselves to make a significant difference, if they are offset by a concomitant increase in population. Recent developments in the UK illustrate this problem: Lucas and Jones (2009) observe that the historical trend towards increasing car use per person seems to have stopped in recent years and as a consequence “since the early 2000s annual car mileage has grown only in line with increases in the adult population” (p. 12). Clearly, this does not constitute an improvement for transport-related GHG emissions (all other factors equal). Since world population is increasing at an unprecedented rate, notably in developing countries, this leads to a need for even greater reductions in travel distance per capita (all other factors equal). Furthermore, one must take into account how emission reductions will be divided among countries. While this is a very controversial issue (Walker, 2012) the assumption in most studies is that of a “contraction and convergence” scenario, whereby “per capita emissions eventually should converge, allowing an initial increase in emissions in developing countries with a simultaneous reduction per capita in developed countries” (Johansson, 2009, p. 3213). Accordingly, emission reductions in developed countries will have to be larger, in order to compensate for growth elsewhere. Arguably, this makes it even harder to adress the problem of transport-related GHG emissions in the “first world”: Johansson (2009) for example estimates that emission reductions of 70-95% in industrialised countries will be necessary by 2050, meaning “that the transportation and energy services will have to provide their services with near zero emissions in a 50y perspective” (p. 3212).

Such considerations have prompted scholars to wonder whether restrictions on CO_2 emissions will require reductions in travel demand – or whether technology will be sufficient to solve this problem (Johansson, 1998; 2009). Many studies have tried to answer this question, using very different approaches and producing diverging results (for a short overview see Johansson 2009): however, there seems to be an emerging consensus among transport scholars that "technological innovation is unlikely to be the sole answer (and) behavioural change brought about by policy will also be required" (Chapman, 2007, p. 354). As a matter of fact, even though some argue that the possibility of breakthrough innovation in the transport sector (allowing both continued transport demand growth and massive emission reductions) cannot be entirely ruled out, "relying solely on technical measures would, however, be risky as there is no guarantee that the technology will develop at a sufficient rate" (Johansson, 2009, p. 3219). In that sense, trying to reverse the historical trends towards increasing travel distances and car use would be consistent with a precautionary approach to climate change.

Accordingly, many industrialized countries have launched comprehensive transport policy packages to achieve 'environmentally sustainable transport'. As I illustrate in more detail in §1.6, §4.1 and §5.1, these generally include various types of measures (including technological improvement, pricing measures, changes to spatial planning, improvements to alternative modes, etc.). The reason for this is that each of these measures has serious limitations, and it is assumed that combining them together increases the chances of success. As Rothengatter et al. argue, "no instrument is capable to solve the problems alone, while a combination of tools should be preferred which is adjusted to the country situation" (Rothengatter et al., 2011, p. 5).

Reductions in motorisation rates are rarely mentioned explicitly in policy recommendations, which seem to favour modal shift and reductions in car use (rather than ownership), probably because the latter option would be more controversial with the public[6]. However, existing research shows unambiguously that car ownership is a crucial determinant of modal choice and travel behaviour (Simma & Axhausen, 2001; Kwon & Preston, 2005; Scheiner, 2009a; Van Acker & Witlox, 2010). Accordingly, the pursuit of (environmentally) sustainable transport arguably includes the goal of reducing motorisation in industrialized countries, thus increasing the share of households and individuals who do not own cars. While I will expand on sustainable transport policies later on in this chapter (§1.6), the next three sections (§1.3-§1.5) will present and discuss complementary approaches to the study of motorisation.

1.3. Mainstream approaches to the study of motorisation

1.3.1. Car ownership modelling

As Schwanen and Lucas (2011) argue, while car use has been approached by different theoretical and disciplinary perspectives (among others: accessibility and time geography, utility theory, social psychology and the "new mobilities paradigm"), "car ownership has been studied (..) from fewer theoretical perspectives" (p. 4). Indeed, attempts to understand and predict the level of car ownership date as far back as the 1930s (Whelan, 2007, p. 206) and, as illustrated by de Jong et al. (2004, p. 379) have a variety of purposes and publics: for instance, they are of interest to oil companies and car manufacturers (in order to predict future demand), transport planners (in order to plan future investment in road and parking infrastructure or forecast the use of public transport) as well as national and local governments interested in forecasting tax revenues. More recently, in the context of growing concerns about the unsustainability of current trends in transport, these studies have been increasingly used as tools in order to forecast energy consumption and emission levels and to determine the extent to which motoring could be reduced by various (mostly price-related) policy measures (de Jong et al., 2004, p. 379).

In that sense, motorisation has been the focus of much scholarly work along the decades – so much so that Clark defines it as "probably one of the most popular areas of study (..) within the transport research literature" (2009, p. 526). However, most of this work consists of econometric modelling studies, which generally use a multiple regression model to represent the relationship between car ownership and a series

[6] A recent exception is the municipality of Milan that has set the goal to reduce the motorisation rate from 55 to 45 cars per 100 inhabitants (AMAT, 2012).

of independent variables. In this context, as argued by Whelan et al. (2000, p. 255), demand for cars is studied as a particular case of demand for economic goods, in accordance with product life cycle and diffusion theories, and the atomistic paradigm of economic theory more in general. Accordingly, rising income is generally considered to be the main driving force behind car ownership growth, even if other factors are often taken into account. The main explanatory variables used in this kind of studies are listed below:

- *economic variables* of two kinds:
    - income: at the aggregate level, per-capita income is generally considered as the main explanatory variable, even though some studies have shown the relevance of income distribution (Storchmann, 2005); disaggregate models also invariably include household disposable income as the main predictor of car ownership
    - price factors such as motoring costs (including both fixed costs, such as purchase costs and car ownership fees, and variable costs such as fuel prices and maintenance expenses, etc.) as well as the costs of "substitutes" (i.e. competing modes, such as public transport) are often included as predictors in aggregate models
- *socio-demographic variables*, such as size and composition of the household (number of adults and children, number of working members, age and sex of the household reference person, etc.) are generally included in disaggregate models; even though they might have an independent influence on car ownership, economists often argue that they capture part of the effect of unobserved economic variables, such as savings or access to credit, that are in turn correlated with socio-demographic variables (Gardenhire, 1999). Socio-demographics are also sometimes included in aggregate models, under the form of age structure of the population, adult/population ratios etc. (see for example Dargay & Gately, 1999)
- *geographic variables*, including nature of the residential area (urban or rural), population density, accessibility to services in the neighbourhood area (including, importantly, access to public transport), as well as features of the built environment (in terms of density, diversity and design) and even traffic parameters (Karlaftis & Golias, 2007). In this area, more recent studies have employed Geographical Information Systems (GIS) tools to better explore the connection between land use and car ownership (see for example Potoglou & Kanaroglou, 2008; Whelan et al., 2010)
- aggregate models also sometimes include variables related to *infrastructure provision*, such as road network density (which generally encourages car ownership) and car parking availability

The main goal of most of these studies is predictive (forecasting future car ownership trends with the greatest possible accuracy) rather than explanatory, even though they also often draw conclusions about what are the main drivers of motorisation (in causal terms). In this context, the estimation of the elasticity of car ownership with respect to changes in other variables (generally income and costs) is of great importance, as this estimates are then used for forecasting and assessing the potential of transport policy measures (Goodwin et al., 2004; Litman, 2010a).

Car ownership studies can be classified according to a large number of criteria (de Jong et al., 2004). In this context, it is sufficient to distinguish between aggregate studies, which generally use time-series data at the national level in order to predict future trends at the global or world-regional level (see for example Dargay & Gately, 1999; Ingram & Liu, 1999; Gately & Huntington, 2001; Storchmann, 2005), and disaggregate studies, in which car ownership is modeled using micro-data, typically at the household level (see for example Dargay, 2001; Dargay & Hanly, 2007; Karlaftis & Golias, 2007; Whelan, 2007; Matas & Raymond, 2008; Clark, 2009; Nolan, 2010).

In the context of this thesis, I do not aim to provide an exhaustive review of this area for research (excellent reviews already exist in the literature, see de Jong et al., 2004). Rather, in the remainder of this section I will illustrate briefly a selection of empirical findings (mostly from disaggregate studies) that are relevant in the context of the present research work. The section concludes with the argument that these studies have theoretical limitations and interpretative shortcomings, which in turn demand the recourse to other kind of complementary approaches to the process of motorisation. Such alternative approaches are illustrated in the next section (§1.4).

1.3.2. How to model autolessness?

In most disaggregate studies, household car ownership is generally modelled as a count variable: accordingly the models put forward represent in a simplified way how the different values assumed by the dependent variable (no cars, one car, two cars, etc.) can be predicted as a function of a series of independent variables (see list above). Some researchers, however, have argued that the factors influencing "autolessness" (the absence of a household car) are fundamentally different from those driving multiple ownership: Karlaftis and Golias, for example, observe that:

> "a household's decision to purchase the first automobile is primarily based on socioeconomic factors, whereas the decision to purchase a second automobile (or more) is largely based on traffic network, efficiency, and transit level-of services parameters" (2007, p.29)

It is for this reason that researchers have often used discrete choice models where the decision concerning car ownership is modelled following an ordered response mechanism (that is, where the decision about owning a second car nests the decision to purchase the first one, see Cohen et al., 2003, p. 519) (de Jong et al., 2004, p. 9; Matas & Raymond, 2008, p.190). Accordingly, Meurs (1993) argues that policy interventions should be aimed at influencing second car ownership, rather than decisions concerning the first car, which seem to be "difficult to affect" (p.461) – a view shared by Caulfield (2012), who has studied multiple car ownership households as potential targets for electric vehicles and car sharing schemes.

In a nutshell, then, the mechanisms responsible for the owning of the first car seem to be quite different than those driving the purchase of a second or third vehicle. In the context of a thesis focused on households without cars, this is a research finding that is worth keeping in mind.

1.3.3. Saturation

As stated above, econometric modelling of car ownership analyzes demand for cars as a particular case of demand for economic goods. Accordingly, the relationship between income and car ownership is assumed to be highly non-linear, following an S-shaped curve similar to that depicted in Fig. 1.3.

As Whelan et al. (2000) observe:

> "the economic rationale *(for this)* is provided by product life cycle and diffusion theories whereby the take-up rate for new products is initially slow, then increases as the product becomes more established, and finally the rate of increase diminishes as the market becomes close to saturation" (p.255)

The S-shaped curve (which in practice is approximated by various specific curves, including the logistic and Gompertz curves) implies that the elasticity of car ownership with respect to income is low (below 1.0) at low levels of income, where an increase in (per-capita) income results in a less than proportional increase in car ownership levels. Elasticity increases rapidly at medium levels of income, where an increase in (per-capita) income results in a *more* than proportional increase in car ownership levels. At higher levels, elasticity starts to decrease before eventually reaching the limit-value of zero: when this happens, *saturation* in car ownership is reached. In that sense, most models of car ownership assume that, beyond a certain threshold, car ownership is not sensitive to further increases in income, because income elasticity declines as motorisation grows. This phenomenon is hardly observable with time-series data at the national level, but becomes apparent if different nations with different levels of per-capita income (Dargay & Gately, 1999; Dargay et al., 2007) or different income quintiles (Collet et al., 2010) are observed. In studies that span several decades, this evidence is often used to argue that car ownership evolves from a luxury to a necessary good, which is hard to renounce (Dargay, 2001, p. 808; Goodwin, 1995; Berri & Dargay, 2010).

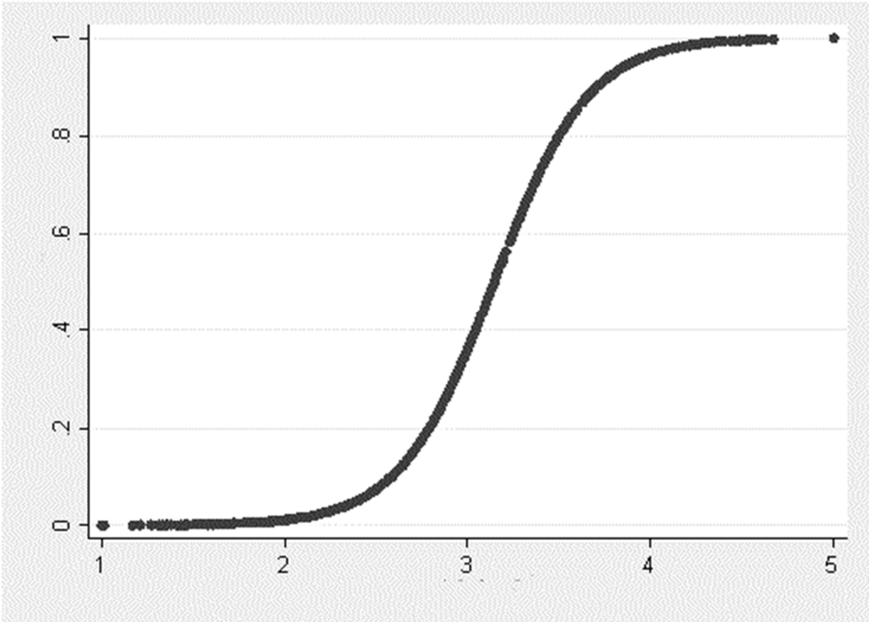

Fig. 1.3 – An example of S-shaped curve. Source: own elaboration.

Recent studies have tried to estimate how saturation levels vary for different countries and/or different groups in the same society. So for example Dargay et al. (2007) have put forward an aggregate model "that explicitly models the saturation levels as a function of observable country characteristics", thus allowing this threshold to be different across countries. The resulting estimates show that "the vehicle saturation levels vary across countries – from a maximum of 852 (per 1000 people) for the USA (and for Finland, Norway and South Africa) to a minimum of 508 for Chinese Taipei". Similarly Collet et al. (2010), using a disaggregate model on French data, have estimated different saturation levels for different income quintiles, finding inconclusive evidence.

The notion that motorisation levels will not increase indefinitely is undisputed, and the issue of saturation is particularly relevant for developed countries, which are likely to be closer to this threshold. However, the question remains controversial: reviewing aggregate models, Ingram and Liu (1999) observe that more recent estimates of saturation levels are generally larger than earlier ones, and thus question the validity of the concept:

> "if estimated vehicle ownership saturation levels change over time, they are of little use for forecasting. In fact, that seems to be the case as there is little direct evidence that saturation levels are stationary or that they have a straight forward behavioral interpretation" (Ingram & Liu, 1999, p. 13)

Similarly, Chlond (2006) observes that car ownership forecasts in the second half of the 20th century have for a long time underestimated the development of motorisation, and questions whether, by contrast, current forecasts might instead have a tendency to overestimate future increases, given recent evidence suggesting that demand for daily travel might have saturated in a number of industrialized countries (§1.1.4). Millard-Ball and Schipper (2011), for example, analyzing international time-series data from the 1970s to 2007 find signs of saturation in vehicle ownership in a number of industrialized countries. Even though the saturation levels vary across different countries, they are systematically lower than those estimated econometrically by Dargay et al. (2007).

1.3.4. *Geographical differences*

In a disaggregate study focused on cost-elasticity (the extent to which car ownership is sensitive to changes in motoring costs) Dargay (2002) observes that, in the UK:

> "car ownership in urban areas is twice as sensitive to car purchase costs as it is in rural areas (..). In addition, while car ownership in urban households is mildly sensitive to fuel costs, rural and other households appear to be totally price insensitive" (p. 361)

Similarly, the study shows that also income elasticity is lower for rural households (all other factors equal). These differences are ascribed by Dargay to the fact that car ownership is higher (and thus closer to saturation) in the countryside, as well as to the greater "car dependence" of rural areas: the car is "more of a necessary good" there (given the poor provision of alternative modes of transport), and thus "the possibility to adjust to increasing in motoring costs will be more limited" (p. 352). Matas and Raymond (2008), analyzing car ownership trends in Spain across the period 1980-2000, also observe that income elasticity is lower for rural households in 2000, although this has not always been so. Similarly Preisendörfer and Rinn (2003), reviewing car ownership models, point out that a common finding is the existence of interaction effects between income and type of area, whereby the effect of income is weaker in rural areas (p. 31).

According to Dargay (2002), these findings carry profound equity implications, for they show how policy measures aimed at reducing car use by increasing motoring costs would hit rural households harder. As a result, they should be considered as problematic from an equity perspective (see §1.6.6, §2.4.7).

In the context of this thesis this is an important point, as it shows that the drivers of motorisation manifest themselves in different ways across different types of area: this is something that will be explored in more depth in the empirical chapters of this thesis (see §6.1.2, §7.1.2). The possible equity impacts of sustainable transport policies will also be discussed: at the end of this chapter (§1.6) as well as in the next (§2.4.7).

1.3.5. *The "stickiness" of car ownership: asymmetry, hysteresis and ratchet effect*

While the estimation of elasticities is one of the main goals of car ownership modeling, most studies assume that the effect of an increase (in, say, income) are equal and opposite to the effects of a reduction (Goodwin et al., 2004). This is equivalent to assuming that the effects of rising and falling income on demand are 'symmetrical'. In recent years, however, an increasing number of studies has shown that this assumption does not hold.

Dargay (2001) applying a pseudo-panel methodology to cohort data for the UK (in the period 1970-1995), shows that "car ownership responds more strongly to rising than falling income" (p.807). This situation is defined by the author as one of hysteresis, whereby "the effect of rising income on car ownership is not totally reversed as income falls"[7] (2001, p. 809). This "stickiness" of car ownership appears also in relation to variables other than income: Bjørner and Petersen (2004), on the basis of a descriptive analysis of a large household panel data set in Denmark (spanning nine years), show that changes in household size and location have an asymmetric effect on vehicle ownership: whereas an increase in household size brings about an increase in the degree of car ownership of the household, equivalent reductions (due for instance to separation) do not result in a downward adjustment of the same magnitude. The same appears to be valid for people moving from urban to rural areas and vice-versa. In interpreting the results, Bjørner and Petersen suggest the possibility of a "ratchet effect" in car ownership, and refer to the notion of "state dependence" (whereby "past car ownership increases the probability of car ownership in the future", p.2)[8].

[7] There are signs that this might be the case also for car travel, although the evidence on this is inconclusive (Dargay, 2007)

[8] At the aggregate level, Gately and Huntington (2001) have studied the effects of changes in income on oil and energy demand in 96 countries across the world for the period 1971-1997. The results also show evidence of asymmetry, whereby oil and energy demand have increased more following increases in per-capita income than it has decreased following reductions. These findings suggest that the significance of notion of hysteresis goes beyond the domain of transport, and should be of interest to scholars studying energy demand.

In the field of car ownership modelling, the phenomenon of hysteresis has first and foremost a methodological relevance, because elasticity estimates are biased downwards if this asymmetry is not properly taken into account, and thus need to be revised upwards (Gately & Huntington, 2001). However, these findings have also been given substantive interpretations, and these are arguably revealing of the theoretical limitations of the econometric approach to motorisation. Both this topics will be discussed in the next section.

1.3.6. The need for complementary approaches

In her first paper on hysteresis in car ownership, Dargay (2001) interprets it as follows:

> "Rising incomes make it easier for households to own cars. They become *accustomed* to car use and this trend is not so easily reversed as income falls. The acquisition of a car is seen as a luxury, but once acquired the car becomes a necessity, so that disposing of a car is much more difficult. Car ownership is *clearly associated with habit and resistance to change*. Once the *habit* of motoring is acquired, it is not so easy to abandon, even if the economic consequences – in terms of alternative consumption foregone – are greater than previously. The existence of hysteresis is an indication of the difficulty of reducing *car dependence* in favour of other transport modes" (p. 819, emphasis added)

It is indisputable that hysteresis represents a serious challenge to efforts to contain or reduce car ownership. However, this passage shows clearly how this phenomenon is interpreted primarily in individualistic and psychological terms: the problem lies with individuals and their propensity to become accustomed to the convenience of the automobile. In a nutshell, it seems that with cars, as with drugs, "once you try it, you're hooked". In this context, both the psychological concept of habit and a micro-social understanding of the notion of 'car dependence' (see §1.4.1) are brought to the fore.

The role of habit in making car use behaviour resistant to change is a well-researched topic (Gärling & Axhausen, 2003), and there would be no point in denying that psychological processes play a role in explaining why households are reluctant to give up their cars. Economic constraints, such as higher transactions costs of selling a car as a private seller probably also play a role (Bjørner & Leth-Petersen, 2004, p.15). However, it is unlikely that this is the whole story, and it is reasonable to suggest that other relevant factors are at play. Indeed, countless scholars in the transport field have observed that the acquisition of a car significantly increases the activity space and the "travel horizons" of an household, and this can result in commitment to new activities – or in the choice of more distant (albeit more convenient) destinations for previous activities. To exemplify this point, let us consider a fictional example: a couple with a young child, following a salary raise, buys its first car. This allows them to enroll the kid in a primary school that is not close to home, and is difficult to access by public transport; however, the school enjoys a better reputation and thus seems a better choice. At the same time, the car allows the couple to do their shopping in a superstore that is more distant, but is cheaper and provides more choice. A few years later, the father loses his job, thus reducing household income considerably. Obviously, the couple will be reluctant to get rid of the car, as they have commited to patterns of activities that take place in areas that are difficult to access with other transport means.

This fictional account of how the automobile can change the activity space of an household is deliberately simplistic, but it helps illustrate why psychological constructs such as 'habit' are not sufficient to explain the 'stickiness' of car ownership. Indeed, the car allows the carrying out of activities which are inherently social, as well as located in space and time. However neither the social nor the geographical sides of the question are given adequate consideration in the psychological interpretation quoted above.

The fact that histeresis is often observed at an aggregate level (using cohort data that span decades, see Gately and Huntington, 2001) gives further strength to this argument: indeed, just as the activity spaces of households change with the acquisition of a car, so does society change its spatial and temporal organization under the influence of increasing motorisation. A wealth of studies in the urban and transport sciences have shown how the advent of private motorised transport has brought with it the dispersal of activities across the territory, as well as the restructuring of services on a larger scale (see §1.5.1, §4.1.1, §5.1.1). So for example, the increasing concentration of health care services in a few sites makes it more difficult for carless households to reach the nearest hospital than it might have been a couple of decades before (see SEU, 2003). In that sense, a single man who bought his first car at the age of 40 in 1970 might well be reluctant to sell it in 1995, when he experiences a decrease in salary (due to retirement). Even though it cannot be excluded that habit partly explains this resistance, it would be inaccurate to overlook the fact that the conditions of accessibility to services and opportunities have changed significantly across the period of reference.

In sum then, this discussion reveals four theoretical shortcomings of econometric car ownership modelling:

- first, the focus on the individual preferences, which is in accordance with the atomistic paradigm of economic science, leads to an overlooking of macro processes of change that happen at the societal level
- second, the focus on psychological (rather than social) explanations for household's behaviour, obscures the extent to which social relationships are embedded in car ownership and use
- third, even though geographical differences in elasticity are sometimes pointed out (§1.3.4), the significance of space for understanding increasing motorisation is not adequately thematized
- finally, car ownership modelling is based on regression models that assume unidirectional causality; accordingly, it struggles to come to terms with evidence showing that increasing car ownership *per se* brings about increasing car ownership, as the example of hysteresis shows (but see Kitamura et al., 1999). In this context, the concept of positive feedback might be an useful complement, as well as the concept of motorisation as a 'self-reinforcing' system (see §1.4.4). Similarly, both the notion of 'state dependence' and the observation by the Dargay that "for each income level we have two rather than one car ownership level" (2001, p. 813) reminds the concept of 'path dependence' (also see §1.4.4), which is often used in the social sciences to convey the fact that "history matters"

To conclude then, car ownership modelling has built a considerable body of knowledge, and several findings from this field are relevant in the context of the present thesis. However, it is my argument here that this approach to motorisation lacks a specific theoretical conceptualisation of the process of motorisation and its systemic properties. This is probably the result of the fact that the main goal of these studies has always been to predict the (ever increasing) levels of car ownership with greater accuracy, rather than achieving a thorough understanding of the macro-social process that brings about this seemingly endless growth. Accordingly, in the next section I turn to alternative and *complementary* approaches to the study of motorisation, which are able make up for the shortcomings illustrated above by framing 'car dependence' as a macro-social, systemic process.

1.4. "Car dependence": literature review

1.4.1. Car dependence: a disputed term

The term 'car dependence' (also 'car dependency' or 'automobile dependence') is used in a variety of ways within the academic and policy literature. In short, while in some cases it is an attribute of individuals, other times it refers to the dependence on the automobile of society as a whole, or to particular trips, activities or practices that are difficult to carry out without a car. This co-existence of different meanings has fostered recurrent complaints among scholars that the concept is not properly addressed or defined (see for example Gorham, 2002; Mo. Ve Association, 2008, p. 3). Lucas and Jones, for example, complain that:

> "the term car dependence is used in a multiplicity of ways in the academic literature to describe a broad spectrum of quite different kinds of car use behaviours and dependencies – which is confusing and unhelpful" (2009, p. 110)

Source	Concept	Definition	Level
Gorham (2002)	Physical / environmental car dependence	"the built environment (..) and the nature or status of collective transportation modes (..) causes an individual without a car to feel cut off from social activities, friends, family, businesses, shops, and work" (p. 109-110)	Macro
	Psycho-social car dependence	"emotional and behavioral associations with the car (that) render the individual reluctant to alter his or her association with it" (p. 110)	Micro
	Circumstancial car dependence	"the nature of the activities in which a household regularly engages renders it dependent on the car (..) the household adopts its lifestyle to the technological capacity of the car" (p. 110) "it might also be called economic or technological car dependence" (p .113)	Meso
Stradling (2003)	Car dependent places	"*places* where there are high per capita motor vehicle ownership, high per capita motor vehicle use, low land use density, single use-land development patterns, large amounts of land for roads and parking, road design favouring automobile traffic, large scale signage for high speed traffic, and reduced pedestrian environments" (p. 100-101, quoting Litman, 2002)	Macro
	Car dependent people	"we might want to call a person car dependent if they travelled a lot by car, or to reserve the term for those who did most or all their travel, however far or often they travelled, distinguishing those who felt they had no alternative and were unable to reduce their car dependence and those who could travel otherwise but eschewed all opportunity to do so, being unwilling to cut their car use" (p. 102)	Micro
	Car dependent trips	"the type of trips that is seems it would be the most difficult to transfer away from the car" (p. 102)	Meso
Mo.Ve Association (2008)	A car dependent city	".. one in which the car is very much the dominant means of transport for people, with public transport, cycle and foot accounting for only relatively small shares. It is a city which could not function if the use of cars, but no other vehicles, was suddenly to be severely restricted" (p. 19)	Macro
	Car reliance of individuals	"..when there is absolutely no alternative to the car for a particular journey" (p. 26)	Micro / meso
	Car dependence of individuals	"..implies depending on the car regardless of alternatives" (p. 26)	Micro
Lucas & Jones (2009, p. 116)	A car reliant trip	"when there is no other form of motorised transport available and the journey distance is too long to walk or cycle"	Meso
	A car reliant activity or journey purpose	"where it would be very difficult to make the journey another way because of carrying shopping or other heavy goods or undertaking a complex multi-destination trip"	Meso
	A car reliant location	"where it is virtually impossible to access a given location by any other mode of transport, or where it is impossible to live in place without a car (e.g. deeply rural village with no local facilities)"	Macro
	A car reliant lifestyle	"where it would be difficult to retain existing activity patterns and maintain a current way of life without the car"	Meso
	A car reliant person	"someone who would not be able to get around without a car, because of his or her limited mobility"	Micro
	A car convenient journey	"where the car is most convenient, as the alternatives are perceived as less attractive or unreasonable, due to additional cost or longer journey time, or escorting young children"	Meso
	A car dependent person	"someone who uses their car as a statement of status or for reasons of self-esteem or identity"	Micro
	A car addicted person	"a car fanatic, who talks incessantly about cars and whose whole life revolves around the need to drive"	Micro
	A car reliant society	"high and increasing levels of car use are observed among the population as a whole and where people without cars are excluded from essential activities"	Macro

Tab. 1.1 – Overview of some definitions and different understandings of "car dependence" in international literature reviews. Sources: Gorham (2002, p. 109-113), Stradling (2003, p. 100-102), Mo.Ve Association (2008, p. 19, 26), Lucas & Jones (2009, p. 116).

In this section, I will first show that this variety of meanings can be better disentangled by drawing on long-established sociological concepts such as ‘micro-level’ vs ‘macro-level approach’ and ‘agency’ vs ‘structure’. In doing that, I will discuss the advantages and the disadvantages of each approach[9]. Subsequently, I will argue that a macro-social understanding of motorisation as a systemic process is the more useful in the context of this thesis. Accordingly, in the following sections (§1.4.2 to §1.4.4), I will extensively review three bodies of work in this vein. In a subsequent chapter (§3.1) I will put forward an integrated working definition of car dependence, wich draws largely on these works and has constituted the basis for the empiical work[10].

Tab. 1.1 shows some of the different definitions and understandings of car dependence that are found in the international literature. Although most of the sources quoted in the table consist of literature reviews, meant to summarize existing definitions and to put forward a few, well-distinct categories, the variety of competing categorizations is still staggering . In the last column, I indicate whether the definition corresponds to a micro-, macro- or meso-social level understanding of car dependence, according to my own categorization.

The micro-social understanding of car dependence is perhaps the most widespread, and the closest to common sense. In this perspective, it is an attribute of the individual, who is considered to rely or depend on the car. There is no agreement, however, on who should be considered car dependent. Farrington et al. (1998, quoted in Stradling, 2003), for example, make a distinction between two kinds of (micro-level) car dependence: structural dependence (for “those who are dependent on the car because there are no viable alternatives”) and conscious dependence (for “those who rely on their vehicle but could realistically undertake their journeys by alternative modes”). Similar distinctions are very common in the literature, as illustrated in Tab. 1.1.

A conceptual discussion of this opposition is instructive about the nature of the micro-social approach to car dependence. What structural and conscious car dependence (to adopt the Farrington’s terminology) have in common is that they correspond to resistance to change, whereby individuals are very unlikely to use other modes of transport. The source of this resistance, however, could not be more different: while a “structurally dependent” individual *might want* to use other modes, but *can not* do it, a “consciously dependent” individual *can* travel by other modes, but *does not want* to. Central to the distinction is the presence or absence of *choice*. In sociological terms, then, the micro-social understanding of car dependence is concerned first and foremost with individual agency (or lack thereof).

Because of its emphasis on choice, the micro-social understanding of car dependence can be considered as a paradigmatic example of what Shove (2010), with reference to climate change policy, has defined the “ABC” paradigm. In this perspective:

> “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. The ABC model, derived from a strand of psychological literature grounded in theories of planned behaviour (Ajzen, 1991) and in variously rational concepts of need (Gatersleben & Vlek, 1997), resonates with widely shared, commonsense ideas about media influence and individual agency” (p. 1274)

If we reinterpret the micro-social understanding of car dependence in the light of this paradigm, we observe the following: in “conscious” dependence, the resistance to change is motivated by “pro-car” *attitudes*, that prompt individuals to *choose* car use (*behaviour*), regardless of other circumstances (availability of other modes, etc.). By contrast, in the case of “structural” dependence, the problem does not lie with attitudes, but rather on “external” factors that actually prevent choice. Such factors usually appear in the ABC model under

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[9] Notably, in this section I stress the limitations of the micro-social understanding of car dependence. This rethorical device serves to introduce the macro-social approach to car dependence that is adopted in this thesis. However, this should not be taken to mean that there are no merits to the micro-social approach, nor that there are no limitations to the macro-approach. Notably, it is not my intention to claim the superiority of an ‘old fashioned’ structuralist approach.

[10] It is important to emphasise that in this section I discuss different *theoretical* understandings of car dependence, and not different *methodological* approaches to the study of car use. In fact, there is no clear correspondence between the two levels. While many studies focused on pro-car attitudes employ qualitative methods, many others (such as for example the studies on ‘soft transport policy measures’, see §1.6.5) use the quantitative methods developed by psychologists. On the other hand, while this study adopts a macro-social understanding of car dependence and employs quantitative methods, other approaches are possible. For instance, most empirical works inspired by the notion of ‘automobility as a system’ (Urry, 2004) have adopted a qualitative approach.

the label of ‘contextual factors’, often in the role of ‘barriers to change’ that prevent an effective translation of pro-environmental attitudes into pro-environmental behaviour[11] (Shove, 2010).

It is my argument here that the micro-social understanding of car dependence suffers of several limitations, many of which it shares with the ‘ABC’ paradigm. First of all, the coexistence of two rival understandings of the car dependence of individuals (structural vs. conscious) is highly confusing. Indeed, if both being unable and being unwilling to use alternative modes correspond to ‘car dependence’, the concept loses all specificity and ends up covering the entire spectrum of ‘car use’.

Secondly, even if one were to opt for one of the two understandings, delimiting the concept of car dependence is still likely to be extremely difficult. Indeed, in both definitions the availability of alternative transport modes is crucial. In most concrete situations, however, people will be located somewhere along the *continuum* between the two ideal types: that is, alternatives to the car (almost) always exist, but are often judged not viable, reasonable or convenient by the individuals. As Zhang (2006) puts it:

> “If asking an ordinary citizen why she or he drives so much, most likely one would get an answer such as, “I have to” or “What else can I do?” *Lack of viable alternatives to driving is a main reason (or excuse) for many to drive for their daily activities*” (p. 311, emphasis added)

As it is obvious to everyone, judging what is a valid reason and what an excuse is an inherently normative endeavor, and thus not one that can be settled in an objective way. As Gorham puts it “defining lifestyles that are “car-dependent” is particularly problematic, since doing so implies value judgements that transport analysts are frequently reluctant to make” (2002, p. 109). To further complicate things, a wealth of qualitative empirical studies show that in most cases car use is justified by the need for ‘convenience’, ‘comfort’ and the like. These notions however are social constructions that are not fixed in time: indeed, they have evolved spectacularly over the last few decades, together with the practices that they sustain (Shove, 2003). Crucially, for example, notions of convenience and comfort in travel have evolved hand in hand with the diffusion of the car, as people have come to appreciate and expect the kind of “semi-private” travelling environment that the car provides (Urry, 2006). Considerations of this kind, however, are rarely found in studies with a micro-social understanding of car dependence, that tend to take the meaning of concepts such as ‘comfort’ and ‘convenience’ for granted. In that sense, as Shove argues, “while social norms are often cited as driving factors, there is no scope at all for wondering about how needs and aspirations come to be as they are” (2010, p. 1277). This can be regarded as a first blind-spot of a micro-social approach to car dependence.

Third, as said, this understanding focuses first and foremost on attitudes, choice and behaviour at the individual level. While it provides a framework to conceptualize the relationship between these elements, it is less effective when it comes to deal with other, more structural factors. As Shove argues, the generic concepts of “contextual factors” and “contextual barriers to change” are “catch-all variables” where very different factors (virtually everything ranging from the built environment to the ambiguous concept of “habit”) are blurred together (2010, p. 1275). Of course, it is in the nature of analytical concepts to draw attention to certain elements, while giving less attention to others: indeed, most human thinking is based on such processes of simplification. In that sense, framing car dependence in terms of individual attitudes and choice would be a sensible move if it could be assumed that “other” (so-called contextual) factors have a negligeable influence on behaviour. This does not seem to be the case for car dependence: indeed, this is probably the very reason why the concept of car dependence is so widely used and immediately appealing. As Shove puts it, “by focusing so exclusively on individual action, such enquiries miss the bigger picture” (2003, p. 4) or, in sociological terms, the excessive focus on individual agency makes this approach ill-suited for apprehending the complex web of powerful structural constraints that underpin car ownership and use. Therefore the micro-social understanding of car dependence cannot be the sole approach to car use, and needs to be complemented by alternative approaches, more suited to shed light on those structural constraints.

[11] Indeed, “contextual factors” is the ‘C’ in the “original” ABC model of environmentally significant behavior put forward by Stern (2000).

Macro-social understandings of car dependence provide a welcome antidote to the shortcomings of the micro approach. A typical definition of a "car dependent city" is the following:

> ".. one in which the car is very much the dominant means of transport for people, with public transport, cycle and foot accounting for only relatively small shares. It is a city which could not function if the use of cars, but no other vehicles, was suddenly to be severely restricted" (Mo.Ve. Association, 2008, p. 19)

It is apparent that here car dependence is an attribute of a (local) society as a whole, rather than of an individual. The accent here is on structural factors (in this case the built environment) that sustain and reproduce increasing reliance on the car of the whole (local) society, and thus explain why it is difficult to bring about change. In sociological terms, this approach is thus much closer to the paradigm of structure rather than to the paradigm of agency. Accordingly, the reasons behind individual choices are given little attention, since it is more or less explicitly assumed that "people drive mostly because they have no alternative" (Newman et al., 2009, p. 84). Such an emphasis on structural factors has prompted criticism, which tellingly resonates with the arguments that for decades, in the discipline of Sociology, advocates of the paradigm of agency have addressed to followers of the paradigm of structure. Gorham (2002) for example criticizes the work of Newman and Kenworthy on 'automobile dependence' (see §1.4.2) in the following way:

> "…all of the attributes of the car-dependent city relate in one way or another to the physical development of the city (..) the implication (..) is that (..) the actual built environment determine behavior (..). (However) households can be said to be participants in the dynamics of land use change, rather than passive victims of land use (..) They actively engage in the construction of their built space, and the more they do so, the more bound they are to the very tool of that construction, the car. The cycle of dependence is so hard to break precisely because of the active role that households have in building it up in the first place. In the loop of car dependence, households are active victims, or passive victimizers, depending on one's perspective"[12] (Gorham, 2002, p. 108-109).

Most of the research works that employ a macro-social understanding of car dependence focus on the structural constraints brought about by land-use and the built environment, given their alleged prominence in determining the mobility of people. So for example Gorham (2002) talks about "physical / environmental car dependence", Stradling (2003) points to "car dependent places" and Lucas and Jones (2009) mention "car reliant locations" (cfr. Tab. 1.1) in their typology of understandings of car dependence. However, it is my argument here that the approaches that focus exclusively on the built environment should be conceived as just a subset of the macro-social understandings of car dependence. In the next sections, which present different contributions in this vein, I will show that while some authors focus predominantly on land-use (§1.4.2), others take into account a much greater variety of factors (§1.4.4).

Even though micro- and macro-social understandings of car dependence account for the great majority of the research work carried out on the topic, there is a third understanding that is worth mentioning in this context. Several authors have used car dependence as an attribute neither of individuals nor of societies, but of trips and related practices and activities. For example Goodwin (1995) introduced the idea of 'car dependent trips', meaning:

> "tightly constrained journeys for which a car is simply the only mode available, or the only one which is fealt to be feasible, because the traveller is disabled, or has children, or heavy shopping, or feels insecure, or has no information about alternatives" (p. 151)

While not all the examples mentioned by Goodwin are relevant here, the reference to shopping and travelling with children is of particular interest. In a similar way, Gorham (2002) cites as an example of "circumstantial

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[12] Although I do not expand on this point, this quote highlights a major shortcoming of the macro-social understanding of car dependence, namely that it overlooks the role of individual agency in reproducing and sustaining existing car-oriented social (and spatial) structures. In that sense, I do not mean to argue that the micro-social understanding should be abandoned in favour of a macro-social approach. Rather, I argue that the two approaches should be: a) well distinguished from a theoretical point of view b) considered as complementary in empirical research.

car dependence" (whereby "the nature of the activities in which a household regularly engages renders it dependent on the car", p. 110) the case of a "freelance string bassist", whose very job is dependent on car availability, given the weight of the bass and the unavailability of instruments at the workplace (p. 113). In all such cases, 'car dependence' is an attribute of *trips* or rather, more precisely, of the related activities or practices. Indeed, several empirical works on car use show how households find it especially hard to give up the car for shopping trips, regardless of their attitudes towards car use or of the built environment. This observation invites to research more in depth why and how some activities have become so strictly dependent on the automobile. In this context, might be helpful to draw on social theories of practice.

The concept of 'social practice' has a long history and its origins can be traced back to a number of authors (Giddens, 1984; Reckwitz, 2002; Shove et al., 2012). While there exist a variety of approaches to social practices, an essential common feature is that they turn the assumptions of behaviourist approaches upside down: 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 et al., 2012, p.7). From this point of view:

> "understanding social change is in essence a matter of understanding how practices evolve, how they capture and lose us, their carrriers, and how systems and complexes of practice form and fragment" (Shove, 2010, p. 1279)

More recently, Shove and colleagues (2012) have put forward a deliberately simple framework for the study of practices, whereby they consist of three kinds of elements (materials, competences and meanings), which are integrated when practices are performed. In 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 could be: how has shopping come to depend so much on the availability of a vehicle? How have the materials, competences and meanings once involved in daily shopping changed in this transition? Is it possible to encourage a new transition, in order to break the links between the car and other elements of shopping as an integrated practice?

While this might sound like an intriguing research direction, it is not one that will be pursued here[13]. I mention it here because it allows me to show how theoretical debates about care dependence mirror broader debates about the role of agency in structure in society. Indeed, this approach to car dependence would represent a kind of compromise between the micro and the macro approach described above. As a matter a fact, the social practice approach makes it "possible to describe and analyse change and stability without prioritizing either agency or structure" (Shove et al., 2012, p.22), because the agency of individuals is constrained by the features of existing practices, but these latter are in turn incessantly reproduced (and slightly modified) by the performances in which individuals take part in everyday life. In that sense I define this as a meso-level understanding of car dependence.

In the rest of this section, however, the focus will be on macro-social understandings of the process of car dependence. The reason for this is twofold: first, I believe that, as Lucas and Le Vine (2009) put it:

> "we live in a car-dependent society, where many of our daily economic and social activities would be impossible without the car and it is within the context of this 'whole system' that individual car use behaviours needs to be understood" (Lucas & Le Vine, 2009, p. 41)

Secondly, the macro-social understanding *allows to integrate in a single framework the social and the environmental consequences of increasing motorisation* (see §3.1). This would not be possible if I adopted a micro- or meso-social understanding of this notion.

[13] In this section, for the sake of brevity, I do not elaborate on the limits of the meso approach. However, it is important to stress that the reason why I do not adopt this approach in this thesis have nothing to do with these limits. The choice of a macro-social understanding of car dependence is justified by the need to make the connections between the environmental and the social consequences of increasing motorization.

Therefore, I will first proceed to review some theoretical contributions to the understanding of car dependence as a macro-social process. This is a large field, as many scholars in the urban and social sciences have analyzed the macro-social, systemic and self-reinforcing properties of motorisation: in doing that, however, they have used a variety of notions, such as 'automobile system' (Dupuy, 1995), 'car system' (Dennis & Urry, 2009), 'automobilisation' (Kuhm, 1997), 'automobility' (Urry, 2000; Urry, 2004; Sheller & Urry, 2000; Beckmann, 2001; Böhm et al., 2006) and 'automobile dependence' (Newman & Kenworthy, 1989; 1999; Dupuy, 1999a; 1999b; Héran, 2001; Litman, 2002). This understanding is thus not always conveyed by the term car dependence, as several rival terms exist in the literature, and notably the concept of automobility (Urry, 2000; 2004; Sheller & Urry, 2000) has been increasingly used in recent years.

For this reason, the choice to use the "old-fashioned" concept of car dependence requires an explanation. I thus argue that this notion has a number of advantages:

- first, in contrast to other terms, the word 'dependence' is particularly appropriate to stress the dynamic nature of the process. As Goodwin (1995) argues, both at the individual and at the societal level, "car dependence is a process, not a state" since it "grows, rather than simply existing" (p. 152). As a consequence, "the idea of car dependence at a point in time is almost meaningless (and) the concept can only be addressed in terms of change over time" (*ibidem*). Crucial in this context are the positive feedbacks and the self-reinforcing dynamics of this process: in societies around the world, it seems that the sheer force of 'more motorisation' creates the preconditions for further motorisation. This is a crucial point, and one which the concept of car dependence allows to grasp more clearly
- second, concepts are not born in a political vacuum: accordingly, the term car dependence is meant to stress the resistance encountered by policy measures aimed at reducing car use and ownership. In that sense, it is generally used "as testimony of the difficulty of moving away from the car system, despite the increasing awareness of the negative externalities" (Mo.Ve. Association, 2008, p. 3). In that sense, it is closely related to the notion of "path dependence", since both convey the idea that "history matters" and "the extent to which existing technologies and practices structure the avenues of future development" (Shove, 2003, p. 12). Of course, the path-dependent properties of the process of motorisation, which account for its resistance to change, are not without relation with the self-reinforcing tendency illustrated above
- finally, it is often observed that the term 'dependence' has a negative meaning. Particularly in the context of a micro-social understanding of car dependence, this has fulled a recurrent debate: many scholars have expressed the concern that the term "dependence" may be too emotive and too "demonising", insofar as it suggests a "pathological behaviour" on the part of car users (Lucas & Le Vine, 2009, p. 40). For this reason, several authors have proposed to differentiate between "reliance" and "dependence" on the car (see Tab. 1.1), apparently in order to set apart individuals who deserve to be morally condemned for their "excessive" car use from those who do not. By contrast, focusing on a macro-social understanding of car dependence makes these concerns irrelevant: indeed, I argue that the negative meaning of the term is here well deserved, since it is meant to stress how society has come to rely on a mode of transport which is responsible for huge externalities (§1.2), and how such trends prove extremely resistant to change

Having made clear the theoretical implications of using a macro-social understanding of 'car dependence' as a key concept in this thesis, in the next few section I briefly summarize three bodies of work that I consider particularly relevant: the works of urban planners Newman and Kenworthy, who popularized the term at the end of the 1980s (1989; 1999); the writings of British sociologist John Urry and his research team on "automobility" (Urry, 2000; 2004; Sheller & Urry, 2000; Dennis & Urry, 2009); and finally, the work of French scholar Gabriel Dupuy, who applied the concepts of club and network effects to the automobile sector (1999a; 1999b).

1.4.2. Newman and Kenworthy: automobile dependence as an urban planning issue

Although the use of the term 'automobile dependence' dates at least from the 1970s (see for example Carpenter, 1979), environmental scientist Peter Newman and his research group are ultimately responsible for popularising the term at the end of the 1980s, with the book "Cities and Automobile Dependence. An International Sourcebook" (Newman & Kenworthy, 1989), that summarised ten years of comparative work on a database of thirty-two metropolis around the world. This work has subsequently been updated in 1999, with the publication of "Sustainability and cities: overcoming automobile dependence" (Newman & Kenworthy, 1999), that has expanded the analysis to sixteen additional towns. In this section, in order to summarize the approach of Newman and Kenworthy to car dependence, I will refer mainly to the latter work.

Although Newman has often been criticised for not offering a proper definition of the concept (see for example Gorham, 2002, p. 108; Héran, 2001, p. 3-4), it is possible to detect a very clear understanding of automobile dependence in "Sustainability and Cities". Newman and Kenworthy define it explicitly as a "a situation in which a city develops on the assumption that automobile use will predominate" so that it is given priority in its design, infrastructure and operation (1999, p. xiii, 60). In that sense, it manifests itself as "a combination of high car use, high provision for automobiles, and scattered low-density use" (p.124). It is thus a pathological and addictive state ("an urban sickness") where "the problem is (..) not the automobile in itself but an overuse of and dependence on it"[14] (p. 60). As a result "other modes (..) become increasingly peripheral, marginal or nonexistent until there are no real options for passenger travel other than the automobile" (p. 334).

The starting point of the authors' analysis is the famous Zahavi's conjecture of (aggregate) travel time budget (TTB) stability across societies and time periods (Zahavi & Ryan, 1980; Mokhtarian & Chen, 2004). According to this perspective, at the aggregate level, when travel speeds increase due to the introduction of a new kind of transportation technology, travel distances tend to increase while travel times remain approximately constant, because people take advantage of the additional speed to travel further. Newman and Kenworthy thus identify three main (ideal)types of cities that have followed one another across human history (1999, p. 27-33): first, the walking city (from the neolithic revolution until the middle of the nineteenth century), defined by small size, high density, mixed land use and narrow streets. The transit city, that emerges from about 1860s in the then industrialising countries, is larger in size (up to thirty kilometers wide), accomodates more people and stretches outwards with train (or tram) routes: along the latter, medium-density, mixed use nodes are found next to transit stations. When the car becomes the predominant mode of transport, it gets then possible for cities to increase in size even further and, more importantly, to spread in any direction: the automobile city is thus defined by a decentralised and dispersed pattern of low-density (suburban) housing and by the separation of urban functions through zoning. The consequences of this evolution are enormous, since the automobile city breaks down the connection between land use and transportation that had been the rule ever since the first cities. In the authors' words, "for the first time in history, houses and businesses could be located almost anywhere, because personalized transportation could be used to join them together" (p. 64); on the other hand, car use is increasingly necessary in order to overcome the distances produced by this "ungluing" process. Increasing car use then brings about more pressure to provide for more car-oriented infrastructure, often with the aim of mitigating congestion: this in turn results in higher speeds and thus in "induced traffic" and further dispersal of the city. This is the fundamental mechanism that produces automobile dependence according to Newman and Kenworthy.

Building on this theoretical framework, the authors analyse their database on global cities in order to prove the link between urban density, car use and transport-related energy use (p. 68-111): their result show strong correlation between the three factors at the aggregate city level, with sprawling, car-dependent cities in North America and Australia consuming considerably higher shares of energy for transport, whereas compact, denser urban areas in Europe and Asia perform better in this respect. In that sense, automobile dependence constitutes a major threat in the light of issues such as oil depletion, climate change, and thus urban sustainability.

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[14] Although Newman and Kenworthy insist that the problem is not car use per se, but rather "excessive use" (1999, p. 60), they do not provide any clear definition of the threshold that should be used to define car overuse.

Complementary to this account is the concept of 'institutionalized automobile dependence' put forward by Newman and Kenworthy, which highlights the role of a number of institutions and professional praxis in constantly re-producing the conditions leading to increasing car use. Examples of the relevance of institutional arrangements and regulations in fostering car dependence are, among others (p. 62-63, 138-139): the institutional separation of transportation and planning agencies; mechanisms for funding that are biased in favour of road construction rather than transit; hidden and taken for granted subsidies to automobiles and road expansion; a transportation system that is demand-responsive rather than demand-management-oriented; lack of strategic planning at an appropriate scale; planning processes that have built-in subsidies in favour of capital investment on the urban fringe.

As far as (modernist) professional praxis is concerned, the authors observe that, since its establishment as a distinct area of expertise in the 1950s, land/use transport modelling has been strongly associated "with planning for roads and cars rather than a balance of transportation modes"[15] (p. 139). The (in)famous "predict and provide" approach was also born at this time, with the distinctive purpose "to plan for anticipated growth in population, jobs, and traffic flows as far as ahead as twenty years, so as to ensure an equilibrium between the supply of transportation facilities and demand for travel as it arises out of land use" (*ibidem*). However, failure to recognise the phenomenon of "induced traffic" has set in motion "a vicious circle or self-fulfilling prophecy of congestion, road building, sprawl, congestion and more road building" (p. 140), that in this perspective is a crucial driver of automobile dependence[16]. The computerised transportation planning methodologies that have been exported from the West to the rest of the world since their inception, have also brought with them a strong bias toward car-oriented mobility (p. 163), compounded by inability to provide an accurate picture of the travel and environmental consequences of alternative strategies (Wachs, 2002).

Thus, according to Newman and Kenworthy, the "black box" nature of institutional arrangements, regulations and professional praxis that are "acquiescent to "unavoidable" increases in automobile dependence" (Newman & Kenworthy, 1999, p. 340) often gives rise to "a situation of "forgotten" alternative options, due to a quick (a priori selective) generation of options" (van Geenhuizen et al., 2002, p. 9). This is increasingly seen as problematic, as new, sustainable transport policies meet strong resistance on the part of the "institutionalised automobile dependence" complex[17] (see Newman et al., 2009, p. 142-147).

On the basis of the analysis conducted, Newman and Kenworthy suggest then five main policies in order to overcome automobile dependence (p. 144): traffic calming; providing alternatives to the car (quality transit, bicycling and walking); creating dense "urban villages" linked to good transit; growth management to discourage urban sprawl and redirect development into urban villages; taxing transportation in order to internalise the externalities of car use and finance the previous policies.

In sum, two features of Newman and Kenworthy's understanding of car dependence are particularly prominent: first, the appropriate scale at which to analyse this process is the urban area; the micro-level choices and behaviours of urban dwellers are by contrast worth little attention, since in this perspective – as Newman and colleagues explicitly state in a more recent work – "people drive mostly because they have no alternative" (Newman et al., 2009, p. 84). Second, even though the relevance of economic and cultural priorities is recognised, the main focus of the analysis is here on the relation between urban land use (form and density), car use and energy consumption, under the assumption that transportation priorities are one the (if not *the*) most important factor in shaping cities (Newman & Kenworthy, 1999, p. xiii, 27). In this perspective, car dependence is primarily an urban (planning) issue to be resolved as such, and the authors

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[15] On this point, see for example Brown (2006) and Schmucki (2003).

[16] In short, the notion of "induced traffic" means that "under certain conditions the provisions of new road space could induce car owners to make journeys they otherwise would not have made" (Walton, 2003, p. 81). In that sense, it points at the fact that the level of car usage is not independent of the amount of road space, as generally assumed in the predict-and-provide approach (*ibidem,* see also SACTRA, 1994).

[17] The remarkable scale of this kind of resistance in the U.S.A. has prompted New-Urbanism activist G.B. Arrington to say that "most transit-oriented development in the U.S. is illegal" (quoted in Newman et al., 2009, p. 142). Less emphatically, Schweitzer and Valenzuela have stated that "the existing legal and planning context of transportation in the United States may not lend itself well toward the resolution of international environmental problems" (Schweitzer & Valenzuela, 2004, p. 392). For some examples of institutionalized automobile dependence in the UK, see Docherty & Shaw (2003).

constantly stress the significance that policies and appropriate planning actions could have in changing the situation and “overcoming automobile dependence”. In that sense, Newman and colleagues seem to be driven mainly by what Héran defines “the natural inclination of urban planners to stress the consequences of choices that concern them directly” (2001, p. 9).

1.4.3. Dupuy: the club effect

French scholar Gabriel Dupuy (part engineer part human scientist) has proposed an original explanatory model of car dependence, by adapting to the automobile sector the concepts of club and network effects, usually applied to telecommunications (1999a, 1999b). His main attempt is to measure the positive effects produced by the automobile system, building on the basic idea that “what a person gains by joining a club (or a network) depends on all its present members (those already in the network)” (1999b, p. 2) and that “to belong to the (automobile) system has become essential, and to a large extent it is the fact that many others are in the system that motivates us to enter it (or to remain in it)” (p. 12). In this perspective, what makes automobile dependence strong and extremely difficult to overcome, despite its negative effects, is the cumulative interaction of a club effect, a fleet effect and a network effect, that produces considerable positive effects to the car driver in terms of accessibility (measured by comparing the situation of non-car users)[18]. This process results in a considerable pressure to enter the automobile system for those who are outside of it, which in turn increases as the number of members increases, thus bringing about a self-reinforcing process.

First, the club effect is related to the obtaining of a driver’s licence, and is measured by Dupuy by comparing the situation of those who do not have it: the related benefits are thus measured by “the increase in accessibility as shown by the difference between the maximum speed authorized to licensed drivers and that authorized to non-licensed drivers driving “voiturettes””[19] (p. 4). It is assumed in this perspective that this difference depends on the proportion of licensed drivers in the population, since Automobile Clubs collaborate with public authorities in establishing the highway code. In that sense, Dupuy estimates that “an increase of 1% in the number of driver’s licence owners (..) leads to (..) an actual accessibility advantage of approximately 0,8%” (p. 5).

Second, the fleet effect is related to the fact that “the benefit of owning a car increases as the number of cars already on the road (the fleet) increases” (p. 5). That happens because there is a direct proportionality between the number of services offered to car drivers and the number of registered cars. Even if Dupuy limits its analysis to intra-sectorial effects (those internal to the automobile sector, such as car dealers and agents), he argues that also other services such as car parks, shopping centres and cinema theatres “seem to spring up according to the same principle” (p.6). In that sense, an increase of 1% in the fleet of cars will correspond to an increase of at least 1% (but probably much greater) in the accessibility of services provided to the car owner.

Third, the network effect entails that the benefit that the car driver will gain on entering the road network depends on the number of drivers already using it. In fact (apart from congestion, which is a relatively minor and short-term phenomenon) “the denser the traffic on a road network, the more money is devoted to improving that network” (p. 8), often with the declared aim of easing congestion or improving security or environment[20]. Moreover, the budget for road investment is often supplied, at least in part, by taxes levied on consumptions (fuel, car, oil, etc.) that are to a great extent proportional to road traffic. Improvements bring about increased possible speed on those parts of the network with the heaviest traffic, thus resulting in

[18] The definition of accessibility provided by Dupuy refers to “both the possibility of reaching a place or specific service within a given amount of time and the choice of available destinations from a given point within a given travel-time” (1999b, p.3).

[19] “Voiturettes” are small cars that, according to French law, can be driven by those who do not have a driver’s license but cannot go faster than 45 km/h (Dupuy, 1999b, p.3-4). Dupuy justifies this choice by pointing out the technological similarity between the car and the voiturette and by arguing that “the door-to-door difference in speed between a regular car and a voiturette corresponds, on average, to the difference of speed between a car and public transportation” (p.4).

[20] This is precisely the predict and provide approach that has been described in the previous section (§1.4.2).

increasing (albeit sometimes temporary) benefits for the car-driver and, accordingly, in an increasing pressure to join the automobile system (or not to leave it)[21].

Those three effects tend to accumulate and reinforce each other, resulting in a considerable global positive effect: Dupuy estimates that "all things being equal, in France, a 1% increase in motorization gives the driver an accessibility gain of close to 1,9%" (p. 11). If it is assumed that demand would react to the increase in accessibility with an elasticity of 1, the effect would then be much greater than that of factors usually considered as crucial such as the price of fuel, the cost of using a car or household income (*ibidem*).

In this context, the term 'car dependence' refers both, more generally, to "a virtuous (..) circle of positive effects spurring from the growth of the automobile system which, in turn, generates negative externalities" (p. 12) and, more specifically, to a extra-sectorial negative externality that affects "those who cannot enter the automobile system, (..) who are obliged to leave it (and) drivers unable to use their cars because of a serious and prolonged energy or environmental crisis"[22] (*ibidem*). In that sense, Dupuy puts the question of the inequity between car drivers and the rest of the population at the very centre of the dynamic process of car dependence: this is a very important point, that will be further developed in this thesis (§3).

Implicit in this approach is also the idea that car dependence is a phenomenon that spans well beyond urban boundaries, and should thus rather be studied at a scale appropriate to the size of the car system: that is, the national or even global scale (1999b, p.15,16). This means that policies that focus on the urban level such as those put forward by Newman and Kenworthy are unlikely to be effective. Dupuy thus recommends then three possible alternative ways to reduce automobile dependence (p.15): first, diminishing the club effect by authorizing different categories of drivers to drive different categories of vehicles (such as mini-cars) at different speed. Second, implementing short-term rental and car-sharing schemes, in order to reduce the fleet effect. Third, building a road network with more, but less rapid, roads, that correspond more closely to the desired lines of travellers: this would be beneficial in order to hamper the network effect. Finally, limiting the expansion of the road network, thus actually giving up the 'predict and provide' approach.

1.4.4. Urry: automobility as a system

British sociologist John Urry and his Lancaster-based research team have put forward the concept of automobility (or "car system"), which in many ways can be equated to that of car dependence as a macro-social process (Urry, 2000; 2004; Sheller & Urry, 2000; Dennis & Urry, 2009). In this perspective, the car system owes its continuing expansion to its being a phenomenon that spans across almost all main spheres of contemporary social life: production, consumption, resource use, geopolitics, form of human settlements, state regulations, family life and culture. Particularly relevant in this respect are its 'mundane' character and the spatial and temporal effects on daily lives of the increasing access to car mobility.

In their book "After the Car" (2009), Dennis and Urry situate explicitly their approach at the intersection of complexity sciences, system thinking and path dependence theory. Complexity thinking, in particular, "investigates systems that adapt and evolve as they organize themselves through time", and argues for the necessity to take into account their processual nature, abandoning the notion that systems naturally tend to equilibrium (p. 49-52). Accordingly, it is important to focus not only on negative feedback loops (that re-establish equilibrium within a system) but also on positive-feedback loops (or increasing returns), that "occur when a change tendency is reinforced rather than dampened down": as a consequence "over time, networks may bear no tendency to equilibrium" and produce a long-term irreversibility that is predictable, but extremely difficult to reverse (p. 54-57).

[21] According to Dupuy , already in the 1960s the American oil industry and road engineers were aware of the existence of what they named the "magic circle" of automobile development. For instance in 1966 Asphalt Institute Quarterly observed that "the increase in automobile traffic led to the expansion of the road network, thus encouraging car owners to drive more, more people to buy cars, an increase in traffic was once again followed by the growth of the network and so on and on" (1999a, p. 1).

[22] It is important to state that the three effects described by Dupuy may as well be relevant for other modes of transport (such as public transportation), provided of course that they reach a critical threshold (Dupuy, 1999a, p. 13; Héran, 2001, p. 6)

A striking historical example of this dynamic is precisely "the twentieth century growth of (positive) externalities in the spread of the car system" (p. 55): in this context, the predict and provide approach, whereby the car "seems to provide the solution to the problems of congestion that it itself generates" (p. 59), is a prime example of positive feedback. In that sense, the notion of increasing returns is connected with the concept of 'path dependence', that conveys the idea that socio-technical systems often become "locked-in" on a specific evolutionary pattern as a result of a series of events that, even if maybe minor and contingent, significantly influence their subsequent development (p. 59).

The car is exactly one of such path-dependent systems, locked-in since the late nineteenth century when "small causes occurring in a certain order (..) turned out to have irreversible consequences" (p. 63). Even its petroleum-based domination is, according to the authors, rather accidental, since battery-powered electric cars were probably more efficient at the time (p. 28-33). However, once locked-in, its system nature has enabled it "to adapt and to evolve, becoming central to, and locked in with, the leading economic sectors and social patterns of twentieth century capitalism" (p. 132). In that sense, the car system is paradigmatic of other related high-carbon systems that, in the light of issues such as oil depletion and climate change, are perceived today as increasingly problematic.

The key features of the car system, that explain its power and ability to constantly drive out competitors, are to be found primarily in its many interlocking dimensions. The car is in fact, at the same time (Dennis & Urry, 2009, p. 36-38; Urry, 2000, p. 57-59): a mode of transport; a major manufactured object, crucial for the main industrial sectors of twentieth-century capitalism; an item of individual consumption; a complex with countless technical and social interlinkages with other industries and institutions; a dominant culture; the ultimate cause of massive environmental resource use. In that sense, the car system should be considered as made up not only of vehicles, but also of things as diverse as "humans (driver, passengers, pedestrians), machines, materials, fuels, roads, buildings and cultures" (Dennis & Urry, 2009, p. 63), all of which contribute to its reproduction.

On the other hand, "the absolutely key feature of the car is its mundane character, its significance for ordinary, everyday social life" (p. 39), i.e. its being "a way of life and not just a means of transport" (p. 35). The reinforcing pattern of the car system has affected social life so much that the latter is now "irreversibly connected to the mode of mobility that automobility both generates and presupposes"(p. 57-58). The growth in automobility has in fact involved new kinds of movement, additional journeys and routes, and is thus to be considered "much more than the historical replacement of public transport journeys by car journeys": in that sense, it is possible to talk of "socializing automobility" (p. 39-40). Particularly important in this context are the spatio-temporal effects of the car-system: the automobile has in fact brought about increasing fragmentation (or "disembedding") of space, which in turn requires the use of a vehicle – and a much more reflexive organisation of time – to be suitably re-embedded[23] (see also Beckmann, 2001).

However stable and unchanging it may seem, according to Dennis and Urry, the current car system has been moved into "a chaos point, a state of self-organized criticality" (2009, p. 60) and will thus end at some stage during the current century (p. 12). The reasons for that are four major processes – climate change, oil peak, increased digitization and massive global urbanization – that are increasingly undermining the continuation of the high-carbon societies of the twentieth century, and thus also the car system (p. 131-132). These developments could eventually usher in a new "post-car" system, that would have to be defined, according to the authors, by new fuel systems, new materials, smart and de-privatized vehicles, digitization, new transport policies (different from 'predict and provide'), as well as by new living practices in more densely organized places (p. 62-107).

The implications of this understanding of car dependence for policy are twofold: first, given the systemic and path dependent nature of the process it is impossible to bring about change with a single policy (such as pricing measures or technological fix, etc.), even if each of them may be significant as part of a broader set of transformations aimed at changing the system as a whole (p. 64). Second, change will not be linear or incremental, but rather rapid once a certain 'tipping point' is reached: for this reason, it is important for

[23] On the implications of increasing mobility for socio-temporal coordination see also Shove (2002).

technical-economic, policy and social changes to be realized in the right order, in order to 'tip' the system into a new state (p. 63). However, the authors fail to provide any more specific clue about how change should be brought about because, they argue, "the complex interdependencies of systems (makes) it almost impossible to predict what would effect change in such a system (p. 59).

1.5. Motorisation, urban structure and the built environment

The relationship between mobility and spatial development is arguably one of the most intensively researched and discussed topics in both the transport sciences and the urban sciences. Accordingly, it is impossible to provide an exhaustive summary in this section. I will thus limit myself to highlight some points that are useful to set the context for the remainder of the thesis. In doing that, I argue that it is useful to analytically distinguish between two different ways in which the relationship between travel and land-use has been conceptualized: on one hand, historically, the trends towards faster and more car-based travel has been tightly related with huge changes in the geography of human settlements. On the other hand, from a synchronic perspective, much effort has been put into investigating the extent and nature of the alleged causal relationships between the built environment and travel behaviour, primarily in order to assess the potential of urban planning in curbing travel growth. While the two processes are of course strongly intertwined, it is useful to analytically distinguish the two debates. Therefore, in the first section (§1.5.1), I focus briefly on the historical perspective, while studies in the synchronic approach are reviewed in the following (§1.5.2-§1.5.4).

1.5.1. Motorisation and urban structure in historical perspective

The fact that, historically, changes in travel patterns have gone hand in hand with changes in land-use patterns is not surprising. Indeed, it can be inferred from the historical travel trends illustrated in the introduction of this chapter (§1.1.1). As Metz (2008) puts it:

> "average trip rate is conserved in the long run. This implies that induced traffic in aggregate does not arise from increased journey frequency (..). Rather, induced traffic is generally the consequence of the choice of more distant destinations for the same journey purposes and is associated with changed land-use patterns" (p. 327)

In other words, the reason why we travel further than our parents and grand-parents did (when they were our age) is not so much that we are engaged in new activities that make us travel further, but rather that we tend to cover more distance in order to carry out more or less the same activities as in the past (see also Pooley et al., 2006). Clearly, the *destinations* of our activities must have spread out in space over time. This is consistent with what Knowles (2006) argues: the diffusion of new transport technologies (including the motor car) has brought about the twin processes of time/space and cost/space convergence; this in turn has induced a spatial reorganization of human settlements which consists not only of dispersion, but also of centralisation and specialisation of activity centres. The result is a "more intermeshed and interdependent" society (p. 408), but also one where the ability to cover greater distances (as well as access to motorised transport) is paramount.

Such trends have been studied intensively in the urban sciences, where the process of suburbanization that has taken place in the course of the 20th century has drawn much attention. In this context, the link between suburban growth and motorisation is generally acknowledged. It would be wrong, however, to see motorisation as the sole driver of this process: indeed, in many countries the start of suburbanization has preceded mass motorisation, and in some cases even the invention of the motor car (Jones, 2008; Pooley, 2010; Banister, 2011, p. 952). Indeed, suburbanization has had a number of different drivers, unrelated to transport, such as (in short) the changing nature of capitalism, the increase in per-capita income (which contributes to reduce the friction of distance), and, in some context, the flight of the middle-classes from social problems in inner cities. However, motorisation has arguably contributed to this process in at least two ways: first by physically enabling it and accelerating its pace; second, the diffusion of the automobile has exerted a powerful influence on the *density* and the *design* of a new generation of suburbs. As Newman and Kenworthy (1999) point out (§1.4.2), there is a great difference between star-shaped suburban developments that are clustered around pubilc transport nodes and the kind of sprawling, low density suburbs that have sprung up under the impulse of mass motorisation. Moreover, it must be recognised that, at least for some decades, urban planning has enthusiastically endorsed the motor car, going to extraordinary length to accomodate car traffic into the city (Norton, 2011): the effects of this endeavour are more visible in the suburbs rather than in inner cities, where efforts to plan the city around the automobile have encountered a stronger resistance (Jacobs, 1961).

The car has also been instrumental in bringing about what some scholars see as a new phase of urban development, at least partially distinct from suburbanisation and characterised by the dispersion of activities and settlements on an even larger scale. This processs has been studied under different names, such as (among others) “periurbanisation” (Prost, 2001) and the “boundless city” phenomenon (Martinotti, 1999; 2005; Colleoni, 2011). In this context, it is important to point out that the process of dispersion has not interested all types of activities to the same extent: the greatest decentralisation is observed for residential and retail developments, with the latter undergoing a parallel process of centralisation in fewer, larger centres; by contrast, at least in Europe, jobs and services (notably leisure and third sector services) remain concentrated to a greater extent in the centre of urban areas (Colleoni, 2011), partly as result of the location preferences of previous periods and the symbolic value that is still associated with European inner cities (Næss, 2006, p. 23). Thus suburbanization and periurbanisation have not resulted in an uniform dispersion of activities, but rather in a differential process that, in turn, is also partly responsible for the increase in travel distances. Insofar as many new developments at the margins of existing urban area have been low density and auto-oriented in design, this has also caused an increase in car use and ownership.

While such processes might appear the natural and inevitable product of growing economy and improving technology, one should not overlook the role that political and economic powers have had in driving urban development. For example, eco-marxist scholar Gonzalez (2008) has focused on the role of public powers in shaping urban development in the USA in the course of the 20th century. According to his analysis, the goal of public powers has been to maximise the economic demand for (single-family) housing and consumer durables (such as the car), and thus profits. Accordingly, he explains how, in the 1930s, the U.S. Federal Housing Strategy (FHA) launched a program of new home construction, that was strongly biased towards predominately single-family housing on the urban periphery while neglecting city cores (p. 158-160). One of the aims of this big public push for urban sprawl was to revive U.S. capitalism from the Great Depression: low-density suburban development in fact greatly increases the need for automobiles, consumer durables and energy consumption, and the industrial bases of the States was by the 1920s particularly geared toward the production of consumer durables (notably cars) and oil. Thus, the FHA action was highly consistent with the interests of American economic elites and producer groups (p. 166-167). In this perspective, sprawl and car dependence are “less the by-product of unplanned urban and suburban expansion than the consequence of a deliberate economic policy designated to increase consumption, (that) has historically relied on abundant supplies of cheap oil along with the presumption that its combustion was benign” (Vanderheiden, 2008b, p. xxi). While Gonzalez’s analysis is focused on the particular case of the american New Deal, and is thus not directly transferable to the European context, it shows the importance that political and economic powers can have in promoting car-dependent patterns of suburbanization.

1.5.2. Travel and the built environment

The historical process described in the previous section is not controversial. Much more lively, by contrast, is the debate which goes under the name of ‘travel and the built environment’ (Ewing & Cervero, 2001; 2010). This research field is different in two main respects: first, the focus here is not on the interrelations between the historic trends of travel and urban development, but rather on the *synchronic* and *causal* relations between travel demand and the built environment in the present time. Second, studies in this field are generally motivated by the attempt to assess the potential of densification strategies in contributing to a more sustainable transport. In that sense, while the discussion illustrated in the previous section is focused on past developments, this debate is more concerned with the present and the future. As Handy (2005) puts it:

> "..most participant in the debate agree on the historic strength of the connection between transportation and land use but diverge on the current and future strength of this connection. How much impact do new transportation investments have on development patterns? How much impact do changes in development patterns now have on travel patterns?" (p.148)

This body of quantitative research has grown rapidly over the last three decades: indeed, while empirical studies on travel and the bult environment were not numerous until the 1980s, they were much more common in the following decade, when a lively debate has followed the publication of Newman and Kenworthy's main work (1989). The intensity of this debate has increased in the last decade: so for example, while in 2001 Ewing and Cervero reported "more than 50 recent empirical studies" in this vein (Ewing & Cervero, 2001), in an updated review ten years later the same authors state that "there are now more than 200 built-environment/travel studies, of which most were completed since our 2001 review" (2010, p. 266) and go as far as to claim that "the potential to moderate travel demand by changing the built environment is *the most heavily researched subject in urban planning*" (p. 267, emphasis added).

The debate is particularly lively in the US, where:

> "emphasizing the policy environment, many researchers have cast their analysis in comparative terms, noting the differences in automobile use between European countries and the US. It is argued that US patterns of metropolitan form, with low development densities and dispersed population and employment, reinforce auto dependence. In contrast, most European metropolitan areas, with higher densities and more centralized land use patterns, have lower levels of auto use. Stronger controls on land use employed in many European countries are seen as having preserved the compact form of metropolitan areas" (Giuliano & Narayan, 2003, p. 2295)

At a broad level, both in the US and in Europe, studies focused on urban areas have repeatedly shown that "those living in the outer parts travel considerable longer by motorized means of transportation, compared to the residents of inner and central parts of the city" (Næss, 2006, p. 31). While this makes good sense, a closer look into the findings of these empirical works reveals a much more nuanced picture, and a considerable degree of complexity.

A first reason for this complexity is that while it could make sense, on a theoretical level, to talk about the relationship between "travel" and the "built environment", on an empirical level both are very general concepts, that can be operationalised in a variety of ways. Reviews of the existing literature (Ewing & Cervero, 2001; 2010; Stead & Marshall, 2001; Handy, 2005) mention the following as the most common travel-related dependent variables: trip frequencies; average journey distance; travel distance, in terms of either passenger kilometers (PKT) or vehicle kilometers travelled (VKT); travel time; trip chaining behaviour; transport energy consumption. The complexity is further increased by the fact that these variables can refer to overall travel, but also to travel by specific modes (for example, PKT by car), or to travel for specific purposes (several studies focus only on commuting). The effect of the built enviroment on these variables varies considerably, depending on the travel-related dependent variable that is taken into consideration; so for example Ewing and Cervero conclude their 2001 literature review by observing that:

> "trip frequencies appear to be primarily a function of socioeconomic characteristics of travelers and secondarily a function of the built environment; trip lenghts are primarily a function of the built environment and secondarily of socioeconomic characteristics; and mode choices depend on both (though probably more on socioeconomics)" (Ewing & Cervero, 2001, p. 96)

To add a further layer of complexity, there is a staggering variety of spatial variables that are used to assess the built environment. Tab. 1.2 shows some of the indicators used in the research literature, sorted according to the typology put forward by Ewing and Cervero (2010).

Category	Indicators
Density	residential density; employment density; overall activity density
Diversity	mixing of land-uses (entropy indexes); job ratio (jobs/workers in the area); job/housing balance
Design	street network characteristics (e.g. network shape, street connectivity, directness of routing, block sizes and shapes, sidewalk continuity, proportion of four-way intersections etc.); urban design features (building orientation, landscaping pedestrian amenities, etc.); type of residence (e.g. share of single-family detached residences)
Destination accessibility	regional accessibility (e.g. distance of residence to the urban centre); provision of local facilities and services; number of destinations accessible within a given travel time; measures of micro-accessibility
Distance to transit	proximity to main transport networks (distance from the residence to the nearest public transport stop, etc.)
Demand management	availability of residential parking; parking costs

Tab. 1.2 – Spatial variables used in travel and built environment studies, sorted according to the 'six Ds' (Ewing & Cervero, 2010). Sources: Ewing & Cervero, 2001; 2010; Stead & Marshall, 2001; Handy, 2005; Giuliano & Dargay, 2005

The variety of built environment characteristics that are considered in these studies is further increased by the fact that, while they generally refer to the area of residence (i.e. to the presumed origin of most trips), some studies have considered spatial features of bounded travel destinations (such as the workplace), as these can have quite an impact on travel behaviour (e.g. mode choice) (Ewing & Cervero, 2001). Given this multiplicity of variables, both on the dependent and the independent side of the equation, it is not surprising that this field of research is still very fragmented, despite the considerable number of studies. As Ewing and Cervero observe, once studies are segmented by variable type, the number of empirical works reduces considerably (2010). This is particularly true for studies that focus on design features of the built environment, which only recently have begun to catch the attention of researchers[24].

As a result, several controversies are still going on among researchers. Part of the reason is that while it is generally accepted that travel patterns in peripheral, low density and auto-oriented developments are quite different than in central, high density, walkable areas, the exact role of each built-environment characteristics is much less clear. Most of the problem here is that the variables related to density, design, diversity and the like are generally strongly correlated. Accordingly, while their cumulative effect on travel behaviour is often found to be large and relevant, identifying the individual effect of a variable is much more challenging (Stead & Marshall, 2001). So for example Ewing and Cervero note that "an unresolved issue is how much the impact of density on travel patterns is due to density itself as opposed to other variables with which density covaries" (2001, p. 93). Reflecting on this problem of multicollinearity, Stead and Marshall observe:

> "while this may allow reasonable deductions to be made about travel behaviour in existing neighbourhoods (dense, traditional neighbourhoods being equated with relatively high transit use, for example), this is not sufficient for predicting the effects of new development forms which may only have some, or have different combinations of, these attributes" (2001, p. 135)

[24] It must be noted that the interest for design has been much greater in the American scholarship. According to Næss, this is because "in a European context (..) the location of the residence relative to the main metropolitan centre and sub-centres within the metropolitan-scale spatial structure have turned out to be more influential on travel behavior, compared to local-scale neighbourhood characteristics" (2009, p. 295).

In sum then, the problem for urban *planners* is to draw from the data indications on how to design urban areas in the future, in order to foster sustainable transport. While this makes perfect sense from a planning perspective, in the context of this thesis the multicollinearity of different spatial features is advantageous. Indeed, the data sources used in this research work (national travel surveys) only provide very general variables such as settlement size and population density which, however, can be expected to be good proxies for the cumulative effects of the variables listed in Tab. 1.2.

1.5.3. The self-selection debate

A much more fundamental controversy in the travel and built environment research has to do with the problem of causality and the possibility of a residential self-selection bias. As Handy et al. (2005) argue, empirical studies which show the existence of correlation between built environment characteristics and travel behaviour generally do not prove that the first element *causes* the second. An alternative explanation might be that attitudes and preferences about travel are correlated with the choice of neighbourhood, and this process biases the observed correlation. In other words, the fact that more people drive in low-density, suburban areas might be due to the fact that people who (for any reason) are more likely to drive also prefer the kind of single-family detached housing that is found more frequently in the suburbs. As a result, the observed correlation might be (also) a result of the *self-selection* of different kind of households in areas that are consistent with their mobility preferences and needs. If this is true, the impact of changes in the built environment would be less than otherwise expected. As Ewing and Cervero put it, "more than anything else, the possibility of self-selection bias has engendered doubt about the magnitude of travel benefits associated with compact urban development patterns" (2010, p. 266)

The debate concerning residential self-selection is particularly lively in the US, where it often appears to be quite ideology-driven. On one side, advocates of smart growth and new urbanism strategies (see §1.6.3) stress the impact of the built environment on travel behaviour and call for more public intervention in transport and land-use planning, in order to bring about densification and a more European-like urban development. On the other side, opponents of these policies often present land use and urban form simply as the result of well-functioning market mechanism of supply and demand, in which consumer's preferences for larger (and often cheaper) suburban housing play a key role. In this perspective, the huge level of car dependence of American urban areas is depicted as "simply a lifestyle choice made by free-willed economic units maximizing their utility" (Gorham, 2002, p. 107). Accordingly, scholars on this side of the debate often argue that the only way to curb traffic growth would be to increase motoring costs (particularly low in the US).

In Europe, the debate on residential self-selection is less intense, but both less ideology-driven and more theoretically grounded (Scheiner, 2009a, p. 41): accordingly, european scholars have often framed this issue in the context of the long-standing debate about the relevance of agency and structure in constituting society (Næss, 2006; Scheiner, 2009a). Næss, for example, has argued that, while studies on travel and the built environment assume that "structural conditions have a potential to influence human actions" (2006, p. 12), researchers have to take into account the "mutual influences between the urban structural situation of the dwelling (..) and the individual and household characteristics". In that sense, while the location of household residence can be (at least partly) the result of "socio-economic characteristics and attitudes predisposing them for a certain type of behaviour" (p. 29), there might also be influences in the other direction, as travel preferences are quite likely to be (at least partly) the by-product of the local built environment. Accordingly, while scholars ignoring the first process might overstate the impact of the built environment, authors who take attitudes as given, inherent in people and independent of context run the risk of overlooking it (Næss, 2009). Scheiner (2009a) goes even further, situating this discussion within the framework of individualisation theory, drawing in particular on the concept of 'lifestyle', in accordance with the German social theory of the 1990s (Beck, 1986). In this perspective, because of social change, "transport behaviour is characterised today by much greater degrees of freedom (than in the past)" (Scheiner, 2009a, p. 17, own translation). This in turn motivates the need to consider, beside structural factors such as socio-demographic characteristics and the built environment, also the agency of individuals. Scheiner argues in particular that Giddens' notion of a mutual constitution of agency and structure (1984) is very relevant for research on travel and the built environment, because there are similar mutual influences between the built environment in the residential area (which can be the outcome of residential mobility and choice) and travel behaviour (which is conditioned by the land-use in the area). Accordingly, he argues, daily mobility and residential mobility need to be studied in conjunction, rather than in isolation.

On a methodological level, the issue of self-selection has prompted several attempts to develop techniques capable of overcoming the limitations of traditional studies on travel and the built environment. As the latter generally limit themselves to provide evidence of statistical association, recent work has focused on satisfying the other three criteria required for establishing causality (Handy et al., 2005):

- in order to prove that the built environment (BE) is the cause behind differences in travel behaviour (TB), it must be possible to rule out that there is a third factor (associated with both) which accounts for the statistical association betweeen them. In this perspective, the self-selection argument amounts to assuming that the relationship between BE and TP is *spurious*, because unobserved socio-demographic characteristics or attitudes are ultimately responsible for it. In response to this limitation, researchers have increasingly include these factors into their multivariate regression models: while the inclusion of socio- economic characterists of household was already common practice, more recent research works also include travel-related attitudes among the independent variables (Bohte et al., 2009). Studies with this approach have often concluded that self-selection accounts for most of the relationship between BE and TB. However, some authors argue that the inclusion of attitude variables is also likely to lead to “over-control” and underestimation of the impact of BE on TB, because there are several indirect effects of BE which are actually mediated by attitudes (Næss, 2009, p. 314)
- in order to infer causality, there should be an understanding of the mechanism relating the cause and the effect. The responses to this requirement have been very different methodologically: some scholars have reccomended the use of forms of path-analysis, such as structural equation modelling (SEM) (Cao et al., 2009; Scheiner, 2009a), which are suitable for the analysis of complex webs of cause-effect relationships, since they allow to analyze the relationships between several dependent and independent variables at the same time. Others have drawn on qualitative methods in order to highlight how the rationales influencing travel behaviour might explain the relationship between BE and TP (Næss, 2006; 2009)
- finally, the concept of causality assumes a temporal order whereby causes precedes effect. However, the kind of cross-sectional models generally used in transport and the built environment studies are poorly suited to provide evidence on this point. This has prompted different responses: a panel approach would be ideal, but is very difficult to carry out in practice. Accordingly, researchers often opt for the inclusion of retrospective questions (assessing for example travel behaviour before residential relocation) in cross-sectional surveys, which allow the use of *quasi-panel* data (Handy et al., 2005; Scheiner, 2009a). This allows better assessment of causal priority: for instance, observing that car use increases *after* relocation to the suburbs speaks in favour of a causal effect of BE on TB; conversely, observing that car-owning households have a greater propensity to move to the suburbs is consistent with the self-selection hypothesis (Scheiner, 2005; 2009a). More broadly speaking, the ‘mobility biography’ approach points at the need to analyze the development of travel behaviour across the life cycle and in relation with key biographical events (*ibidem*)

As Cao et al. (2009) argue, the ideal method to study travel and the built environment would adress all the previous limitations at once, i.e. a longitudinal SEM approach wich measures travel-related attitudes at multiple points in time. However, this is clearly a very demanding survey design: accordingly, it is not surprising that it has only rarely been tried out. As a result, different findings found in the current research literature are often the by-product of the different methods used. Handy et al. (2005) illustrate this point brilliantly: drawing on a multivariate analysis of cross-sectional data, they show that the effect of the BE on TB is statistically non-significant, once attitudinal variables have been accounted for. However, re-analyzing the same data with a quasi-longitudinal approach (including retrospective questions about travel behaviour), it turns out that changes in accessibility due to a relocation are the single most important determinant of changes in travel behaviour, even after accounting for attitudes and socio-demographics (similar results are reported by Scheiner, 2009a). These contrasting results might be explained by assuming that people adapt their attitudes and preferences to the characteristics of the residential area. Consistently with these results, the recent literature review by Ewing and Cervero (2010, p. 266) shows that nearly all of the 38 recent studies that have attempted to control for residential self-selection have found that, even if it does attenuate the effects of the built environment on travel, there is nonetheless a statically significant association between travel and the built environment, independent of self-selection influences.

In sum then, the self-selection debate does not challenge the basic assumption of a causal relationship between the built environment and travel (Cao et al., 2009). Rather, it points at the need to focus on *how*, *why* and *to what extent* this relationship occurs (Næss, 2006, p. 36). This means:

- focusing on the complex web of *interrelationships* between the structural contraints of the built environment and the agency of households (e.g. through residential relocation)
- focusing on the *mechanisms* through which the built environment influences travel behaviour (Næss, 2006, p. 36)
- focusing on the *magnitude* (rather than the existence) of the net influence of the built environment, in order to inform better policy-making[25] (Cao et al., 2009)

The discussion presented in this section is relevant for the present research work. Indeed, the main empirical finding of this thesis is the existence of a significant relationship between the type of area and the composition of the group of carless households. However, the analysis draws on cross-sectional national travel survey data, which do not include travel-related attitudinal variables, and does not use a SEM approach. As a result, every relationship between the type of area and car ownership and/or travel behaviour that will be illustrated in what follows will be open to interpretation as to to what extent it might (also) be the product of self-selection. However, it worth keeping in mind that, as Næss argues "built environment characteristics is a variable prior to residential self-selection in the causal chain" (2009, p. 298), since:

> "the fact that people to some extent 'self-select' into areas matching their transport attitudeds and car ownership is in itself a demonstration of the importance of urban structure to travel behaviour. If there were no such influence, people who prefer to travel by non-motorized modes might as well settle in the peripheral part of the metropolitan area, far away from public transport stops and and the concentration of workplaces and services facilities found in the central and inner cities" (Næss, 2009, p. 298)

1.5.4. Car ownership and the built environment

As argued in the previous section, the relationships between travel, the built environment and individual attributes and preferences are very complex. In this context, taking into consideration the role of car ownership (or availability) adds another layer of complexity[26]. Indeed, in transport studies car ownership has an ambiguous status: while it is sometimes considered as a socio-economic factor (see for example Stead & Marshall, 2001, p. 131-132), other times it is reffered to as a 'transport resource', similarly to access to public transport (Giuliano & Dargay, 2005). All in all, it appears that, while studies on travel and built environment have focused on different aspects of travel behaviour, they have paid much less attention to the role of car ownership. Perhaps a division of labour is at work here, as car ownership has been intensively studied with an econometric approach (§1.3), where the focus is more on the influence of income than on the built environment.

As argued by Van Acker and Witlox (2010), most empirical studies under the heading of 'travel and the built environment' have studied car ownership in either one of the following two ways: first, car ownership has

[25] As Handy (2005) puts it: "although the connections between transportation and land use at first brush seem both obvious and simple, our appreciation of the complexities of these connections increases as the research on these connections progresses: the more we know, the least we seem to know. Researchers have made more progress on some of these propositions than others, but even in the best cases, our ability to predict the impact of different policies remains limited" (p. 149).

[26] As illustrated later (see §2.2.1, §3.2.3), there is obviously a difference between car ownership and availability, with the first implying the latter but not vice-versa. In this section, however, I will use the two terms interchangeably.

been studied as a dependent (endogenous) variable that is explained by socio-economic characteristics as well as by the built environment. As far as the latter is concerned, it is generally observed that each of the six D's listed by Ewing and Cervero (2010, see Tab. 1.2) is associated with car ownership (Van Acker & Witlox, 2010): car ownership is lower in higher densities areas, as well as in more diverse areas and where spatial design is more suitable for modes alternative to the car; similar effects are generally observed for destination accessibility, distance to public transport networks and demand management measures (such as restrictions to parking availability). Second, several studies use car ownership as an independent (exogenous) variable, often in order to control for its effect while assessing the net influence of the built environment on travel behaviour (see above). In this context, it is generally concluded (unsurprisingly) that more car ownership is associated with more car use. In reviewing this literature, Van Acker and Witlox argue that the specific role of car ownership as a *mediating variable* between the built environment and car use has been generally overlooked: in this perspective, the spatial characteristics of the residential location (which is the outcome of a long-term decision) influence the medium-term decision to own a car, which in turn strongly affects daily travel behaviour (i.e. short term decisions about travel) (2010, p. 65). This happens because car ownership is best conceived as "a commitment to a specific mode" which reduces the usage of other modes (Simma & Axhausen, 2001, p. 287). Accordingly, built environment has two kind of effects on travel behaviour: direct and indirect (i.e. via the effect on car ownership), and the latter can be very significant (Van Acker & Witlox, 2010; Næss, 2006). Moreover, car ownership appears to mediate also the effect of socio-economic variables, such as income (Van Acker & Witlox, 2010; Scheiner, 2009a).

Scheiner (2009a) goes even further, by considering not only socio-economic characteristics (i.e. life situation), built environment and car ownership but also lifestyle and location preferences, with the explicit aim of adressing the issue of residential self selection. The result is a very complex web of relationships among the elements, and a myriad of both direct and indirect effects between the elements (see for example the graph in Scheiner (2009b, p. 531). Notably Scheiner (2009a) illustrates how:

- the socio-economic situation impacts on car ownership both directly and via its influence on lifestyle: the empirical data analyzed by Scheiner using SEM, however, show a much stronger direct effect of the life situation, while the relationship with lifestyle apperars to be weak and unclear
- car ownership is strongly related to both the built environment and location preferences, even though the first relationship appears to be stronger; moreover, car availability can in turn influence the choice of the residential location, both directly (because car owning households have, all other factors equal, access to a bigger share of the housing market) and indirectly (possibly by inducing preferences towards more car-oriented areas, as argued by Næss, 2006; 2009)
- in accordance with what argued above, car ownership is a crucial mediating variable both between life situation and travel behaviour and between built environment and travel behaviour (Scheiner, 2009a, p. 178)

Concerning the issue of residential self-selection, further work carried out by Scheiner with a mobility biography approach in the Cologne area (2005; 2009a) shows that:

- the built environment influences car ownership, even after controlling for residential self-selection: this is demonstrated by the fact that household moving from inner city to suburban areas increas their motorisation after the residential relocation, while households who move in the other direction reduce it
- on the other hand, residential self-selection mechanisms are at work: this is shown by the fact that households who move from inner city to suburban areas, even before moving, already had higher levels of motorisation (if compared to households who did not move); conversely, households moving from the suburbs to the inner city already had lower levels of motorisation (if compared to 'stayers') when they were living farther away from the city centre

To sum up, in the last few sections I have shown that disentangling the relationship between travel and the built environment is considerably complex, both theoretically and empirically, given the multiplicity of factors involved and the abundance of interrelations among them. In the context of a thesis that is focused on households without cars, it is important to note both the importance of car ownership in determining travel behaviour and its role in mediating the influence of both the built environment and socio-economic characteristics. Both of these findings highlight the relevance of focusing on car ownership, even when the primary concern is car use and its the negative externalities. Finally, previous research indicates that the varying degree of car ownership across different types of areas has to be interpreted as both the result of the causal influence of the built environment on car ownership *and* of residential self-selection.

1.6. Policies for environmentally sustainable transport: an overview

1.6.1. Environmentally sustainable transport

In the context of this thesis, the analytical concept of car dependence is crucial: it would thus make sense, in the closing section of this chapter, to focus on policies meant to contrast and reverse the systemic process of car dependence, as defined in this chapter (§1.4). However, this would be misleading, since most policies in this area have instead been framed by the concept of 'sustainable development'. This notion, as originally defined in the Brutland Report (World Commission on Environment and Development, 1989), comprises three dimensions: economic growth, social inclusion and environmental balance. In this context, the major innovation brought about by the report was its focus on intergenerational equity, as shown by the title ("Our Common Future") and the famous definition of sustainable development as "the development that meets the needs of the present without compromising the ability of the future generations to meet their own needs" (p. 43).

Similarly, even though several definitions of 'sustainable transport' have been put forward (Black, 2010), they generally comprise three goals (see for example Commission Expert Group on Transport and Environment, 2000):

- the environmental externalities of transport should be limited, in order not to compromise the welfare of future generations
- transport policy should be consistent with the goal of economic growth
- intra-generational equity should be promoted

Providing a comprehensive review of policy measures for sustainable transport is a huge task, and one that cannot be accomplished in the context of this thesis (for updated reviews see Banister, 2005; Holden, 2007; Black, 2010; Schwanen et al., 2011). Accordingly, I will narrow the scope of this section in several ways:

- the focus here is only on the first goal, i.e. on environmentally sustainable transport; a review of policies which tackle the 'social equality' side of transport is provided at the end of the next chapter (§2.4)
- in accordance with the rest of this chapter, I limit my focus to surface passenger transport in developed countries, thus excluding both freight and air transport
- I do not consider technological solutions to the problems of unsustainable transport; accordingly, I concentrate on policy measures meant either to reduce the demand for travel or to reduce the energy intensity of travel by intervening on human factors (for example by promoting modal shift away from the car) (see §1.2.4)
- I will make only scant reference to the institutional and organizational issues related to achieving an environmentally sustainable transport system (Rietveld & Stough, 2005)

The focus of the remainder of this section will thus be mostly on *policy measures meant to directly reduce car travel and/or ownership*. For the sake of brevity, I will limit myself to provide a very general description of five broad areas of intervention[27] (improving modal alternatives, changing the built environment, pricing

[27] I also do not consider the possible role of information and communication technologies (ICT) in reducing travel demand (Andreev et al., 2010).

disincentives, changing individual attitudes and behaviour). More concrete examples of policy measures are provided in the chapters focused on the case studies (§4.1, §5.1). Given the focus of this thesis on car dependence, I will consider in particular the limitations of each bundle of policy measures. In the last section (§1.6.6), I will briefly elaborate on the limits of environmentally sustainable transport policies more in general.

1.6.2. Improving modal alternatives

A first, obvious approach to curb car use and ownership is to get people to use other modes of transport instead. As Schwanen et al. (2011) explain:

> "the rationale underpinning this focus is that by extending in space and time the availability and accessibility of more sustainable forms of transport, such as walking and cycling, local public transport, high-speed trains (HST) and freight transport by rail, the choice sets available to persons and firms becomes larger. They are offered more and better opportunities to switch from high to low-carbon forms of transport" (p. 995)

As far as public transport is concerned, improvement policies have targeted the following areas:

- from a *spatial* point of view, efforts to increase the supply of public transport might take the form of network extensions, as well as of better route penetration
- from a *temporal* point of view, it is often argued that both higher service frequencies and longer operating hours might contribute to a modal shift
- in terms of *quality*, it is often argued that rail-based public transport is a better solution than buses, and one more capable to generate a shift from private cars to public transport (Newman & Kenworthy, 1999, p. 154), even though this is sometimes disputed (Prud'homme et al., 2011). In this context, Bus Rapit Transit (BRT) systems, such as those pioneered by Latin American cities, are increasingly considered as an alternative, because they combine the quality of rail-based networks with the affordability of bus-based systems (Wright, 2002). Broadly speaking, efforts to improve the quality of public transport in urban areas have often resulted in the prioritization of buses (segregated lanes). Besides this endeavours, improving the spaces of public transport vehicles in terms of comfort and convenience is seen as a promising way to improve their attractiveness, particularly when they allow travellers to use travel time in a meaningful way
- in terms of *costs*, reducing fares is generally assumed to foster more public transport ridership, by counteracting historical trends towards increasing relative affordability of car travel; accordingly, public transport providers have often tried to reduce the prices of monthly or annual tickets, in order to encourage travellers to commit themselves to this mode of transport. Free (tax-funded) public transport services, by contrast, have been only rarely implemented on a large scale (Steenberghen et al., 2006)

Promoting cycling and walking is also seen as a priority in order to achieve environmentally sustainable transport: indeed, non motorized modes of transport offer, at least in theory, a promising alternative if the goal is to reduce fuel consumption and polluting emissions (Tolley, 2008). Their potential appears greater in urban areas, where 'slow' modes of transport have more chances to compete with the motor car for short journeys, and where they seem capable to provide the same level of flexibility as private motorised transport. Efforts to increase the modal share of walking and cycling have generally resulted in the provision and/or improvement of dedicated infrastrucure, such as bike lanes, cycle parking and sidewalks, as well as in traffic calming measures wich aim to make cycling and walking safer (Newman & Kenworthy, 1999; Litman, 2010b). Such interventions on street design often go hand in hand with more wide-ranging efforts to change the built environment in order to reduce car use (see below). However, it is sometimes observed that the provision of adequate infrastructure is not enough to bring about the desired modal shifts, which might therefore require a more fundamental change in the willingness of individuals to use those modes of transport (Pooley, 2011).

Other ways of providing an alternative to car use are subsumed under the label of Flexible Transport Services (FST), that is:

> "an emerging term in passenger transport which covers a range of mobility offers where services are flexible in one or more of the dimensions of route, vehicle allocation, vehicle operator, type of payment and passenger category. This encompasses traditional dial-a-ride/paratransit services which have existed for over 40 years, more recent telematics-based Demand Responsive Transport for the wider public, taxis, and informal transport solutions mainly associated with developing countries. Importantly the definition of FTS also includes car sharing and lift sharing services" (Nelson & Wright, 2012, p. 1)

While FTS have a variety of goals (among others, allowing people with mobility difficulties to travel, see §2.4.3), they are increasingly seen as a way of providing an alternative to private motorised vehicles while offering the same degree of flexibility (unlike traditional public transport). In this context, car sharing is promoted as a way to decouple car use from car ownership, since the latter tends to make the choice of the car a matter of habit (Barter, 2008), and particularly as a way to reduce multiple car ownership (Caulfield, 2012).

However, improving modal alternatives has several limitations, among others:

- providing additional public transport services is expensive, notably when it implies extending the service to areas and/or times of day where ridership is expected (at least initially) to be low. FTS in particular might be particularly expensive (Nelson & Wright, 2012)
- in some kind of areas, such as car-oriented suburbs or rural areas, it can be extremely challenging to provide public transport services that are competitive with the car. In particular low density and certain street design features (such as cul-de-sac streets) make it difficult to provide convenient public transport in these areas, even though some argue that there is scope for improvement (Mees, 2010). The cost of providing public transport in these areas are also likely to be higher. On the other hand, given the right conditions, investment in public transport (especially in light rail systems) is likely to increase densities on the medium-long term (Handy, 2005)
- with regard to walking and cycling, the modal share of non motorised modes of transport (notably in terms of travel distance) is quite low in most developed countries, including those (such as Germany) renowned for the walkability and cyclability of their cities (see §4.1.2). Accordingly, most transport scholars see promoting walking and cycling as only a small part of the solution to unsustainable transport
- more broadly speaking, alternative modes, almost by definition, compete with the automobile for the same resources: street space, public investment, etc. Accordingly, improvement to modal alternatives might need to be complemented by measures directly constraining car use and ownership, as well as by a draining away of resources from motoring

1.6.3. Changing the built environment

As illustrated in §1.5, the existence of a relationship between the built environment and travel behaviour has resulted in attemps to use urban and territorial planning in order to achieve sustainable transport. In this context, compact, mixed-use and public transport oriented urban developments are promoted as a tool to reduce car use and the associated environmental externalities. In the US, these strategies are commonly referred to as New Urbanism, Transit Oriented Development (TOD) and Smart Growth (Leinberger, 2008). In Europe, where urban development is generally more dense, it is more common to talk about 'compact city policy' (OECD, 2012, see also §4.1.1 and §5.1.1). 'Car free' or 'low car' developments have also been promoted in Europe (Glotz-Richter, 1995; Ornetzeder et al., 2008; Morris et al., 2009; Melia 2010; Melia et al., 2010; Ghent, 2012; see §3.2.1).

Another way to promote sustainable transport is to realize traffic calming measures such as (among others) speed limits, restrictive measures against private traffic and parking restrictions (Newman & Kenworthy, 1999). These are often implemented in combination with densification measures and the provision of facilities for cycling and walking. More broadly speaking, advocates of sustainable transport often suggest to limit the provision of new road infrastructure to the minimum, in order not to fuel the self-reinforcing dynamic of the predict-and-provide paradigm that has dominated transport policy for a long time (Goodwin et al., 1991; SACTRA, 1994; Walton, 2003; Parkhurst & Dudley, 2008)

It is important to observe that implementing this agenda has wide-ranging institutional and organisational implications: as a matter of fact, car-oriented development of the past are (at least in part) the consequence of a lack of coordination between local policies of urban development and public transport planning. Accordingly, it is usually agreed that a greater level of coordination between transport and land-use policies is required if public transport oriented developments have to be realized (Kaufmann & Sager, 2006; Gallez & Kaufmann, 2010). However, the need for coordination is not limited to these sectors, nor to the local level: as shown in Britain by the Social Exclusion Unit (SEU, 2003), the location decisions of a number of key pubilc services (for example, health care services) have for long been taken with little (if any) concern for their accessibility by modes alternative to the car. Accordingly, providers of public services also need to be involved in coordination processes, if the trends towards increasing car use have to be reversed.

While sustainable transport strategies that intervene on the built environment might appear more radical and effective than simple improvement to modal alternatives, they also have several limitations:

- first, the built environment changes only very slowly. This means that, on one hand, existing car oriented developments will continue to exercise their effect for the foreseeable future. On the other hand, realizing new, more sustainable areas (and redevelop existing ones) is likely to require a great deal of time. Accordingly, changing the built environment is best seen as a long term strategy, unlikely to make a difference in the short term
- the implementation of changes in land-use and transport policies is likely to meet a lot of institutional and organisational resistance, because of what Newman and Kenworthy (1999) call ‘institutionalized car dependence’ (§1.4.2) and of path dependencies in transport and urban planning policies (Pflieger et al., 2009)
- while there is a broad agreement among scholars that the built environment influences travel behaviour (§1.5), it is much less clear to what extent the implementation of ‘smart growth’ strategies does effectively lead to reduction in travel distances, car use and the like (Handy, 2005). As a result, the effectiveness of changing the built environment is often called into question, quite apart from the ease of their implementation
- even assuming that densification strategies bring about reductions in car travel on a sufficient scale and speed, they are likely to result in collateral effects, which could ultimately undermine their effectiveness and/or their acceptability. An example of this is ‘the paradox of intensification’ (Melia, Parkhurst, and Barton, 2011) whereby densification results in greater concentration of traffic in the local area, with associated impacts in terms of noise, local air pollution and safety. In that sense there is a risk that densification might increase environmental problems at the local level, even while reducing them at the global level. This, in turn, can offset the gains at the global level, in at least two ways: first, increased congestion in the local area might increase emissions and energy use; second, worsening local environmental conditions might result in further demand for suburban housing. Moreover, local residents might oppose intensification strategies on the ground that they increase traffic, and this can be an important obstacle for their implementation. Accordingly, Melia and colleagues suggest that intensification strategies should be accompanied by more radical policies to constrain car use (e.g. pricing measures, increased supply of public transport)
- the impact of public transport oriented development on intragenerational equity is somewhat controversial: indeed, TOD policy documents often include the promotion of mixed-income communities among their goals (Talen, 2002); yet, successful TODs are likely to result in increased land values and housing prices (Cervero, 2004c), with potential knock-on effects in terms of gentrification (Kahn, 2007), displacement of poor households and segregation (Newman et al., 2009, pp. 47-51). Theoretically, these negative impacts are not inevitable, as several strategies exist to reconcile TOD with social equity goals (Policy Link, 2008). However, in practice, such countervailing

> actions generally require high levels of effort and commitment on the part of the public sector (Downs, 2004). As a result, the impact of densification on social equity is often controversial, and this can undermine their acceptability

More broadly speaking, reducing car use by means of changes in the built environment is probably a 'sisyphus work', given the historical trend towards a decrease in the 'friction of distance' (Knowles, 2006). As Fulton (2004) puts it:

> "one of the principal challenges in slowing – and perhaps eventually reversing – travel growth is encouraging people in an increasingly wealthy world to reorganize their lives as to be closer to their destination of choice (..) despite their increasing ability and apparent inclination to arrange these activities farther and farther apart" (p. 190)

Similarly, Weinberger and Lucas (2011) observe that:

> "despite (..) increasing evidence of connectivity between urban form, people's travel choice and the level of their automobile use, land-use planning policies have proved to be extremely difficult to deliver in practice. (..) It is also clear that the opportunity to build new towns and cities or to significantly redevelop existing urban areas to make them more compact and transit oriented is limited, long term and also costly to deliver" (p. 74)

For these reasons, scholars and policy makers generally agree that changing the built environment is not enough, and that more short-term measures are needed. In this context, pricing disincentives are frequently mentioned.

1.6.4. Pricing

Many scholars have argued for the need to use economic instruments in order to reverse the car dependence process. The main argument is generally that, as of today, "the car is on welfare" (Newman & Kenworthy, 1999, p. 142). According to Newman & Kenworthy, "many studies in different parts of the world have found that the subsidy provided to the car is about US$3,000 to 4,000 per vehicle per year for roads, parking, health costs, pollution costs and so on" (*ibidem*). In that sense, it is often argued that current levels of car use are not an accurate reflection of consumer choice, since the market fails to take into account the true costs of car use, and thus stimulates demand for this mode of travel above the level that would be expected otherwise (Litman, 2002; Mo.Ve. Association, 2008). According to Dupuy (1995a), the car system owes much of its success and endurance precisely to its 'public-private mixed economics', whereby "the individual pays for the car, upkeep, insurance and fuel (while) various public bodies pay for the network of roads and streets" (p. 26-27). Even if taxes on motoring exist, in fact, until now, they have rarely been used in order "to make the motorists pay the real costs of the advantages which they gain from the system", but rather to "mantain a certain fluidity in traffic and parking", thus playing a role of active accompaniment for the expansion of the automobile sector (*ibidem*).

In short, then, pricing measures (such as road pricing, congestion pricing, emission charging and increases in fuel or other motor-related taxes) can be used to fullfill at least four different goals: first, internalise the costs of the externalities produced by the car and thus, arguably, enhancing equity between those who are responsible for them and the others (Musso & Burlando, 1999, p. 6; Docherty, 2003, p. 16); second, increase the perceived costs of car driving for the user, in order to bring it closer to the perceived price of other modes and thus reduce demand; third, to gather resources in order to finance the improvement of alternative modes (such as public transport), or other policies aimed at reducing car use (Newman & Kenworthy, 1999, p. 142-144); fourth, higher fuel taxes may be required in order to allow the introduction of new, highly fuel-efficient vehicle technologies or alternative fuels (Schäfer et al., 2009, p. 236).

Interventions aimed at changing the cost structure of car-based travel generally focus either on increasing the fixed costs of vehicle purchase and ownership, or the marginal costs of vehicle use (Weinberger & Lucas, 2011). Pricing car use can also have a variety of forms, such as: fuel taxes; parking charges; road pricing, tolling schemes and congestion charging (particularly in urban areas). Moreover, the case for the use of carbon taxes has often been made, even though actual implementations are still rare (Litman, 2010c).

The case for pricing motoring is strong, and it generally features prominently in most sustainable transport agendas. However, it is not devoid of limitations:

- the price increases required to bring about the necessary changes are likely to be very high, at least as far as car ownership is concerned. Indeed, Ingram and Liu (1999), in their comprehensive econometric study of the determinants of motorisation worldwide, find that income elasticities are about double than price elasticities. In a context of continuning economic growth, this means "prices would have to grow twice as fast as incomes to stabilize vehicle ownership" (*ibidem*). This is likely to be unpopular and difficult to implement
- it is often suggested that these measures are potentially threatening to intragenerational equity, as they might be punitive and regressive towards low-income car-owning households (Huby and Burkitt, 2000; Lucas et al., 2001), especially in suburban and rural areas (Gray et al., 2001). The equity of transport pricing measures is a highly debated and controversial subject, which has produced a vast quantity of literature that it is impossible to expand on here. In a nutshell, pricing measures have raised concerns about equity among both scholars and the general public, and these concerns may effectively hamper their implementation. The main issue is that, as motorisation has increased, car ownership and use, which used to be a luxury good (in economic terms) have become a necessary good: as a result, motoring taxes tends to have a regressive effect (Berri & Dargay, 2010). The issue is compounded in rural areas, where the elasticity of car ownership is lower (Dargay, 2002). Accordingly, the Mo.Ve. Association has explicitly recognised that "the introduction of coercive measures could generate significant economic and social impacts, particularly within specific groups of the population and within certain areas of the country" (2008, p. 35). Also Newman & Kenworthy admit that the implementation of economic instruments "will have immediate social and equity impacts" unless they are part of a broader strategy aimed at reducing the need to travel: otherwise, "with no other option provided, the increased costs of driving can only be punitive and regressive" (1999, p. 142-143). Similarly, Lucas et al. (2001) have conducted a study of transport and accessibility from the perspectives of disadvantaged groups and communities in the UK, collecting data by means of focus groups: they have observed a "surprising" level of animosity towards pricing policies to restrict car use, even among those without cars (p. 38), while local authorities have often expressed their uneasiness in implementing such measures. Accordingly, the authors conclude that "policies to 'cost the environment' into car use are essentially inequitable in that they effectively 'pull the ladder up from the bottom', have a disproportionate negative impact on low-income car-owning households and increase the travel poverty of non-car-owning households who rely on lifts from others". Lucas & Le Vine thus warn politicians against "enter(ing) blindly into policy or scenarios that run the risk of undermining the very basis of people's economic and social well-being"[28] (2009).

1.6.5. Changing individual attitudes and behaviour .

The previous three kinds of policy measures are often referred to as 'hard', because they act on structural factors behind car use and ownership (transport supply, built environment, prices). By contrast, 'soft transport policy measures' may be defined as those which:

> "try to influence individual decisions making less by using force and restrictions, but rather by persuasion that is by changing people's perceptions and motivations. For this purpose soft transport policy measures sistematically use social marketing technologies in which psychological concepts like perceptions, values, attitudes, social norms or perceived self-efficacy play an important role" (Möser & Bamberg, 2008, p. 11)

[28] An interesting example of how equity concerns may effectively hamper the implementation of the sustainable transport agenda is the UK Fuel Tax Escalator on petrol (see §5.1.2).

In that sense, soft transport policy measures can be seen as the application to transport of a more general approach to promoting pro-environmental behaviour (Lucas, Brooks et al., 2008). This corresponds to what Shove has critically defined as the 'ABC' paradigm, whereby policy makers aim to change the attitudes of individuals in order to get them to choose behaviours that are more environmentally benign (Shove, 2010). Examples of soft transport policy measures are the following (Cairns et al., 2004; Möser & Bamberg, 2008; Black, 2010; Weinberger & Lucas, 2011): advertising and awareness campaigns; demonstrations providing environmental information and/or personalised motoring information; personalised travel planning; marketing campaigns to promote modal alternatives.

Often included in this field are workplace and school travel plans, often referred to as 'mobility management' in mainland Europe (Senn & Ravasio, 2002): such plans aim to reduce the car use of employees (or, in the case of school travel plans, pupils' parents) but usually include a variety of measures, not all of which can be defined as 'soft'. They tipically include (among other measures): public transport incentives, personalised journey plans, car sharing or car pooling schemes, car parking restrictions, as well as the provision of new dedicated buses. The bottom line is generally to achieve a modal shift away from the car by getting people to voluntarily choose other means of transport.

The main limitation of soft transport policy measures is the same that I have outlined above (§1.4.1) for the 'ABC' paradigm more in general (Shove, 2010): by focusing on individual attitudes and behaviour, such measures tend to be ineffective when structural factors (such as, for example, limited availability of modal alternatives, car-oriented built environment, or low motoring costs) are the main cause of car use. Moreover, they also tend to obscure the role of public powers in sustaining those structural factors (Reigner et al., 2009; Shove, 2010). This does not mean that soft transport policy measures cannot be effective in particular contexts such as, for example, compact urban areas with good public transport networks. In that sense, while the effectiveness of soft transport policy measures is a much debated issue (Cairns et al., 2004; Möser & Bamberg, 2008), there is an urgent need to "increase (the) understanding of which contextual factors promote or impair the effectiveness of a specific soft transport policy measure and how they do this" (Möser & Bamberg, 2008, p. 21).

1.6.6. The limits of sustainable transport policies

As illustrated in the previous few sections, every kind of policy measures to reduce car use and ownership has important limitations. Accordingly, it is not surprising that most scholars and policy makers argue that an integrated set of policies is required if enviromentally sustainable transport is to be achieved (see Givoni et al., 2013). A typical example is Næss' claim that:

> "it is not reasonable to expect any single instrument to be able in itself to induce the necessary reduction of emissions. If the reductions of transportation's environmental loads necessary to make a difference in relation to the global climatic challenges are ever to be possible, there will probably be a need to combine both more energy-efficient vehicles, fuel taxes, road charges, improved public transport in cities, and a spatial planning limiting the needs for transport" (2006, p. 5)

On the other hand, however, there is a widespread impression that current policies for sustainable transport are falling far short of their goals. The European Commission, for example, reviewing more than ten years of european policies on transport, has recently admitted that "the european transport system is still not on a sustainable path in several aspects" (European Commission, 2009, p. 3). In that sense, as observed by Schwedes, "the field of transport policy (..) is characterized by extraordinary discrepancy between programmatic goals and real transport development" (2011a, p. 7). In this context, several scholars have noted that the loose concept of sustainable transport is interpreted in very different ways by various social actors: as a result, behind the apparent agreement lay powerful, contrasting interests and hidden agendas (Cucca, 2009; Schwedes, 2011b). Accordingly, Schwedes argues that in order to understand the aforementioned discrepancy it is necessary to analyse the field of transport policy with a political science approach, capable of shedding light on the vested interests that stand in the way of a radical change in current transport trends (2011a, 2011b).

In this context, it is interesting to discuss one example of conflict that the consensual notion of sustainable transport contributes to hide, i.e. the tension between the environmental and the social goals of transport policies. Indeed, it is worth reminding that the roots of the sustainability concept “did not come so much from academic discussion as from a global political process” (Newman and Kenworthy, 1999, p.1). In that sense, it is probably better seen as comprising three meta goals (rather than analytical dimensions): growth, intra-generational equity and intergenerational equity (environmental protection) (Feitelson, 2002, p. 142). Accordingly, sustainable development that simultaneously achieves all three meta-goals seems to be more of a political goal than a scientific notion. In this context, the potential trade-offs between growth and environment and between growth and intra-generational equity have been frequently addressed; by contrast, the third potential trade-off, between intragenerational and intergenerational equity, has received only limited attention (Feitelson, 2002, p.142). Similarly, in the field of transport, the tension between economic growth and environmental sustainability has been widely discussed, leading to the debate about the possibility of “decoupling” the environmental impacts of transport from economic growth (OECD, 2006); however, the tension between the environmental and the social agenda in this context has been studied less often (Lucas et al., 2001; Lucas, 2006; Cucca & Tacchi, 2012; Mattioli, 2013).

The review of policy measures carried out in this section has shown that changes to the built environment (§1.6.3) and pricing measures (§1.6.4) have a limitation in common, as they both might worsen existing social inequalities. As a matter of fact, while pricing disincentives can disproportionately disadvantage low-income car-owning households, densification strategies can result in gentrification and increased urban segregation. Accordingly, it makes sense to assume that concerns for possible negative social impacts of these policies can make their implementation difficult. The existence of this trade-off might help us make sense of why, in spite of increasing awareness, it is so difficult to tackle the environmental externalities of transport. The latent tension between social and environmental goals in the context of sustainable transport will be dealt with again in the closing section of the next chapter (§2.4.7), which is entirely focused on the relationship between transport and social exclusion.

2. Car-related transport disadvantage

2.1. The field of transport and social exclusion research

The first chapter of this thesis focused on increasing levels of mobility, motorisation and car dependence. Notably, I have highlighted the consequences that this process has on the environment, why they are of concern and the policies generally envisaged to achieve environmentally sustainable transport. It has been pointed out, however, that the growth of car ownership and use has also profound implications for the dynamics of (intra-generational) social inequality (§1.1.6): in a nutshell, it appears that in a more mobile world, the ability to cover greater distances and the access to motorised means of transport (such as the automobile) is increasingly important for social status and participation in society (Knowles, 2006). In this second chapter I focus on this topic, by discussing the various ways in which car ownership and use (or lack thereof) are related to patterns of social inequality (§2.2). The spatial dimension of this phenomenon (§2.3) and the policies aimed at reducing (car-related) transport disadvantage (§2.4) are also discussed. This sets the context for the empirical work, focused on households without cars, that is the object of the remainder of this thesis.

In this first section (§2.1), however, I focus more generally on the field of transport and social exclusion research. While it is beyond the scope of this chapter to provide a full review of this literature (for recent overviews see Currie & Delbosc, 2011a; Lucas, 2012), it is necessary to give a sense of the issues and complexities that it involves. This sets the context for the rest of the chapter, that is focused more specifically on 'car-related' transport disadvantage.

2.1.1. Delimiting the field

From the outset, it is necessary to delimit the scope of the discussion. Indeed, in recent years there is increasing interest for the interface between transport and social equity: this can be described as a "complex and wide-ranging topic area, with a common focus on social impacts, distributional and social equity effects of the transport system and the policy decision process" (Lucas & Jones, 2012, p. 1). This research field includes very different topics (Jones & Lucas, 2012), including (but absolutely not limited to): road casualties and injuries (Fleury et al., 2010; Haddak et al., 2010), air pollution (Schweitzer & Valenzuela, 2004) and forced residential relocation (Geurs et al., 2009; Jones & Lucas, 2012)

In a nutshell, there are several 'goods and bads' associated with transport and both are distributed unevenly across society. Accordingly, some authors argue that there is a need for comprehensive approaches that take them all into account (Lucas & Jones, 2012, p. 1). Notably, researchers often argue that disadvantaged groups in society suffer from both a lack of access to 'transport goods' *and* a disproportionate exposure to 'transport bads'. In the UK, the Sustainable Development Commission recently argued that:

> "the inequality is two-fold. In general the people experiencing the worst access opportunities also suffer the worst effects of other people's travel. They are both 'less travelled' and 'travelled-upon'" (Sustainable Development Commission, 2011, p. 8)

When talking about the field of *transport and social exclusion research*, however, the reference is generally to studies focused on the distribution of what is arguably the main good that transport is expected to deliver: *accessibility*. While accessibility is a notion with a long history and a variety of competing definitions (Farrington & Farrington, 2005), in "its broadest interpretation" it provides

> "measures of the degree to which people can reach the goods and services that society considers are necessary for them to live their daily lives, but with an emphasis on potential/capability rather than actual behaviour" (Jones & Lucas, 2012, p. 6)

A lack of accessibility (at the individual, household or local community level) is generally considered as being negative, insofar as it can contribute to bring about *social exclusion*. Therefore, before introducing the notion of transport disadvantage, it is necessary to discuss the notion of 'social exclusion'. While the precise definition of what is meant by social exclusion is the subject of a complex and ongoing debate, a satisfactory definition in this context is the following:

> "the unique interplay of a number of factors, whose consequence is the denial of access, to an individual or group, to the opportunity to participate in the social and political life of the community, resulting not only in diminished material and non-material quality of life, but also in tempered life chances, choices and reduce citizenship" (Kenyon et al., 2002, p. 209)

The definition provided above has several defining features, which can be contrasted with the (more traditional) notion of 'poverty':

- instead of focusing on only one aspect such as insuffient income, social exclusion is conceived as a *multidimensional* construct, highlighting the variety of contributing factors that may lead to non participation in society, as well as their inter-relationships. In this context, "the issue becomes one of (..) understanding what these factors are and how the impact of improvement in one area affects the system as a whole" (Stanley, 2011, p. 29)
- instead of narrowly focusing on material aspects, a framing in terms of social exclusion stresses *non-material* dimensions, such as participation in social and political life: in that sense, the concept has "drawn attention to the fact that being part of society and having good well-being is a lot more than material and economic gains" (Stanley, 2011, p. 34)
- instead of focusing on a state or outcome (such as poverty), this approach focuses on the *processes* that bring about exclusion from society
- the concept is meant to stress that exclusion is the emergent property of the interaction between individuals and households, on one hand, and society on the other. In that sense, "in highlighting the *denial* of access to opportunity, (it) places emphasis upon structural constraints to participation, removing the individual culpability that is implied by definitions suggesting an *inability* to participate in society" (Kenyon et al., 2002, 209). This is often contrasted with the stigma attached to the notion of poverty
- the notion of 'participation in society' highlights the inherently relational nature of the social exclusion concept (Litman, 2003). With regard to transport, this implies that "what is necessary for full 'social' inclusion varies as the means and modes of mobility change and as the potential for 'access' develops with the emergence of new technologies" (Cass et al., 2005, p. 542)

While the concept of social exclusion was first put forward in the French context in the 1980s, it has been increasingly adopted as a framework for social policy internationally (Council of the European Union, 2010). According to Smyth "for researchers on transport and disadvantage (..) this approach represents what has become the new mainstream in terms of thinking about poverty in contemporary developed economies" (2007, p. 02.5). In this context, several authors have put forward the concept of 'mobility- (or transport-) related social exclusion'. One possible definition is the following:

> "the process by which people are prevented from participating in the economic, political and social life of the community because of reduced accessibility to opportunities, services and social networks, due in whole or in part to insufficient mobility in a society and environment built around the assumption of high mobility" (Kenyon et al., 2002, p.210-211)

While a great variety of theoretical constructs (beside social exclusion) is used in the literature (see §2.1.3), this definition is still useful to identify a research area. This, however, is not equally developed all over the world: indeed, while some countries have led the way, in others the study of the relation between transport and social exclusion is still in its infancy. Moreover, in countries where a wealth of studies have been conducted, this has sometimes happened under other theoretical frameworks. In the next section, I provide a brief account of this variety.

2.1.2. *Different national perspectives*

The UK is generally considered the leading country in the research on transport and social exclusion. In this context, the surge in interest for the topic in the last 10-15 years has been policy-driven. According to Lucas and Markovich, most studies "emerged in response to the social welfare concerns of the then newly elected Labour administration" (2011, p. 225). Indeed, with the election of the first New Labour government 1997, 'social exclusion' became a key policy concept in Britain, as shown by the launch of the Social Exclusion Unit (SEU) that very same year. The remit of the unit (now disbanded) was to advance knowledge about social exclusion and promote solutions to the associated problems (Lucas, 2004a, p. 40): given that a first report the following year (SEU, 1998) highlighted the importance of transport problems for social exclusion, in 2001 the then Prime Minister Tony Blair asked the SEU to start a wide-ranging study on this topic involving literature reviews, public consultations and local area research studies. The results of this research effort were made public in 2003 with the publication of 'Making the Connections: Final Report on Transport and Social Exclusion" (SEU, 2003). This has been a turning point for the research on transport and social exclusion, in at least two respects. Firstly, it has improved the quantity and quality of British research by leaps and bounds: indeed, while transport inequalities had been studied in the UK since the 1970s, these efforts had been "fragmented and piecemeal" (Lucas, 2004b, p. 145). After 2003, more concerted research efforts have considerably advanced both the theoretical and the empirical understanding of transport and social exclusion in the UK (Lucas, 2012). Secondly, the SEU has raised academic and policy interest in the issue in other countries such as, among others, France (Orfeuil, 2004a) and Australia (Currie et al., 2007; Currie, 2011a).

In the case of Australia, most research efforts have been conducted in the state of Victoria. Similarly to the UK, the main driver has been the interest of governmental institutions: as reported by Morris and Kinnear (2011), in recent years the Victorian government has developed an interest in the social impacts of transport, notably in relation with the low-density nature of many settlements on its territory. Accordingly, the Australian Research Council has funded a five-year research program ('Investigating Transport Disadvantage, Social Exclusion and Well-Being in Metropolitan, Regional and Rural Victoria') whose results have been recently internationally published (Currie, 2011a). A defining feature of the project is the effort to draw lessons from the UK, which has been accomplished with the involvement of leading British scholars (Lucas & Currie, 2012).

In the United States, considerable research efforts have been devoted to investigating the links between transport and employment. However, this has generally happened under other theoretical frameworks such as the spatial mismatch hypothesis (McLafferty, 2001), which has prompted studies on the role played by public transport and car availability in the welfare-to-work transition (Taylor & Ong, 1995; Cervero et al., 2002; Ong, 2002; Blumenberg, et al., 2003; Kawabata, 2003; Lucas & Nicholson, 2003; Blumenberg & Manville, 2004; Ong & Miller, 2005; Grengs, 2010, see §2.2.1 below). Studies in this vein are also sometimes seen as part of a broader 'environmental justice' agenda, and as such they have received increasing attention in recent years[29] (Kennedy, 2004). According to Lucas, while "US policy and practice is more advanced" than the British in this field (2004d, p. 291), there are limits to existing research and policy approach, namely the excessive focus on certain disadvantaged groups (racial minorities and the unemployed) and on the welfare-to-work transition, while access to other services and opportunities is only rarely considered, and the lack of consideration of the influence of land-use planning (Lucas, 2004c; 2004d). In this context it is revealing that (unlike the UK and Australia) the issue has not been framed around the concept of social exclusion - a term which is rarely used in US policy and research[30] (Rosenbloom, 2007).

[29] The term 'environmental justice' has a long and complex history, and a variety of meanings (Walker, 2012). According to Kennedy "(it) has been used to embrace notions of discrimination, equity, denial of benefits, adverse effects, initially to people of color and other minority populations, but more recently to low-income populations. In relation to transportation issues, this would include consideration of the effects from road building and other transportation infrastructure, transportation-related air and noise pollution, congestion, denial of access to transportation and community severance" (2004, p. 157).

[30] However, there are signs that this might be changing: for example a recent study by Casas et al. (2009) focuses on children access to urban opportunities in the State of New York and makes reference to the notion of 'transport-based social exclusion'.

The situation is partially different in Canada: even though also here the concept of social exclusion is not widely used (Litman, 2003), recently a large research project called ‘Mobility and social exclusion in Canadian communities. An empirical investigation of opportunity access and deprivation from the perspective of vulnerable groups’ (Páez et al., 2009) has been launched, whose results have been internationally published (Páez et al., 2010a; 2010b; Roorda et al., 2010; Morency et al., 2011). In this context, Canadian researchers have paid particular attention to the temporal aspects of transport-related social exclusion (Farber & Páez, 2009; 2011a; 2011b; Farber et al., 2011, see §2.2.3).

In mainland Europe, France is probably the country where the most research efforts have been undertaken in this field, since the early 1990s (Conseil National des Transports, 1991). In this context, there have been attempts at drawing lessons from the British approach (Orfeuil, 2003; 2004a), and the concept of social exclusion is widely used, having been introduced in French policy since the 1980s. However, much research has been framed by the geographical notion of accessibility (MSFS, 2011) or by the concept – very popular in the french-speaking context – of ‘motility’ (Kaufmann et al., 2004). Some peculiar features of French research in this field are a recurrent concern for ‘sensitive urban zones’ (ZUS), where poverty and social problems are often concentrated, and a particular focus on how lack of skills and competences can be an obstacle to the use of transport (see for example MSFS, 2011). Comparatively, the interest for transport and social exclusion in Italy is much weaker than in France, both in academic and policy-making circles. However, in recent years the Department of Sociology and Social Research at the University of Milan-Bicocca has made research efforts to fill this gap (Colleoni, 2008; Borlini & Memo, 2009; Melzi, 2011; Borlini et al., 2011; Castrignanò et al., 2012): in this context, a three-year ‘National Research Project on spatial mobility, accessibility and social equity’, focused on the metropolitan areas of Milan, Turin and Bologna has been launched in 2008 (Melzi, 2011; Borlini et al., 2011; Castrignanò et al., 2012; Colleoni, 2013). Also, the National Association of Italian Municipalities (ANCI) has recently commissioned a report on ‘Rethinking urban accessibility’ (Borlini & Memo, 2009), revealing a growing interest for the issue on the part of local policy-makers. At a theoretical level, however, the debate in Italy has been informed by the French literature as well as by the concepts of ‘accessibility’ and ‘socio-spatial exclusion’ (Cass et al., 2003), rather than by the British debate on transport and social exclusion as a whole. Finally, in Spain, research work has been undertaken recently on mobility and labour-market exclusion in Barcelona (Cebollada, 2009), revealing that interest for the topic is growing in several European countries.

In this context, it is surprising to observe the lack of interest paid to the issue in Germany. When in 2002-2003 the Transport Studies Group at the University of Westminster undertook a scoping study “to compare the position of the G7 countries in relation to transport and social exclusion” (Lucas, 2003), the German paper (Kemming & Borbach, 2003) acknowledged that “social exclusion connected with the field of transport is not a topic at all” in the national debate (p. 26). In the last ten years, not much has changed: even though a few research efforts have been undertaken (Hesse & Scheiner, 2009; Daubitz, 2011; 2012; Wolter, 2012), in 2011 German researchers still observed that “studies on the travel behaviour of low-income people are unfortunately still the exception” (Daubitz, 2011, p. 81, own translation), academic interest for the topic is “still in its infancy” and a policy debate is still lacking (Scheiner, 2009a, p. 186, own translation). Kemming and Borbach (2003) put forward some possible reasons for this lack of interest: firstly, the lack of public debate about poverty and the ‘social question’, partly as a result of assumptions about the efficiency of the well-functioning German social securty system (p.3) (at least until the ‘Hartz IV’ reform of 2004, cfr. Daubitz, 2011, p.192). Secondly, “the concept of social exclusion so far has received only relatively little attention in German academic and political debate, (that) is dominated rather by the concept of poverty” (Kemming & Borbach, 2003, p. 3); arguably, such a narrow focus does not facilitate the taking into account of the multidimensional determinants of social disadvantage, including transport. Finally, “an explicit spatial dimension has been missing from German poverty research for a long time” (*ibidem*); accordingly, unlike for example in France and the UK, disadvantaged urban areas have not attracted much research interest until quite recently. While this might be related to factual differences in the (less unequal) German society and in the urban housing market and policy, it certainly does not help the establishment of a ‘transport and social exclusion’ research agenda: indeed, in several countries (UK, France, US) concerns for disadvantaged and segregated urban areas have been instrumental in bringing this issue to the fore.

2.1.3. Theoretical concepts

The reader who approaches the literature about transport and social exclusion is confronted with a complex and sometimes confusing variety of theoretical concepts. Indeed, according to Lucas and Markovich, given that "the conceptual development of transport-related social exclusion is still in its infancy (..) core definitions and theoretical explanations of the phenomenon are still being elaborated and refined" (2011, p. 225). Similarly, they observe that "whilst the concept of transport-related social exclusion is broadly accepted as a useful approach by scholars from different disciplinary perspectives (..) exactly how this is understood and conceptualised varies greatly across the literature" (p. 226). Accordingly, "there is a need to establish a "lexicon of definitions" to ensure a greater degree of clarity and consistency within and between the academic and policy literature" (p. 233).

While establishing such a lexicon is clearly beyond the scope of this thesis, in this section I briefly review some theoretical concepts that are used in transport and social exclusion research, as well as their interrelationships[31].

The notion of 'transport disadvantage' is one of the most common in the literature (see for example Hine & Mitchell, 2003; Dodson et al., 2004; Currie et al., 2007; Currie, 2011a). Currie and Delbosc, drawing on a framework put forward by Lucas (2004a), have defined it as a "complex, multidimensional construct brought about by the interaction between land use patterns, the transport system and individual circumstances" (2011a, p. 15). In this understanding, the notion of transport disadvantage is strongly related to 'accessibility', or rather the absence of it.

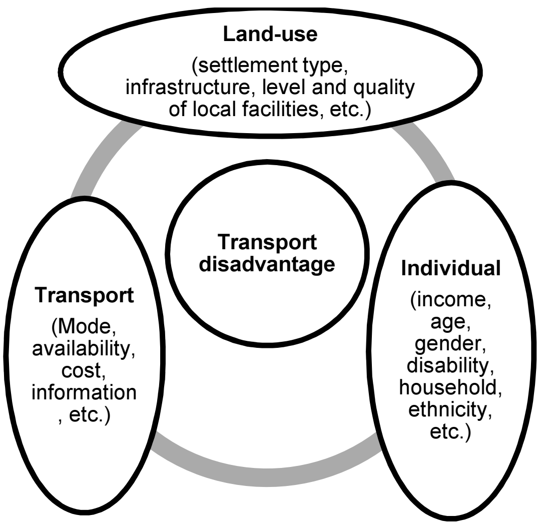

Fig. 2.1 – First diagrammatic representation of factors affecting transport disadvantage. Source: adapted from Lucas (2004a) and Currie and Delbosc (2011a).

As illustrated in Fig. 2.1, in this perspective lack of access to services and opportunities (transport disadvantage) is conceived as arising from the *interaction* of three set of features. Firstly, individual or household attributes: indeed, it is intuitively obvious that factors such as low income or disability can make access to desired services and opportunities problematic. Similarly, transport-related factors such as low levels of public transport provision are clearly very relevant. Finally, factors related to land use (such as population density, diversity, etc.) play a central role, insofar as they determine the distance to desired activity locations.

[31] Throughout all this chapter, I refer to an 'individual' understanding of 'transport disadvantage', i.e. as an attribute of individuals. However, in §2.3, the transport disadvantage of local areas ('collective' understanding) is also discussed.

The apparent preminence of individual and land-use related factors in determining accessibility problems has led some scholars to distinguish between two types of 'transport disadvantage': for example Betts (2007) puts forward the concept of "locational transport disadvantage", occuring when "there is very little or a complete absence of publicly funded transport choices", as opposed to "personal disadvantage", occuring when " a person's mobility is affected by age (including youth), disability, frailty, poor health or language barriers" (p. 12.2). Similarly, Hine and Grieco have put forward the idea that transport disadvantage takes the form of "scatters and clusters" (Grieco et al., 2000; Hine & Grieco, 2003), meaning that transport disadvantaged groups are not only found clustered in transport disadvantaged areas, but also scattered over space, for example when mobility problems are due to personal characteristics (e.g. age). Cass et al. (2003) (2003), presenting the results of interviews with officials and policy makers about transport-related social exclusion, observe that "there was a persistent tendency to think of a) the socially excluded as a category of person and/or, b) to think of social exclusion as the property of particular geographical areas" (p. 6).

While the notion that transport disadvange is both clustered and scattered in space is valuable, I argue here that it would be wrong to postulate the existence of two different types of transport disadvantage: indeed, accessibility problems always arise from the interaction of several factors, as illustrated in Fig. 2.1. For instance, while disability can be seen as a personal attribute, the difficulties that disabled people experience in using public transport can be considered as also the by-product of the shortcomings of public transport infrastructure in accommodating disabled users (Currie & Allen, 2007). Similarly, teenagers are often considered at risk of transport disadvantage, because they cannot drive cars (see for example Currie, 2007); however, this is likely to result in accessibility problems only in areas where desired activities are difficult to reach by other transport means (such as low-density suburban areas). Accordingly, I argue that transport disadvantage is *always* to be considered as the result of an interaction between different factors, and can rarely be attributed to just one of them.

In this context, another factor of interest has to do with the skills and competences of individuals. The key insight here is that even when transport linkages exist, individuals might not be aware of them, lack the skills required to use them, etc. French scholars have been perhaps the most active in exploring the socio-cognitive dimensions of transport disadvantage (Le Breton, 2004a; Allemand, 2008; MSFS, 2011): in this context, they often make reference to the concept of 'motility'. In the framework put forward by Kaufmann et al. (2004), motility "encompasses interdependent elements relating to *access* to different forms and degrees of mobility, *competence* to recognize and make use of access, and *appropriation* of a particular choice" (p. 750). With regard to competence, they write:

> "*Competence* includes skills and abilities that may directly or indirectly relate to access and appropriation. Three aspects are central to the competence component of motility: *physical ability*, e.g. the ability to transfer an entity from one place to another within given constraints; *acquired skills* relating to rules and regulations of movement, e.g. licenses, permits, specific knowledge of the terrain or codes; and *organizational skills*, e.g. planning and synchronizing activities including the acquisition of information, abilities and skills. Competence is multifaceted and interdependent with access and appropriation." (Kaufmann et al., 2004, p.750)

In a similar way, Dijst and Vidakovic (1997, quoted in Borlini & Memo, 2009, p.27) distinguish between 'potential accessibile' and 'perceptual accessibile' activity spaces, higlighting the fact that objective assessments of activity spaces can overestimate their size, since only the part that is perceived as such by the subject (the intersection of the two activity spaces) will be actually accessible.

The issue of 'limited travel horizons', often referred to in the British literature, can be associated with the discussion on competence and transport disadvantage. For example, the SEU report on transport and social exclusion states that:

> "people on low incomes can be reluctant to travel long distances for a long time. This is a particular problem for jobseekers, who may be unwilling to look for or consider job vacancies outside a narrow geographic area, even where opportunities appear to be accessibile. (..) Individuals' travel horizons can be limited because of: trust – they lack confidence that the bus will get them to places on time.

(..) Knowledge – poor knowledge of how to get to places using the transport network. (..) Familiarity – a tendency to look for work in, or travel to, places that are familiar" (SEU, 2003, p. 31)

Similarly, Lucas observes that "long-standing (sometimes intergenerational) and inculcated activity patterns, illiteracy and language barriers, limited travel horizons, low expectations and reduced aspirations" can result or contribute to transport disadvantage (Lucas, 2004b). This can happen even in contexts where suitable transport infrastructure is available, although as Farrington and Farrington observe "people's wants are actually quite well tuned to the realities of their situation, especially in so far as it is determined by location" (2005, p. 7). Overall, there seems to be growing recognition of the need to take into account the socio-cognitive aspects of transport disadvantage.

Scholars at the Department of Sociology at Lancaster University have put forward the concept of 'socio-spatial inclusion/exclusion' (Cass et al., 2003; 2005). Since the authors explicitly state that "by socio-spatial we refer to those forms of inclusion/exclusion that are specifically related to access and mobility", the notion can be considered as equivalent to 'accessibility' and 'transport disadvantage'. However, their framework has some peculiar features, that are useful to expand and integrate the conceptualisation of transport disadvantage put forward in Fig. 2.1.

As illustrated in Fig. 2.2, according to Cass et al. socio-spatial inclusion/ exclusion is "an emergent property of interaction between a) social obligation and associated requirements for proximity and mobility, b) individual resources (..) and c) the physical infrastructure" (2003, p. 5). The element of novelty here is the first factor. Drawing on the notion of 'compulsion to proximity' (Boden & Molotch, 1994) the authors argue that co-presence is a requirement for a wide range of human interactions: accordingly, it is this 'compulsion to proximity' that explains most of the travel undertaken by people (Urry, 2002).

This framework has several major implications: firstly, it highlights that different people need to access to different things: "exclusion arises when people cannot meet *what they take to be* obligations of co-presence" (Cass et al., 2003, p.31, emphasis added). In doing that, the authors stress the "relative and contextual nature of inclusion/exclusion", whereby "rather than (..) a fixed attribute (..) being included or excluded is a function of the groups and situations to which different people belong and/or want to be a part of, and their means to realise these ambitions" (p. 7). This in turn highlights the "need for a better understanding of peoples' social networks and of whether and how these are changing" (p. 9) and the impossibility of assuming that certain categories of people or certain areas are *ipso facto* excluded.

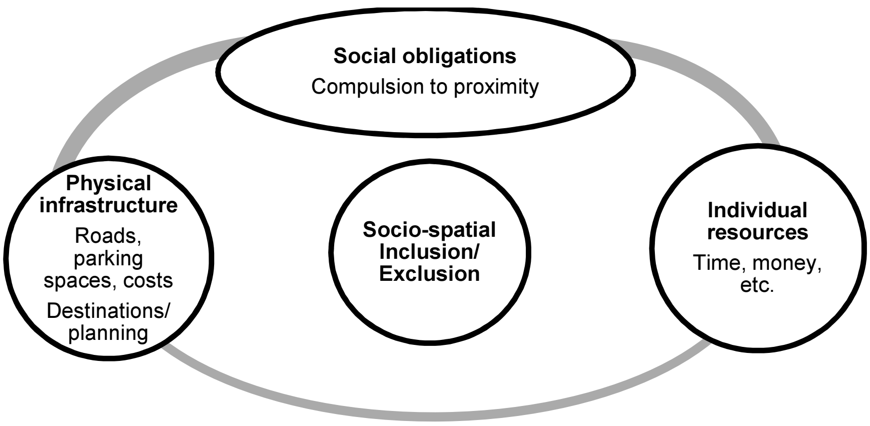

Fig. 2.2 – Diagrammatic representation of factors affecting socio-spatial inclusion/exclusion. Source: adapted from Cass et al. (2005, p. 28).

The second major implication is that obligations to proximity are not only individually varied, but also socially defined: from this it follows that, as society changes as a result of various processes (including increasing levels of car dependence), new obligations to proximity are likely to arise. To cite but one of many possible examples, older people today engage in a wider range of leisure activities than it was a case some decades ago: accordingly, while difficulties in accessing these activities might not have been a problem then, they are likely to have an impact on social exclusion now, given how obligations to proximity have changed for this group. As the authors argue then, “the relation between social exclusion, mobility and access (is) a dynamic one, and one that plays at the level of society as a whole” (Cass et al., 2005, p. 553).

A third implication of this conceptualization is that researchers should not limit themselves to address access to public and formal services – as it has often been the case in accessibility research – but should rather address the whole range of obligations to proximity. As the authors argue:

> “...analyses of transport-related social exclusion are typically based upon a model that views inclusion in terms of people being able to ‘get at’ pre-defined ‘public’ goods and services located within pre-determined ‘formal’ locations/destinations. This model rests on a definition of what excluded people should want or need and obscures the role that social networks play in maintaining a ‘good life’ and in structuring the meaning of inclusion and participation” (Cass et al., 2005, p.551)

In a nutshell then, Cass et al. encourage transport and social exclusion scholars to adopt a broader understanding of ‘what people needs to access’, stressing notably the need to take into account friend and family networks. This feature of their approach resembles the work of scholars who have investigated the relationships between transport disadvantage, social exclusion and social capital, as it will be illustrated below.

The final defining feature of the ‘socio-spatial inclusion/exclusion’ framework is the emphasis placed upon temporal aspects of accessibility. Indeed, Cass et al “take the temporal to be at least as important as the spatial in characterising mobility related exclusion and inclusion” (2003, p.8): this is in stark contrast with most transport and social exclusion research, where the spatial dimension of accessibility often ends up catching most of the attention. Cass et al. move from the premise that, as a result of social and technological innovations (motorisation, mobile communication devices, etc.) there is “an apparent breakdown of what used to be predictably scheduled events” in contemporary societies, whereby “the scheduling of social life appears to be an increasingly ‘do-it yourself’ operation” (p. 37). As a result, ‘time sovereignty’, i.e. “the degree to which people do or do not have control over, or flexibility into, their temporal regime” (2005, p. 551) is a crucial resource for accessibility, at least as important as the amount of time available. As Shove (2002) argues, this happens because social interactions are increasingly built around the premise of this temporal flexibility: as a result, not being able to reach opportunities ‘at a moment’s notice’ can be a sufficient reason for socio-spatial exclusion. Overall, the emphasis that Cass et al. place upon the temporal aspects of accessibility makes their approach similar to that of scholars who, moving from a time-geography approach (Hägerstrand, 1970) have used the concept of ‘activity-spaces’ to study transport disadvantage (see for example Schwanen, 2011; Farber & Páez, 2011a).

Of course, the socio-spatial inclusion/exclusion framework is not devoid of limitations: notably, while taking into account the variety of obligations to proximity among individuals makes perfect sense from a theoretical standpoint, it is probably too much of an ambitious task for empirical research. Nevertheless, the framework put forward by Cass et al. is useful to integrate common conceptualisations of transport disadvantage with a more sociological perspective: Fig. 2.3 is an attempt to do just that, updating Fig. 2.1 to include the additional factors (competences and obligations to proximity) discussed in the above.

One of the major ambiguities of the transport and social exclusion literature is whether transport disadvantage should be considered as one of several dimensions of social exclusion or as a separate theoretical construct that is *causally associated* with social exclusion. The first position is taken for example by Kenyon et al. (2002) who include ‘mobility’ in a list of “potential exclusionary factors of social exclusion” including also: economic; societal; social networks; organised political; personal political; personal; living space; and temporal factors (p. 210). Lucas, by contrast, argues that:

"it is important to establish that transport disadvantage and transport-related social exclusion are not *necessarily* synonymous with each other, i.e. it is possible to be socially excluded but still have good access to transport or to be transport disadvantaged but highly socially included" (Lucas, 2012, p. 106)

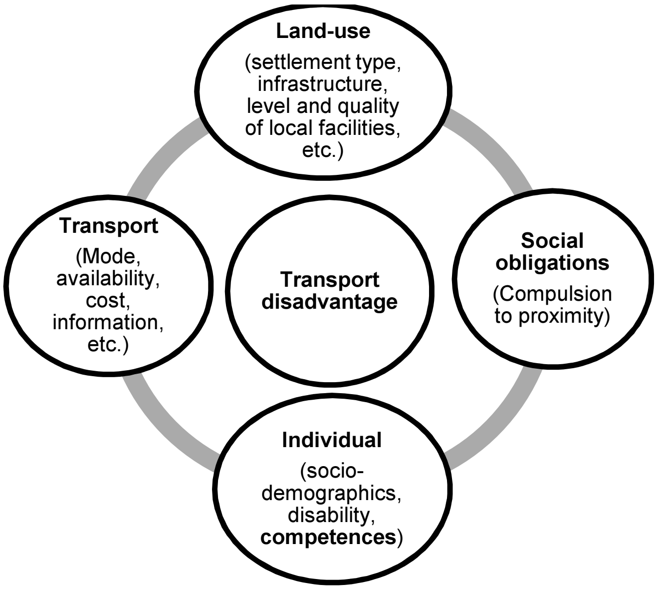

Fig. 2.3 – Second diagrammatic representation of factors affecting transport disadvantage. Source: adapted and integrated from Lucas (2004a), Currie and Delbosc (2011a) and Cass et al. (2005).

In this perspective, adopted among others by Currie (2011a), it is crucial to investigate the causal relationships between two different constructs: transport disadvantage and social exclusion. Indeed, the research and policy interest for transport disadvantage is based on the assumption that this has negative consequences on (other) dimensions of social exclusion. A typical quote is the following:

> "Poor mobility options place people at risk of being excluded from important aspects of society (..). Many young people, older people, people with a disability, those on low incomes and Indigeneous Australians experience transport disadvantage. *The consequences of transport disadvantage can include* reduced educational achievement, poorer job opportunities, less social engagement, less involvement in recreational and leisure pursuits, greater difficulty in obtaining medical services when required, as well as many similar impacts" (Stanley et al., 2007, p.16.1, emphasis added)

However, it is important to note that the cause-effect relationship between transport disadvantage is likely to be bidirectional: for example, the lack of a car can be the reason for unemployment, which in turn results in low income; however, low income is also one of the main determinants of non-car ownership (see §1.3). Similarly, poor public transport provision can indeed contribute to reduced educational achievement, but low education levels can also contribute to transport disadvantage, insofar as they might result in the lack of skills and competences that are required to use public transport. Furthermore, the possibility of self-reinforcing feedback loops cannot be excluded. This is hardly peculiar to the transport disadvantage debate: indeed Stanley, in a discussion of factors "holding back the efficacy of the concept of social exclusion", observes that "often (it) is used in a circular sense as both a cause or driver of a lack of personal opportunities and the outcome of a lack of opportunities" (2011, p. 32).

While most literature in this field focuses on the relationship between transport disadvantage and social exclusion, recent research developments have expanded the range of theoretical constructs to be taken into consideration. For example, recent work in Australia (Currie, 2011a), has pleaded for the introduction of the concept of 'well-being' in transport and social exclusion research. The psychological notion of well being, roughly synonymous to the lay concept of happiness, has been increasingly debated in recent decades (Vella-Brodrick, 2011). In a recent review of literature, Vella-Brodrick distinguishes two understandings of well-being (2011, p. 46-49): subjective well-being, wich refers to the maximisation of positive emotions, the minimisation of pain and an evaluation of life satisfaction; and psychological well-being, associated with factors such as autonomy, personal growth, purpose in life, positive relations with others and the like. In both cases, the emphasis is on the non-material determinants of happiness, stressing the fact that higher income does not necessarily result in greater satisfaction. Indeed, the main determinants of happiness are believed to be genetic factors, personality traits, as well as contextual and activity-based factors: in that sense transport, in enabling access to essential services and activities is likely to have a positive impact on well-being (Stanley & Stanley, 2007a; Vella-Brodrick, 2011; Delbosc, 2012).

In reviewing existing research on transport and well-being, Vella-Brodrick and Delbosc (2011) observe that most of it has focused on the mobility of older people; moreover, in this context, the mediating role of social exclusion has also generally been neglected (Delbosc & Currie, 2011a). By contrast, Australian researchers have strongly argued that studies of transport and social exclusion should take it into consideration as a crucial dependent variable. For example Stanley and Stanley, in a critical discussion of existing transport and social exclusion research, argue that:

> "(A) shortcoming of the present approach is that reducing social exclusion is effectively seen as the end-point goal of a policy process. The authors believe that reducing social exclusion per se is not the ultimate policy goal, which should instead be couched in terms of enhancing individual/community wellbeing" (Stanley & Stanley, 2007a, p. 13.6)

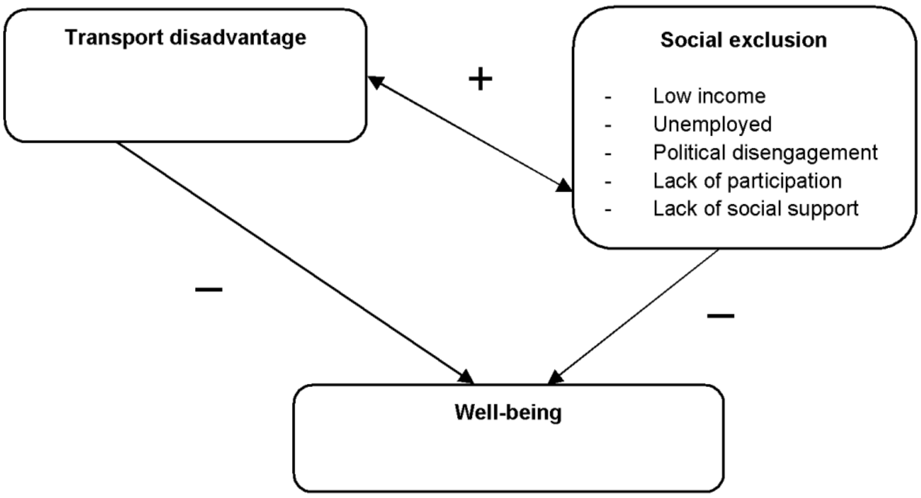

Fig. 2.4 – Diagrammatic representation of the relationships between transport disadvantage, social exclusion and well-being. Source: adapted from Delbosc and Currie (2011a)

In theoretical terms, Currie and colleagues assume that transport disadvantage has two kind of effects on well-being (Fig. 2.4) (Delbosc & Currie, 2011a). Firstly, it increases the chances of social exclusion and this, in turn, reduces subjective well being (indirect effect). It must be noted that in this context social exclusion is defined as multidimensional concept but does not include a mobility-related dimension, in order to distinguish it clearly from transport disadvantage. Secondly, transport disadvantage also has a direct effect on well-being: this can be explained by the fact that (actual or potential) mobility can improve feelings of autonomy, freedom, and psychological security, quite apart from the access to services that it provides (Vella-Brodrick & Delbosc, 2011, p. 94-95).

Another concept that is frequently discussed in the context of transport and social exclusion research is that of 'social capital'. Just like social exclusion, this notion has a long history and a variety of competing definitions: in this context, the works of Granovetter (1973), Bourdieu (1986), Coleman (1988) and Putnam (1995) are usually cited (for an overview see Portes, 2000). In this section, I adopt a minimal definition of social capital as a concept describing "the advantages individuals and communities can gain from social participation, mutual assistance and trust" (Currie & Stanley, 2008, p. 529). When using this concept, sociologists often stress how access to social networks can be considered as a form of capital, sitting alongside and strictly related to the possession of other kinds of capital (economic, cultural, etc.) (Bourdieu, 1986).

Several authors in the field of transport and social exclusion research have hinted at the relevance of social networks in influencing the degree of transport-related social exclusion. I have already noted how the notion of socio-spatial inclusion/exclusion put forward by Cass et al. (2003; 2005) stresses the importance of creating and maintaining relevant social networks by means of occasional co-presence, in order to achieve full participation in society. Earlier work by Urry (2002) has emphasised how social capital is increasingly dependent on "the range, extent and modes of mobility, especially vis-à-vis the mobilities of other social groups" (p. 265), while later work has focused on the notion of 'network capital' in order to stress how physical travel and/or mobile communication are "central to contemporary relations of power" (Urry, 2012, p. 24). French scholars (Coutard et al., 2004; Fol, 2009) have argued that low-income low-mobility households in French suburban areas are better off than their American and British counterparts, partly because they can rely on family support networks in the local area: in this 'local dependence' model, local social capital balances out the constraints associated with poverty and non-car ownership, protecting them from the worst effects of car dependence. By contrast, Gray et al. (2006), in a study focused on poor, non-car owning households in rural areas, have emphasised how "strong local social capital appears important in conferring mobility to certain social groups" (p. 89), especially if the common practice of lift-giving is taken into account. In a study on the size and spread of social contacts in Switzerland, Frei et al. (2009) conclude that "size and spatial dispersion of social network geographies differ according to various stratification dimensions, which in turn are related to various mobilities and inequality patterns" (p. 116). Similarly, Viry et al. (2009) have investigated the impacts of commuting on the structure of social capital, and the associated implications in terms of social inequalities. In the light of these developments, in a recent literature review Lucas and Makovich observe that:

> "the links between social exclusion, social networks and social capital are starting to receive attention (and this) goes some way towards bridging the disciplinary divide that currently exists between transport studies and the social sciences, because most of these studies have adopted the theories and methods that have been previously applied to other areas of scientific enquiry by sociologists" (Lucas & Markovich, 2011, p. 229)

More recently, Australian scholars have put forward a comprehensive framework for studying social capital and its interrelationships with social exclusion and well-being (Stanley & Stanley, 2007; Currie & Stanley, 2008; Stanley et al., 2010). According to them, existing research on transport and social exclusion has overlooked the 'mediating role' of social capital (Stanley et al., 2010). Such a mediating role is apparent from the following quote:

> "the provision of transport may be the means to directly link an unemployed person with employment. Alternatively, transport accessibility may enable people to form associations or relationships and engage with other people and groups. This, in turn, may lead to increased job prospects, as most employment is obtained through personal contacts. This can be understood in terms of the development of social capital, which, in itself, leads to improved health, wellbeing, and happiness" (Stanley & Stanley, 2007a, p. 13.6)

In a nutshell, then, transport disadvantage is identified as having a causal effect not only on social exclusion, but also on social capital. The latter, in turn, is assumed to have a causal effect both on well-being and on social exclusion (and thus indirectly on well-being) (Stanley & Stanley, 2007a). However, there are good reasons to believe that the relationship between transport disadvantage and social capital may be of a more complex nature than simple unidirectional causation. As Viry et al. argue:

> "the links between geographic mobility and social capital (..) should not be understood as merely as an univocal effect of the first factor on the second one. Dynamics between spatial dimension and relational dimension are certainly more interactive: both dimensions may reinforce each over the life course. If high mobility fosters a more widespread social network, this latter may lead to new forms of spatial mobility, given the less localised relational anchoring" (Viry et al., 2009, p.140)

In conclusion, this section has shown that there is a wide range of theoretical concepts that are being used in transport and social exclusion research. To complicate things further, definitions are often elusive and disputed, and the direction of the relationships between constructs is often unclear. Fig. 2.5 provides a diagrammatical representation of this complex web of relationships, integrating the various frameworks discussed in this section.

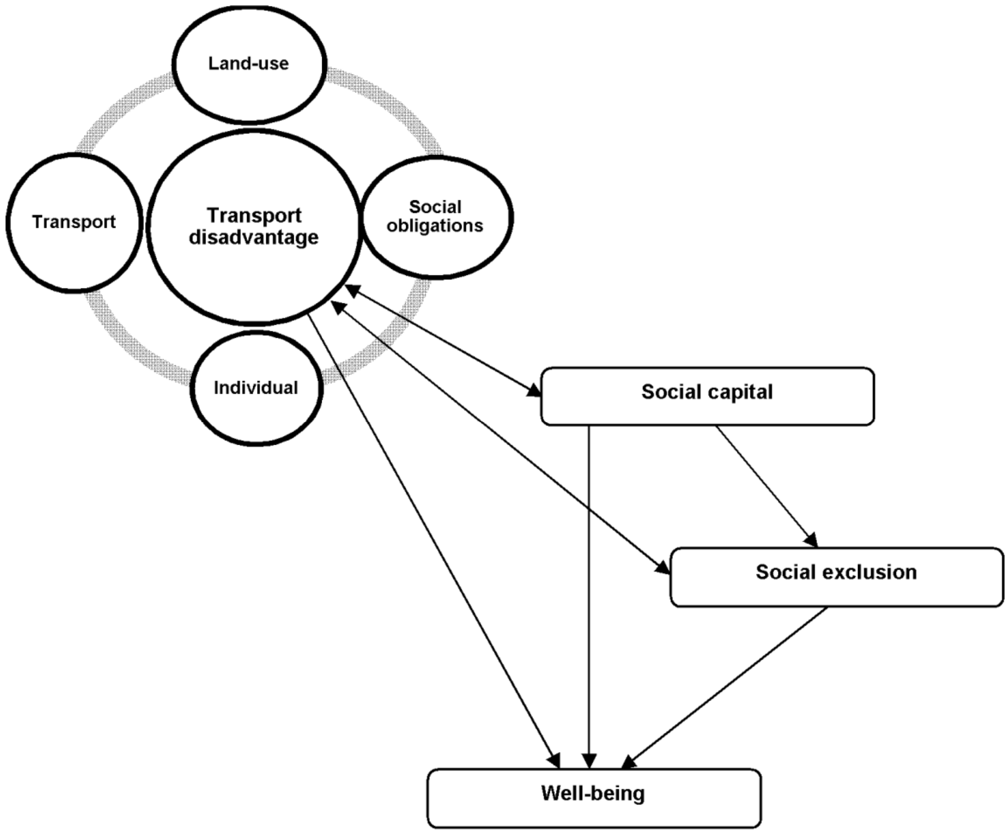

Fig. 2.5 – Diagrammatical representation of factors affecting transport disadvantage and of its interrelationships with other theoretical constructs. Source: own elaboration, adapted and integrated from Lucas (2004a), Cass et al. (2005), Stanley and Stanley (2007a) and Currie and Delbosc (2011a).

2.1.4. Empirical methods

As illustrated in the previous section, transport and social exclusion research has gradually evolved towards greater theoretical sophistication: in this context, while some concepts have been better defined, the greater number of theoretical constructs that are used has considerably increased the complexity of this field of research. The same is true for empirical research: indeed, in the last 10-15 years, the range of methods used has considerably broadened. According to some scholars, this represents a progress. For example Currie, in the introduction of a recent book on “new perspectives and methods in transport and social exclusion research” (2011a) argues that:

> “many of the pre-existing methods used to explore these areas have been useful in developing our understanding of the field. However, they involve *qualitative and anedoctal evidence which limits our ability to prioritise and value the impacts of transport on social exclusion and vice versa*. The methods described in this book aim to provide quantification to enable more powerful analytical approaches with make it possible to value and prioritise links, influences and effects” (Currie, 2011b, p. 3)

In this section, I provide a summary of this evolution, starting from what Delbosc and Currie (2011a) define “anectodal evidence”. A more precise definition is provided in the following quotation:

> “most studies use comparative or category analyses whereby the characteristics of groups are compared based on socio-demographic, mobility, access or spatial differences. (They) identify transport disadvantage based on distance from or travel time to important destinations (..), levels of car ownership, licensing rates or public transport service levels” (Delbosc & Currie, 2011a, p. 158)

In a nutshell then, studies in this vein make use of quantitative data (sometimes derived from secondary analysis of existing datasets) in order to show patterns of inequality in travel behaviour and access, with a particular eye for spatial differences and social groups traditionally considered at risk of social exclusion. In this context, the comparison between different groups and areas is based on the descriptive analysis of indicators of travel behaviour, access to mode of transport and to services and opportunities. Indicators of travel difficulties and problems in accessing services are also often investigated.

Hine and Mitchell (2003), for example, based on a household survey of three case study areas in Scotland (urban, peripheral and a free-standing town) compare indicators of car access, access to public transport and to local services, transport expenditure, travel time and frequency of trips, across a number of social groups (with an emphasis on low income households, the disabled, women, older people and children) and different types of area. They conclude that there is evidence of transport disadvantage for non-car owning households, low-income households and women, based for example on the longer time they spend to access key services (p. 96). With a similar approach, the SEU report (2003) presents a wealth of indicators of travel behaviour and access, often based on secondary analysis of existing datasets: they conclude that a significant part of the population experiences difficulties in accessing work, learning, healthcare, food shops and social, cultural and sporting activities, and that these problems are particularly severe for households without cars, jobseekers and young people. Clifton and Lucas (2004), examine “the empirical evidence of transport inequality in the US and UK”, using indicators related to travel distance, travel time, car availability and distance to local facilities and discussing their distribution by income quintile, gender, age and ethnic origin. They conclude that “the poorest sector of the population travel far less (both in terms of distance and numbers of trips) than the average population” (p. 32) and suggest that this might be due to affordability factors.

While these studies provide invaluable information for the study of transport and social exclusion, they also have several limitations. The main problem is that descriptive analysis is rarely sufficient to properly establish the existence of a relationship between transport disadvantage and the negative consequences that are assumed to arise from it. As Lucas observes:

> “almost every National Travel Survey (NTS) identifies significant inequalities in the travel patterns and access to transport of lower income populations (..). What is less clear from this statistical evidence is the extent to which this reduced mobility and access to services leads to the social exclusion of affected individuals and/or reduces their social capital, life chances and overall well-being” (Lucas, 2012, p. 106-107)

The problem is compounded when indicators of travel behaviour are used: indeed, in such a case the data are open to interpretation, and can be used to support different arguments. For example, transport and social exclusion scholars often interpret lower mobility levels (in terms of trip rates and/or travel distance, but not journey times) as a sign of disadvantage. However, a deeper look at the data shows that car owning households in low-density areas are those who travel the furthest: this is far from being a proof of privilege, as it is likely to be the result of the greater distances that they have to cover in order to reach the same services and opportunities than their urban counterparts. Similarly, lower trip rates are sometimes assumed to be an indicator of disadvantage: however, the argument could be put forward that higher trip rates (all else equal) indicate a fragmentation of mobility behaviour that can be experienced as unpleasant. Also, longer travel time is sometimes taken to indicate disadvantage, assuming that it is the result of forced reliance on slower travel modes (see for example Hine & Mitchell, 2003, p. 96); however, a situation of severe isolation and inaccessibility (for instance due to disability) is likely to lead individuals to give up entirely on activities, and thus to reduced travel time. In a nutshell, the complex nature of transport disadvantage "makes the empirical measurement of behaviour, such as travel, inappropriate as a means of assessing people's accessibility opportunities" (Farrington & Farrington, 2005, p. 2). Similarly, Jones and Lucas observe that:

> "interpretation is much more difficult, particularly regarding the measures of movement. The problem is that – unlike most social indicators – it is *not always evident in which direction a benefit or disbenefits lies*" (Jones & Lucas, 2012, p. 7)

Notably, there is a danger in this approach: using travel behaviour as an indicator of disadvantage might amount to equating "more mobility" with "more inclusion". As observed by Fol:

> "some approaches seem to move from the unproven assumption that mobility is positive value, and that this is true for everyone in the same way, whatever the social position. In doing that, they overlook the costs, constraints, nuisances and risks associated with increasing mobility. In addition, they assume that the groups who do not have the same level of mobility are condemned to isolation in devalued spaces" (Fol, 2009, p. 52, own translation)

In a nutshell then, the empirical approach based on the use of descriptive quantitative data falls short of establishing clear links between transport disadvantage and social exclusion, even though it is essential to set the context for more in-depth analysis. In this context, several studies have used qualitative methods to explore how transport disadvantage is experienced at the individual level and what its consequences are.

Hine and Mitchell (2001) for example studied the travel experiences of public transport users, in the belief that "individual accounts of travel are important, as they provide information on the many levels at which transport disadvantage and exclusion can occur" (p. 320). Fol (2009) interviewed low-income households living in disadvantaged areas in Paris, London and San Francisco, in order to explore their mobility practices in depth without assuming that more travel necessarily corresponds to greater levels of inclusion. Cass et al. (2003) conducted interviews with users of demand responsive transport schemes, as a means of addressing the question of 'blocked' demand (e.g. potential travel demand that is hindered by the lack of public transport provision). Owen et al. (2012) conducted semi-structured interviews and focus groups with representatives of employers and labour market intermediaries in order to explore the impact of transport disadvantage on skills development and the uptake of education in a rural area in England. Daubitz (2012) conducted problem-centred interviews with low-income households in German urban areas in order to explore the relevance of mobility for the poor, as well as the strategies that they deploy to be mobile, despite the scarcity of economic resources. In the UK, researchers working on the definition of a minimum income standard showed 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 et al., 2012). The SEU report (2003) used interview excerpts to complement the descriptive quantitative evidence on transport disadvantage, in order to illustrate concretely how this can result in non-participation in society.

While qualitative methods can go some way in complementing the decriptive approach to quantitative data illustrated above, they are also affected by limitations, mostly in terms of generalizability: indeed, even when they succeed in making visible the mechanisms through which transport disadvantage has an impact on social exclusion at the individual level, they are unsuitable to reveal systematic patterns of variation in these processes across different groups and/or types of area. This is compounded by the fact that qualitative studies usually focus on certain groups (such as low-income households) who are assumed to be the hardest hit by transport disadvantage. A further limitation has to do with the fact that transport planning and decision making rely on evaluation tools (such as cost-benefit analysis) that require quantitative information as an input (Stanley & Stanley, 2007a). Accordingly, if transport and social exclusion research is to make a difference on transport policy, qualitative methods are not going to be sufficient.

Moving from this premise, the research group led by Currie (2011a) has conducted a large survey on a representative sample of households in the Australian state of Victoria, and then has used Structural Equation Modelling (SEM) to assess the causal relationships between various theoretical constructs. These included transport disadvantage (operationalised as the subjective difficulty to carry out mobility-related activities), social exclusion (including five dimensions: income, employment status, political activity, social support and participation), social capital (operationalised as frequency of contact with different social networks) and well-being (see §2.1.3). In this way, Currie et al. are able to estimate that transport disadvantage has both a (small but significant) direct effect and an indirect effect on well being: the latter is due to the fact that transport disadvantage has a small effect on social exclusion, and this in turn is a strong predictor of well-being (Delbosc & Currie, 2011a). Further disaggregate analysis shows that the relationship between transport disadvantage and well-being is strongest in regional and fringe urban areas (Delbosc & Currie, 2011b), thus confirming an assumption often found in the literature. Furthermore, using regression and mediation analysis, the research group concludes that the number of trips act as a mediating variable between social capital and social exclusion (Stanley & Vella-Brodrick, 2011). Accordingly, using econometric modelling, Stanley and Hensher (2011) are then able to impute an economic value on additional trip making, based on the effect that it has in reducing social exclusion, and to show that this value is higher for low-income individuals. Accordingly, testing the method in a case study application in Melbourne, they estimate that the reduction of social exclusion is the greatest single benefit associated with a new route bus service (greater than, for example, travel time savings and emission reductions). With regard to this innovation, Currie argues that:

> "from a policy perspactive, the impact of this development could be significant. For the first time, a creditable valuation of social access benefits is possible. Economic appraisals of transport projects sent to treasury departments for funding can have a tangible valuations rather than less intangible text-based arguments to support the value of access benefits" (Currie, 2011c, p. 302)

In a nutshell, then, a methodological approach based on large-scale surveys and sophisticated multivariate modelling techniques has the main advantage of making it easier to use the results to inform transport planning and decision making. However, these methods are not devoid of limitations. Firstly, the operationalisation of the theoretical constructs (transport disadvantage, social exclusion, etc.) is likely to remain the subject of controversy: indeed, some scholars of transport disadvantage even question the very possibility of measuring social exclusion "despite the political (and academic) expediency (of doing so)" (Kenyon et al., 2002, p.209). Quite apart from that, the boundaries between the different concepts (such as for example social exclusion and social capital) are often blurred: therefore, it is unlikely that any single definition will be universally accepted. Secondly, and related to this, the need to take into account a great number of different constructs, as well as all of their possible predictors, runs the risk of making questionnaires cumbersome to complete, much to the detriment of the quality of data. A third limitation, as acknowledged by Currie (2011c) is related to the fact that household travel surveys "provide a weak basis for sampling disadvantaged households at risk of social exclusion" (p. 301) – a typical example of 'hard to reach population' – even though additional ad-hoc surveys can be used to make up for this problem (*ibidem*).

A final limitation of the approach described above is related to the fundamental question of causality. Indeed, as discussed in the previous section (§2.1.3) social exclusion can be both the consequence and the cause of transport disadvantage. In the work of Victorian scholars (Currie, 2011a) there is little recognition of the fact that cross-sectional survey designs and SEM are ill-suited to ascertain the direction of causality between the constructs (but see Vella-Brodrick & Delbosc, 2011). By contrast in the US, considerable research efforts have been put into trying to ascertain whether car ownership increases the chances of employment, or whether it is the higher income associated with employment that brings about increasing likelihood of car ownership (Raphael & Rice, 2002; Cervero et al., 2002; Ong, 2002). To solve this dilemma, scholars have drawn on data-analytical strategies such as: using panel data on welfare recipients (Cervero et al., 2002); conducting longitudinal analysis of commute patterns (Taylor & Ong, 1995); using aggregated data (Raphael & Stoll, 2001; Raphael & Rice, 2002; Ong & Miller, 2005; Grengs, 2010); using instrumental variables (Ong, 2002); and analyzing the effectiveness of vehicle subsidizing programs (Lucas & Nicholson, 2003). In that sense, it seems likely that the next step for transport and social exclusion research, after having ascertained the existence of a relationship between these two constructs, will be to address the question of causality. This would mirror the development of research in the 'travel and the built environment field' in the last two decades, as illustrated above (§1.5.3).

2.1.5. Recurring characters in transport and social exclusion research

Most studies of transport and social exclusion acknowledge that certain groups in society are more at risk of experiencing transport disadvantage. Indeed, in the literature there is a high level of agreement as to who these groups are (see for example Hine & Mitchell, 2003; SEU, 2003; Lucas, 2004e; Kennedy, 2004; Currie & Allen, 2007; Denmark, 2007; Currie & Delbosc, 2011a; Sustainable Development Commission, 2011; Hine, 2012). The following 'recurring characters' are usually mentioned:

1. low income households
2. older people
3. women
4. ethnic minorities and immigrants
5. young people
6. disabled
7. the unemployed
8. households without cars
9. residents of low-density urban peripheral or rural areas

In this section, I provide a brief overview of research findings illustrating the forms of transport disadvantage experienced by each of the first seven groups. The issue of the disadvantage associated with non-car ownership will be dealt with more at length in the next section (§2.2.1), while the relationship between transport disadvantage and territorial structure will be the object of §2.3. It is worth noting that the first seven groups mentioned above are also the social groups who are usually assumed to be more at risk of social exclusion at large, as well as the most likely not to own a car. Also, it must be noted that these categories are not mutually exclusive – quite the opposite: indeed, older households are likely to be composed of single women, being unemployed is generally associated with low-income, and so does being a lone mother, etc. Accordingly, there is a considerable degree of overlap between the social groups listed above, as well as between the problems that they experience.

With regard to *low-income households*, predictably most concerns have to do with the problem of affordability. Since income is a main determinant of car ownership (see §1.3), poor households are the least likely to own a car. In car-dependent contexts, where the car is essential to access services, opportunities and networks, this puts them at considerable risk of transport disadvantage (see §2.2.1). For example, in Britain the SEU has highlighted how non-car owning low-income households often have no choice but to buy food from expensive local shops, and this in turn can compound their financial problems. (2003, p. 15).

However, given their limited economic resources, low-income households are likely to experience transport disadvange even when owning a car: indeed, the high cost of purchasing, running and maintaining a vehicle can lead to economic stress. Studies in Britain have shown that low-income households spend a greater proportion of their income on travel (SEU, 2003; Bayliss, 2009; Sustainable Development Commission, 2011; Stokes & Lucas, 2011; see §5.2.1). This condition as been referred to in the literature as 'forced car ownership' or 'transport poverty', and will be discussed in greater detail in the next section (see §2.2.2). As a result of financial constraints, low-income households with cars generally have to limit their travel, and this is reflected in lower distance travelled (Clifton & Lucas, 2004; Stokes & Lucas, 2011). Research and policy interest for this problem has increased in recent years, as the motorisation rate of low-income households has significantly increased (Lucas, 2011b; Stokes & Lucas, 2011, see §5.2.1), and is likely to intensify even more in the future, as fuel prices keep rising (Dodson & Sipe, 2008a, see §2.2.4). The cost of public transport is also a cause for concern, especially in countries where this has increased considerably over the years such as the UK (SEU, 2003). Furthermore, the high cost of motorised transport can lead the poor to walk very long distances, and this can be experienced as a problem (Fol, 2009; Sustainable Development Commission, 2011), especially if one takes into consideration that lowest income groups are more likely to report mobility difficulties, even when age is held constant (Stokes & Lucas, 2011).

Other concerns are related to the concentration of low-income households in disadvantaged areas (Power, 2012). In the UK, these are often poorly served by public transport (SEU, 2003) even though in other European countries such as Germany this is not necessarily the case (Kemming & Borbach, 2003). In Britain, according to the SEU report, people in the most deprived areas are more likely to be concerned about safety and crime in their area, and this can discourage them from undertaking travel (2003, p. 28). The process of urban change is also seen as a major threat to the living conditions of low-income, in terms of transport disadvantage. Changes in the labour market have often reduced the number of employment opportunities in the neighbourhoods were low-income households live; concomitant changes in urban structure have led to the relocation of low-skilled jobs in more distant locations, but poor households often lack the transport means and/or the competences and skills to reach these new destinations (SEU, 2003, p. 31-32; Orfeuil, 2004a; Fol, 2009). Furthermore, at least in European and Australian cities, the increasing cost of housing in inner cities is pushing low-income households to outer suburbs and in these areas poor public transport provision is likely to compound the affordability problems described above (Dodson & Sipe, 2008a; Polacchini & Orfeuil, 1999). Moreover, living in the suburbs generally corresponds to longer travel distances, thus increasing the expenses for mobility, regardless of the mode of transport (Orfeuil, 2004c).

With regard to *older people*, there are two main kinds of problem. Firstly, because of a cohort effect, older people are less likely to own cars and to be licensed drivers, and this is especially true for women (Metz, 2000; 2003; Schwanen & Páez, 2010). Even though this gap is closing (Rosenbloom, 2001), older people who never learned how to drive a car can find themselves disadvantaged, as the car dependence of cities and societies has increased in recent decades. For example in Britain, a recent report on the social exclusion of older people (SEU, 2006) has concluded that "on all dimensions of exclusion, older people with no use of a car or van are more likely to be excluded than older people as a whole", especially when residing in peripheral or rural areas (p.33-34). Accordingly, the condition of older people living in low-density areas has attracted considerable research attention (Lord & Després, 2002; Berger et al., 2010; Pochet & Corget, 2010; Shergold & Parkhurst, 2010; Engels & Liu, 2011).

Secondly, because of an age effect, older people report more mobility difficulties, and this can hinder the use of motorised transport means, as well as walking and cycling. This can result in reduced travel, which in turn can considerably reduce quality of life (Mollenkopf et al., 2005; Spinney et al., 2009). In this context, existing research has focused not only on access to basic services such as health care facilities (Páez et al., 2010b), but also on the participation of elderly people in social relationships (Mollenkopf et al., 1997) and leisure activities (Kasper & Scheiner, 2002; Scheiner, 2006b), in the belief that such activities contribute significantly to quality of life (Davey, 2007). Also, a question that has attracted considerable attention is driving cessation and its potential negative effects in terms of transport disadvantage (Whelan et al., 2006): the key point here is that "as older people have come to depend on the car to maintain their lifestyles, they have made themselves increasingly vulnerable to serious drops in mobility when they can no longer drive" (Rosenbloom, 2011, p. 175). In this context, the need to support the transition from driving to driving cessation has been highlighted (Browning & Sims, 2007). Furthermore, given their mobility limitations, older people are more likely than the rest of the population to rely on car lifts: while this can partially offset their transport disadvantage, it can be a burden for those who offer lifts (generally family and friends) (Rosenbloom, 2010) and it challenges the sense of indipendence of the elderly (Davey, 2007), with potential knock-on effects in terms of reducing their well-being (Currie, 2011a).

Since most older people experience a reduction in income with the transition to retirement, the elderly are more likely to experience the kind of affordability-related problems of low-income households (see above). They are also more likely to report security fears while travelling, and this can hinder their public transport use (SEU, 2003; Sustainable Development Commission, 2011). Given the rapid ageing of the population in most developed countries, the mobility and accessibility problems of the elderly are gathering increasing attention, with scholars suggesting “the prospect of more social exclusion emerging within our cities over the coming decades” (Engels & Liu, 2011, p. 995) and thus stressing the need for a “transport policy for an ageing population” (Metz, 2003).

With regard to *women*, a considerable number of studies have focused on gender inequalities in transport (Law, 1999; Ortoleva & Brenman, 2004). In this context, it has been observed that women are generally less likely to be licensed drivers and to have access to a car than men (SEU, 2003), even though this gap is narrowing down in younger cohorts (Kuhnimhof et al., 2011; Kuhnimhof, Armoogum et al., 2012). Similarly, they are also less likely to commute by car (Schwanen, 2011). Men, by contrast, are both more likely to live in households with cars and to be the main users in households with less vehicles than licensed drivers. Indeed, a recent study by Scheiner and Holz-Rau on the intra-household allocation of cars in car-deficient households in Germany (2012a) shows that women generally have less access to the vehicles, and suggest that both patriarchal structures and gender preferences might play a role. In contexts where car dependence is high, the lower access to automobility by women is likely to result in greater levels of transport-related social exclusion. Dobbs (2007), for example, drawing on primary research undertaken in the North East of England argues that women’s mobility deprivation restricts their employment opportunities – a crucial component of social inclusion.

These problems are compounded for older women, who are still considerably less likely than older men to be licensed drivers. While this is the product of a traditional household division of labour, where the husband “did the driving”, it can result in a drastic reduction of mobility when the husband dies before the wife, as it is often the case (Hensher, 2007; Ahern & Hine, 2012). Even when women are licensed, they are likely to stop driving earlier, and this can have negative impacts on their well-being (Ortoleva & Brenman, 2004).

A particular feature of female transport disadvange is that, while women have less access to the car (as compared to men), the nature of their mobility patterns tends to make them more dependent on the automobile. Indeed, current gender roles result in women having to juggle different responsibilities, including (but not limited to) work and family care. This results in time-poverty and a higher degree of trip-chaining (Turner & Grieco, 2000; Borlini & Memo, 2009), which in turn foster reliance on the car, given the flexibility that it provides (Heine et al., 2001). According to some authors (Dowling, 2002; Schwanen, 2011) there is also a cultural dimension to female preference for the car, as this helps women to implement notions of ‘good mothering’. Conversely, public transport is often ill-suited to the needs of women: Dobbs (2005), based on a large-scale study of women’s mobility in England, has found them “particularly critical of the way in which the current (public) transport infrastructure provides them with the opportunity to negotiate this increasingly complex spatial links” (p. 272). Similarly, a recent report by the Victorian Council of Social Services on young mothers and public transport (Fritze, 2007), ironically titled “You might as well just stay at home”, points at “very high rates of difficulty accessing services and social networks” for those reliant on public transport, mainly as a result of “physical inaccessibility of the public transport system” (p. 4). Similarly Hurni (2007), in a study of transport disadvantage in Sidney, observes that the suitability of public transport is a particular concern for sole parents travelling with children.

A final aspect of female transport disadvantage is related to personal safety issues: indeed, women are much more likely than men to indicate that safety concerns as a reason to avoid public transport (Ortoleva & Brenman, 2004; SEU, 2003) and this, combined with lower levels of car access, can result in further transport disadvantage.

With regard to *ethnic minorities*, transport disadvantage is often related to lower income and the associated affordability problems. A recent report by the British Sustainable Development Commission (2011) identifies Black, Asian and minority ethnicity groups as among the most affected by transport disadvantage: the key point here is that while people belonging to ethnic minorities are less likely to own and use cars, and thus more reliant on public transport (Rajé, 2004), they are also “more likely to encounter problems using it” (Sustainable Development Commission, 2011, p. 34). There are several reasons for this: the mobility needs of ethnic minorities are often too varied and complex to be met by public transport (Rajé, 2004). Lack of competences and skills (for example language and cultural barriers, difficulties in reading maps and timetables, etc.) can be a major obstacle, as well as fear of discrimination and safety concerns (Currie & Senbergs, 2007; Blumenberg & Smart, 2011; Sustainable Development Commission, 2011).

Blumenberg and Smart (2011) argue that *immigrants* are even further disadvantaged: firstly, they face greater barriers to auto ownership, because they lack a credit history and are often put off by the bureaucratic steps required to obtain a driving licence and to buy a vehicle. Furthermore, when they are undocumented they experience an additional “fear factor” that can lead them to reduce their mobility.

These problems are compounded when ethnic minorities are concentrated in remote areas (like Indigenous Australians, see Currie & Senbergs, 2007) or segregated in urban areas: in these cases, a ‘spatial mismatch’ (McLafferty, 2001) can occur, whereby ethnic minorities find themselves cut out of access to employment opportunities. As illustrated by a number of studies in the US, this can result in higher unemployment rates and thus in social exclusion (Blumenberg & Manville, 2004).

With regard to *young people*, much research has focused on lack of access to cars and its consequences, particularly in low-density, car dependent areas. However, problems differ according to age. At a younger age, the main concern is the reduction of the area that children are allowed to travel alone (as compared to a few decades ago), as a result of growing safety concerns about traffic (Sustainable Development Commission, 2011). The importance of independent mobility increases in adolescence, when both distance travelled and the range of destinations increase, as do aspirations for personal independence (Currie, 2007): in this phase, the availability of public transport services is considered to be crucial to avoid transport disadvantage among teenagers. When this is lacking, the consequences can be serious: Currie (2007), in a review of evidence about the transport-related social exclusion of young people in the Australian context, concludes that “access to education, employment and social and recreational activities are the major areas of limitation as a result of transport issues” (p. 08.10). For young people who have reached the age of driving, other forms of inequality have been observed: in France Licaj et al. (2012) have highlighted the “considerable impact (that) socioeconomic factors and gender have on inequalities of access to car driving” (2012, p. 26). In this context, affordability problems can have a crucial role, and have been put forward as an explanation for low levels of licence holding among younger cohorts in recent years (Sustainable Development Commission, 2011). Young people are also more likely to be employed in casual or part-time jobs, which often have an early start or a late finish, and are thus difficult to access by public transport (Betts, 2007). All of these problems are compounded in car dependent contexts, such as rural areas, where car ownership and use are considered as essential for youth employment and skills development (Cartmel & Furlong, 2000; Currie, 2007; Owen et al., 2012).

With regard to *the disabled*, transport issues can be varied: indeed, there are different forms of disability, and each has its consequences in terms of transport disadvantage (Currie & Allen, 2007). For example, while people with vision impairement are often prevented from driving vehicles, they might be able to use public transport, provided that adequate infrastructure is in place. By contrast, paralitic polio can make people very dependent on car use. Broadly speaking, however, disability tends to increase transport disadvantage: in Britain, a recent report by the Sustainable Development Commission has concluded that “many disabled people are restricted in their travel options” and this limits their ability to get a job, access health care, attend education and training and social functions (2011, p. 32).

With regard to *job seekers* and *unemployed,* a huge body of research in the US has shown how car ownership is a crucial factor in facilitating the transition from unemployment into work (cfr. §2.2.1 below). While the American situation is peculiar in several respects, there is growing body of research in Europe that shows how transport disadvantage is an obstacle to employment for many people. For example Cebollada, in a recent study on the Barcelona Metropolitan Region, concludes that “the predominant car-based mobility model and the secondary role of public transport discriminate against non-car users when it comes to job opportunities” (Cebollada, 2009, p. 226). In France, scholars have shown how transport disadvantage is a key concern for both jobseekers and job agencies (Le Breton, 2004b). In the UK, the SEU report has shown the scale of the problem, with 38% of jobseekers reporting that “lack of transport is a barrier to getting a job” (2003, p. 9). While lack of public transport and the cost of transport are the main factors, there is also concern about the limited travel horizons of jobseekers (p. 31). As argued above, these problems are compounded by structural trends towards increasing distance between low-income workers’ residences and low-skilled jobs (SEU, 2003; Orfeuil, 2004a; Fol, 2009).

2.2. Car-related transport disadvantage

Given the focus of this thesis, in this section I put forward a tentative typology of different forms of car-related transport disadvantage. To be clear, the goal here is not to put forward a notion of car-related transport disadvantage as opposed to other mode-specific forms of transport disadvantage (such as, for example, ‘public transport-related’). Instead, the aim is to show how forms of transport disadvantage vary considerably in relation with car ownership and use, as well as other intervening factors. Based on a review of the relevant literature, I argue that four main forms of car-related transport disadvantage can be distinguished: car deprivation (§2.2.1), car-related economic stress (§2.2.2), car-related time poverty (§2.2.3) and oil vulnerability (§2.2.4).

2.2.1. Car deprivation

In this first section, I focus on car deprivation, defining it as the form of transport disadvantage that might derive from not having access to a car. In this context, it is assumed that car deprivation has, at least potentially, a negative impact on social exclusion, social capital and well-being, insofar as it may limit access to essential services, opportunities and networks. To be clear, this does not mean that the lack of a car always corresponds to transport disadvantage, nor that having access to a vehicle is an absolute defence against it. However, a considerable amount of research shows that in certain contexts and for certain categories of people, lack of car availability is a crucial determinant of transport disadvantage.

It is important to state that lack of access to a car is not the same as non-car ownership, even though of course there is a great degree of overlap. Indeed, non-drivers in car-owning households (such as children under the age of driving or non-licensed adults) are to a certain extent excluded from the mobility and flexibility that the automobile provides and have to rely on other household members in order to take advantage of the household’s vehicle(s). Furthermore, households with less cars than licensed drivers – variously defined as ‘car-deficient’ (Anggraini et al., 2008; Scheiner & Holz-Rau, 2012a; 2012b) or ‘low-car ownership’ (Delbosc & Currie, 2012) households – 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 (Anggraini et al., 2008; Scheiner & Holz-Rau, 2012a; 2012b). Accordingly, even licensed adults in car-owning households have sometimes ‘restricted access to cars' (Vandersmissen et al., 2004). Delbosc and Currie (2012), based on a study conducted in Victoria (Australia), show that ‘involuntary low-car ownership households’ (i.e. those that cannot afford another vehicle) are more likely to report transport disadvantage, score higher on measure of social exclusion and lower on well-being, than their ‘voluntary’ counterparts.

On the other hand, individuals in non-car owning households can make use of the automobile, whether as passengers or as drivers of borrowed or rental cars. For example, Paaswell and Recker, in a study conducted in Buffalo (New York) in the 1970s, found out that “less than a quarter of the households that owned no car never had a car available” (1976, p. 5). Although these figures are not generalizable to other contexts, they point at the fact that non-car ownership does not necessarily entail lack of access to a car. In a nutshell, then, car deprivation is best assumed to derive from a lack of car availibility, rather than simple ownership.

There is little doubt that car deprivation is the form of transport disadvantage most intensively investigated in transport and social exclusion research. As Currie and Delbosc observe in a recent literature review (2011a, p. 23), “lacking access to a car is perhaps the most common situation that is said to produce transport disadvantage”. In this context, it is sometimes argued that car availability *per se* is a necessary requirement for social inclusion. For example Lucas, synthesizing the results of a scoping study on transport and social exclusion in the G7 countries, has argued that:

> “there is general agreement (..) that, in the highly mobile and car-dependent societies under analysis, lack of access to a car is the main transport factor in the social exclusion of low-income households and other marginalized groups (..). The question is raised as to whether public transport services, however good, can hope to provide an adequate level of transportation for social inclusion. The implication is that, *in the context of G7 countries at least, a car is essential to full participation in economic and social life*” (Lucas, 2003, p. 13, emphasis added)

The United States is an example of a country where lack of car access generally results in transport disadvantage. Indeed, the US were the first country to reach mass motorisation (Jones, 2008), and currently have the highest motorisation rate in the world, with 812 motor vehicles per 1,000 people in the 2010 (Davis, Diegel et al., 2012). Accordingly, it is not by chance that the first studies focused on car deprivation were conducted here. For example, in a report on the “Problems of the carless” prepared for the US Department of Transportation in the 1970s (Paaswell & Recker, 1976), the authors equated lack of access to a car with ‘transportation disadvantage’:

> “This unique phenomenon of American society, the car, is so ubiquitous (..) that is nearly incomprehensible to imagine that there are those in the U.S. that don’t have one available whenever they want and for wherever they wish to go. (..) Cities and towns have been developed based on accessibility to a car, and public transportation has failed because of accessibility to a car. *If it is possible to find a single expression that could most clearly describe a fundamental reason for being disadvantaged with regard to getting around, that expression would be carless*” (Paaswell & Recker, 1976, p. 1, emphasis added)

Accordingly, based on a survey conducted in Buffalo (New York), Paaswell and Recker found that carless households reported problems visiting friends outside the neighbourhood, as well as accessing clothes and grocery shopping, parks and recreation activities. Similarly, Nutley observed in 1996 that while “in the UK it is generally assumed that with few exceptions car owners in the countryside have no significant problems of mobility” in the US even “the-one car household (..) is seen as a potential problem” and “indicative of disadvantage” (p. 97), thus confirming the high level of car dependence in the American context.

Starting from the 1990s, an increasing number of studies in the US has focused on the role of the car in the transition from welfare to work (for a review see Blumenberg & Manville, 2004). Taylor and Ong (1995) for example, based on a longitudinal analysis of the metropolitan samples of the American Housing Survey, have argued that the reason for the persistent higher unemployment rates among minority workers in central cities is not so much a spatial mismatch between their residence and employment opportunities, but an “automobile mismatch”, i.e. the lower rates of car ownership among minority workers, in a context where public transport is generally not suitable for the journey to work. Raphael and Stoll (2001), based on the analysis of data aggregated at the metropolitan level, have found strong evidence that having access to a car is crucial to explain the higher rates of unemployment among minority workers, and argue that boosting minority car-ownership rates would go a long way in narrowing inter-racial employment gaps, especially in metropolitan areas that are more car dependent. Cervero et al. (2002), based on the analysis of panel data on welfare recipients in a Californian county, have studied the relative influence of public transport versus car ownership in helping the welfare to work transition, concluding that the latter is considerably more important. Lucas and Nicholson (2003) have analyzed the effectiveness of a vehicle subsidizing program in Vermont, concluding that it resulted in a significant increase in both the probability of employment and earned income.

The American situation is peculiar in several respects, given the strong suburbanisation of employment, racialisation of space and segregation of minorities. However, it is indicative of how, in the most car dependent society of the world, car ownership is unanimously seen as an essential precondition to employment – a crucial dimension of social inclusion. In this context, then, lack of access to a car is virtually synonymous to car deprivation. Broadly speaking, however, car deprivation should be considered as an emergent property of interaction between four factors (cfr. Fig. 2.3):

- *individual characteristics*, such as certain types of disability, can make the car the only viable means of transport. When this happens, however, the shortcomings of alternative modes (such as public transport) in accommodating disabled passengers should be considered as a contributing factor
- *transport-related factors*, such as the lack of public transport in the area, are obviously crucial in making lack of access to a car equivalent to transport disadvantage. Even in this case, however, other factors (such as the absence of services at walking or cycling distance in the area) should be considered as a contributing factor
- accordingly, the characteristics of *land-use* in the area are crucial: low-density built environment increases the distance to destinations, and thus makes the car more of a necessity for access to essential services, opportunities and networks. However, even here the lack of competitive modal alternatives may be seen as a contributing factor
- finally, the nature of the *obligations to proximity* of the individual can be a crucial contributing factor in making lack of car access a condition of disadvantage. To mention but one example, transport research has shown how women 'trip-chain' more than men, due to their multiple responsibilities, corresponding to a greater number of obligations to proximity in daily life (see §2.1.5). This condition is likely to exacerbate the disadvantage associated with the lack of car availability, even though other factors (such as the physical separation of different activities in the built environment) contribute as well

Finally, two remarks need to be made about the nature of car deprivation. Firstly, it must be noted that disadvantage can arise (in a rather direct way) by the fact that accessing certain services, opportunities or networks without a car is difficult, and this discourages participation. However, it can also be the outcome of an indirect process whereby, for example, access to employment is possible with modes alternative to the car, but commuting is so time-consuming that little time is left for other activities that are essential for social inclusion, thus resulting in time poverty. In this case, of course, the assumption is made that commuting by car would be considerably faster, thus leaving enough time for other activities. So, for example Farber and Páez (2011a), in a study focused on Canadian metropolitan areas, have shown that non-drivers with long commute times face difficulties in participating in discretionary activities (such as visiting friends and relatives at their home). This highlights the complexity involved in the notion of car deprivation, as well as the importance of the temporal dimension.

Secondly, empirical research on car deprivation can be complicated by the fact that the social groups who are more likely to lack access to a car (low-income households, older people, young people, women, etc.) are also the groups that are commonly considered as at higher risk of social exclusion – for reasons largely unrelated to transport. As Clifton and Lucas put it:

> "since non-drivers and people without regular access to a car tend to be concentrated among households in the lowest-income groups and in the most deprived neighbourhoods, *they are already at risk of social exclusion*" (Clifton & Lucas, 2004, p. 28)

In that sense, disentangling the net effect of the lack of car access on specific outcomes in terms of social exclusion, social capital and/or well-being from the effect of other possible contributing factors (such as lack of income) is likely to be very difficult – regardless of the method used.

2.2.2. *Car-related economic stress*

While car deprivation has undoubtedly attracted most of the attention in transport and social exclusion research, there is increasing recognition that there are forms of transport disadvantage associated with car-ownership. As Currie puts it: "having a car can imply a form of transport disadvantage as much as not having mobility" (2011c, p. 301).

In this context, different terms have been used to indicate the financial stress associated with owning, maintaining and running the household car(s) and its potential consequences in terms of social exclusion and reduced well-being. Currie for example uses the term 'forced car ownership', drawing it from UK research on rural areas and defining it as:

> "a term that has been used to describe low-income car users located in areas with poor accessibility and limited mobility alternatives (..). The high costs of car ownership are said to be forced on households with a limited capacity to afford them were no cheaper mobility alternatives are available" (Currie & Delbosc, 2011c, p. 193)

Another term used in this context is 'transport poverty' (Gleeson & Randolph, 2002; Stokes & Lucas, 2011), that has been defined as occurring "when a household is *forced to consume more travel costs than it can reasonably afford*, especially costs relating to motor car ownership and usage" (Gleeson & Randolph, 2002, p. 102, emphasis added). The reason why this should be considered as a form of transport disadvantage is that excessive expenses for car ownership and use can lead households to cut spending in other essential areas, with knock-on effects on social inclusion and well-being. In a recent qualitative study on the travel needs of low-income households in the UK, Taylor et al. have observed that:

> "car costs were attributed a consistently high level of priority compared to other household costs. Some people indicated that they would be willing to cut other household costs in order to retain the car in the face of increased car costs or a reduced income" (Taylor et al., 2009, p.7)

Alternatively, households may choose to allocate enough money to other activities (considered as essential), and reduce travel spending accordingly: this in turn can restrict their activity spaces and the opportunities to participate in mainstream society. Moreover, when financial resources are limited, individuals have to prioritise between different travel destinations: so for example, a costly commute may lead them to curtail leisure travel. In most cases, all these negative effects (reductions in travel and limited spending in other essential areas) will be present at the same time.

Despite its prevalence in the literature, I argue that the term 'forced car ownership' is potentially misleading. Indeed, in stressing the lack of choice of households (who *would like* to give up the car, but *cannot* do it because of external constraints), this notion is close to the micro-social understanding of car dependence, whose limitations I have pointed out in the above (cfr. §1.4.1). In that sense, it is misleading in two respects. First, it might seem to suggest that wealthier households, who do not experience economic stress as a result of car-related expenses, are in a position where they can freely choose whether to own a car or not. This is unlikely to be true, since the number of households who consider themselves as car dependent is arguably much larger than the subset of those who experience economic stress as a result. Therefore, as I will illustrate in more detail later on (§2.2.4), many household who cannot be considered as transport disadvantaged today, are potentially vulnerable to fuel price hikes that would considerably increase the cost of driving in the future. Therefore, the concept of 'forced car ownership' runs the risk of inadvertently overestimating the agency of wealthier car owning households.

Conversely, the concept tends to underestimate the agency of low-income, 'forced car ownership' households, assuming that they have no choice but to own a car, and suffer the associated financial consequences. This obscures the fact that low-income households often have to choose between 'two evils', namely the lack of access arising from lack of car access (car deprivation) and the economic stress associated with car ownership and use. This is precisely what is meant by Currie and Delbosc when they argue that “those on low incomes (..) face a greater trade-off between transport costs, affordability, mobility and accessibility” (2011c, p. 194).

In a nutshell then, I argue that there is nothing distinctive about the ‘lack of choice’ of ‘forced car ownership’ households. Rather, what is distinctive about them is the fact that they own and use cars despite the negative consequences that arise from it in terms of financial stress. For this reason, I argue that it is preferable to use the notion of ‘car-related economic stress’.

Currie and Delbosc (2011c), in a study focused on low-income households in urban fringe Australia, have observed that most ‘high-car ownership’ households made a conscious decision to locate in car-dependent areas, because other benefits, such as affordable housing and proximity to green spaces, were felt to “outweigh the cost of travel” (p. 200). Therefore, the authors argue that the question of whether these households are ‘forced’ into car ownership should be answered with “a fairly conclusive ‘no’” (p.204). However, most poor households with two or more cars also reported that transport expenses were substantial, and two in five acknowledged that they overlooked the scale of the problem when they decided to move to the urban fringe. Accordingly, they adopted a range of cost-saving coping strategies including combining different activities into one trip, limiting travel to distant destinations and buying second hand cars. Overall, they seemed to be limiting car use considerably, despite high levels of car ownership (2011b). By contrast, low-income households without cars reported that, while this significantly limited the activities that they could undertake, it freed up money for other activities (2011c).

Overall, the results of the study cited above point at two important conclusions. First, households who experience car-related economic stress have a certain degree of agency in deciding where to live and how much to spend on motoring. Second, and relatedly, the financial stress deriving from car ownership and use cannot be studied in isolation, as households trade-off different areas of expenditure when deciding where to live. Notably, the cost burden of car ownership should be studied in conjunction with the cost of housing – and daily travel in relation with residential mobility.

In France, a number of studies have focused on this interrelationship. Polacchini and Orfeuil (1999), in a study focused on expenditure on transport and housing in the Paris Region, have observed that

> “there is a marked rise in the proportion of the household budget spent on transport as one moves from zones with expensive housing (where travel accounts for just 6% of the household budget) to the zones with the cheapest housing where travel accounts for 27% of household expenditure for tenants and 30% for homebuyers” (Polacchini & Orfeuil, 1999, p. 46)

By contrast, expenditure on housing is found to never exceed 30% of household income, partly as a result of the precautionary mechanisms implemented by landlords and banks, who do not rent flats or lend mortgages to households who are considered as unable to afford them. However, there is no control on the share of household income that is spent on transport, and this allows low-income households to adopt the following strategy: moving to more peripheral locations, where they are able to afford bigger flats and keep housing expenditure under the 30% threshold, even though greater transport expenditure more than offsets the financial gain. As a result of this strategy, low-income households in cheap housing but car-dependent areas end up experiencing great financial stress, as the overall expenditure for housing and transport can be as high as 50% of the household budget. This might lead to households cutting spending in other essential areas, as well as to limit their car use for discretionary trips (Orfeuil, 2004c). However, there is some evidence to show that, when the cost burden of motoring becomes too high, low-income households tend to relocate in less car-dependent areas (Motte-Baumvol et al., 2010). Overall, the study by Polacchini and Orfeuil (1999) seems to suggest that, even when housing costs are taken into account, higher motoring costs tend to create a situation of transport disadvantage for the households involved; on the other hand, however, it shows how increasing transport expenditure can be a rational response to the conditions that low-income households face on the housing market.

British transport scholars (Stokes & Lucas, 2011; Sustainable Development Commission, 2011) have argued that it is instructive to discuss this issue in the light of the debate on ‘fuel poverty’ that has taken place in the

UK in the last two decades (Boardman, 1991; 2010). ‘Fuel poverty’ has been defined as the situation occurring “when a household could not have adequate energy services for 10 per cent of income” (Boardman, 1991, p.227, quoted in Boardman, 2010, p.22). Recent studies have argued that 20% of British households (corresponding to 5 million households) were in fuel poverty in 2008, and this could lead them to cut spending in other essential areas and/or to suffer the consequences of an insufficient energy consumption – for example by living in ‘cold houses’, with the associated health risks (Boardman, 2010).

There is indeed some similarity between the issue of fuel poverty and the economic stress related to car ownership and use. However, there also several crucial differences. Firstly, the definition of fuel poverty is based on a normative definition of what a household ‘needs’ in terms of energy consumption: so, for example, the definition assumes that it is necessary to have a temperature of 18-21°C for 9-16 hours a day at home (Boardman, 2010, p. 23). Accordingly, figures on fuel poverty are based on modelling, whereby an household is considered to be disadvantaged if it *needs* to spend more than 10% of its income to satisfy its energy needs within the home. This allows to exclude from the definition those who actually spend more than 10% (even though they do not need to) and to include those who spend less than 10% but are not able to satisfy their energy needs (*ibidem*). Such a normative definition is difficult to apply in the domain of transport; as Stokes and Lucas argue:

> “..the same consensus does not exist for transport and a measurement of transport poverty or affordability is seldom attempted. (..) the prime difficulty relates to how we define the need for travel, which relates to the activities that a person ‘needs’ to carry out, and the distribution of places where they can be carried out” (Stokes & Lucas, 2011, p. 56)

In a nutshell then, the variability of obligations to proximity across different social groups and individuals is arguably much greater than that of energy needs in the house. Similarly, people live in different types of area, and this can make a big difference in terms of the amount of travel required to access essential services and opportunities; this variability is arguably greater (and less amenable to change) than that observed for the energy efficiency of home heating systems. This complicates considerably the definition of a ‘transport poverty’ measure.

Given the difficulties involved in defining the transport needs of households, it might be tempting to rely on figures of actual expenditure on transport. Indeed, the debate on fuel poverty was borne out by the simple observation that low-income households spent 10% of their income on energy within the home, while other households did not exceed 5% (Boardman, 2010). Similarly, in the domain of transport, the SEU has observed that:

> “motoring costs account for 24 per cent of the weekly expenditure of households in the lowest income quintile who have cars, compared with 15 per cent for all households in the UK. So, although poorer people spend less money on travel than the rest of the population, this often accounts for a far greater proportion of their income” (SEU, 2003, p. 29)

However, relying on figures of actual expenditure is also fraught with difficulties, as there seems to be much more variation in spending on transport at the household level than there is for energy use within the home (see also Serebrisky et al., 2009). As Stokes and Lucas argue, there seem to be “a large element of choice on levels of expenditure” on transport, while:

> “..for fuel poverty there is much less variation in what is spent, and much less ‘status’ attached to different heating systems – the definition of fuel poverty can safely assume that no one would wish to spend more than 10% of their income on heating” (Stokes & Lucas, 2011, p. 56)

To sum up then, discussing car-related economic stress in the light of the debate on ‘fuel poverty’ illuminates the complexity of the former issue: in that sense, investigating empirically the financial stress associated with transport is likely to be a challenging endeavour.

2.2.3. Car-related time poverty

Experiencing economic stress is not the only way in which individuals with access to a car may experience transport disadvantage. In this section, I focus on a second form of 'problematic car ownership', related with the temporal consequences of car dependent activity patterns. From the outset, it must be said that this is the least researched and more controversial form of car-related transport disadvantage. The reason for this is the scant attention given to the temporal dimension of disadvantage in transport and social exclusion research. As Farber and colleagues argue:

> "an important characteristics of much of the research in the literature to date (..) is a central concern with the spatial aspects of transportation and accessibility. (..) While research on the topic in the field of transportation has generated valuable information regarding access to opportunities, there have *only been glimpses so far regarding the potential of more in depth investigations of the temporal dimension of mobility and exclusion*" (Farber et al., 2011, p. 20-21, emphasis added)

The notion of 'time poverty' has been defined as "the fact that some individuals do not have enough time for rest and leisure after taking into account the time spent working, whether in the labor market, for domestic work, or for other activities" (Bardasi & Wodon, 2006, p. 77). In this context, with the term 'car-related time poverty' I refer to the transport disadvantage associated with the lack of time deriving from spending an excessive amount of time for car travel. This lack of time can result in lack of participation in essential activities, and thus in reduced social inclusion, social capital and well-being. A typical example in this context is how a long-distance car commuter might give up participating in leisure activities, because of the priority accorded to travelling to and from work.

In the Canadian context, Farber and Páez have conducted studies on whether car travel negatively impacts participation in social and leisure activities (2009; 2011a; 2011b). A first study, based on a travel survey conducted in Portland in 1994 (Farber & Páez, 2009), has shown that 'auto-reliant' individuals (those who used the car as a driver for 100% of the trips recorded in the travel diary) were likely to travel more, but less likely to participate in visiting and out-of-home amusement activities than other ('mixed mode') individuals, even after controlling for other factors such as residential location and socio-demographics. Conversely, automobile reliance was found to have a positive effect on participation in in-home amusements. Overall, the authors conclude that "the automobile reliant respondents with both urban and suburban locations of residence are found to participate in significantly fewer social activities" (p. 224). In a subsequent study, Farber and Páez (2011a) have found evidence that, over the period 1992-2005, while urban sprawl, car dependence and traffic congestion have increased, travel durations for mandatory activities such as work, shopping and childcare have increased significantly for residents of Canadian metropolitan areas. In the meantime, the participation in discretionary out-of-home activities (such as visiting social contacts and volunteering activities) has declined in favour of participation in in-home activties and time spent alone. As a result, while average travel durations have declined across the period of interest, this is due to a reduction in participation in out-of-home activities, rather than to an increase in travel speeds and accessibility. Accordingly, even though the authors are not able to establish causality, they put forward the hypothesis that "mandatory trip durations have grown at the expense of participation in other types of activities" (p. 788). Similarly, they are able to show that those who commute by car participate in less discretionary activities than non-car commuters, even though this might be due to socio-demographic differences between the groups. In a nutshell, Farber and Páez aim to show how suburban "drivers may suffer considerable accessibility losses in comparison to residents of compact walkable cities" (p. 790).

Research findings from other studies confirm that spending too much time commuting can have negative effects on social participation. In a research focused on Swiss metropolitan areas, where metropolisation and long distance commuting are increasing, Viry et al. have investigated how commuting affects social capital, observing that:

> "commuting distance negatively influences the proportion of significant others who give (the commuter) support. This deficit can be interpreted as *an effect of the commuter's mobile living*

> *arrangement, since increasing time spent travelling may foster a weaker involvement in the activities with significant others* (relatives, close friends)" (Viry et al., 2009, p. 131, emphasis added)

Overall, even though the authors conclude that "commuting is indeed associated with a structural recomposition and not a weaking of interpersonal relationships", they also warn that "time spent travelling can (..) be an hindrance to more involvement in social life" (p. 136). Insofar as long-distance commuting is often made by car, these findings provide an illustration of the disadvantage associated with car-related time poverty.

In the context of their wider research project on transport disadvantage in Australia, Currie and Delbosc (2010) have also tackled the issue of time poverty. Firstly, they found out that in their sample "not having enough time" was the most common reason for people to feel "isolated or cut off from society". In a subsequent step, using SEM, they ascertained that feelings of time poverty, associated with transport disadvantage, tend to reduce well-being, thus mediating the relationship beween the two constructs. The authors attribute this result to the "links between long distance commuting, lack of time and mobile working people in congested cities" (p. 962).

Overall, the research findings illustrated above show the relevance of the concept of car-related time poverty. There are, however, several observations to be made. Firstly, this form of car-related transport disadvantage is inherently independent from the lack of economic resources that is usually associated with, for example, both car deprivation and car-related economic stress. Accordingly, several authors have observed that it is actually the middle classes who are the most affected by these problems[32]. For example Cass et al., in arguing that the temporal ordering of society is very relevant for transport-related social exclusion, observe that "in socio-spatial terms, low-income groups may be less excluded than those who are locked into demanding routines of regular travel" (2003, p. 8). Similarly, the work of Currie and Delbosc cited above (2010) has moved from the observation that people with high trip rates were as likely as less mobile people to report subjective transport disadvantage, a phenomenon that is explained by the greater incidence of time poverty among the former. Therefore, the authors conclude that "people who are not commonly seen as disadvantaged (the employed and those with higher incomes) can have feelings of isolation associated with time poverty, and that time poverty can reduce their well-being" (p. 962).

Overall, this observation illustrates the importance of taking into account the differing obligations to proximity of people when thinking about transport disadvantage (cfr. §2.1.3). Indeed, it is arguably the different obbligations to proximity of the middle classes that explains why they appear to suffer more time related problematic car owneship. For example, it is generally observed that qualified workers tend to travel greater distances to work, because the jobs they aspire to are generally concentrated in a few geographic locations, rather than spread out on the territory (Næss, 2006, p. 30). In that sense, as Cass et al. have argued:

> "if the 'need' to be mobile in order to participate effectively in society is unequally distributed, and *if the middle classes are under increasing pressure to travel in order to 'belong'* it is they who are at greatest risk of socio-spatial exclusion" (Cass et al., 2003, p. 14, emphasis added)

Taking into account the differing obligations to proximity of people also suggests that groups with more complex space-time activity schedules such as women (Schwanen, 2011), single-parents (Farber et al., 2011) and precarious workers (Borlini & Memo, 2009, p. 33) might be more likely to experience car-related time poverty, even though there is so far no evidence to substantiate this claim.

Secondly, and relatedly, the fact that car-related time poverty seems to affect more those who are better off economically, might lead us to question whether it is in fact a form of transport disadvantage. Indeed, several research findings from the studies cited above suggest that individuals who have shortage of time due to long car commutes are actually considerably better off than people who, all other things equal, lack access to a car. For example, Farber and Páez (2011a) show that the impact of lenghty commutes on participation

[32] This is consistent with the notion of time poverty, that has been used to highlight how people can be "work rich but time poor" in the liberal market economy (Sullivan & Gershuny, 2004).

in discretionary activities is actually worse for non-car drivers, who also tend, on average, to have longer commutes. Overall, the authors conclude that their results indicate "the relative benefit of being a non-driver in a compact urban form, versus being potentially excluded from participation as a non-driver in an urban spatial structure supportive of and constructed for the automobile" (2011a, p. 782). Similarly, the study by Viry et al. (2009), while suggesting that long-distance commuters might suffer the relational consequences of time poverty, also shows that commuters are more likely to develop bridging social capital (p. 136-137), with potential beneficial consequences for social status. So, is car-related time poverty a form of transport disadvantage? To answer this question, one should acknowledge that disadvantage is a relational concept: while long-distance car commuters might have greater levels of accessibility than their carless neighbours, one might argue that in fact they "suffer considerable accessibility losses *in comparison to residents of compact walkable cities*" (Farber & Páez, 2011a, p. 790, emphasis added).

Another problem in this context is the fact that many households seem to actively pursue a life in the conditions (suburban residence, car dependence, lengthy commute) that have here been defined as potentially exclusionary. In doing that, they clearly trade off the risk of time poverty against other things they value such as: affordable and spacious housing, proximity to green spaces, reduced levels of congestion and pollution, etc.. In that sense, as Lucas observes, "the transport disadvantage or time-poverty that they experience may be the product of self-enforced, rather than externally imposed, physical isolation and exclusion" (2012, p. 109). This again raises the question of whether car-related time poverty should always be considered as form of transport disadvantage, especially in policy terms. Moreover, the exclusionary effects identified by the literature might not be perceived as such by the disadvantaged themselves: for example, lack of participation in out-of-home leisure activities as that identified by Farber and Páez (2009; 2011a) might be the result of a preference towards in-home leisure activities on the part of long-distance car commuters. In that sense, the debate on lengthy commutes and time poverty would benefit from a framing in terms of 'lifestyles' (cfr. Scheiner, 2009a), that would highlight how different preferences (e.g. for spacious housing, car travel and in-home leisure activities) are often strongly correlated: this would help reducing the risk of mistaking lifestyle preferences for transport disadvantage.

A final observation that has to be made on the existing literature on car-related time poverty touches on the distinction between social cohesion and social inequality. Indeed, some of the authors quoted in this section seem more concerned with a process of anonymization at the societal level, rather than with an actual increase in social inequalities and exclusion. So for example Farber and Páez situate their research in the context of the debate on "the atomization and fragmentation of social life and the potential decline of community cohesion and social capital caused by life in suburbia and cars" (2011b, p. 90). While such a process might be a cause for concern (Putnam, 1995), it does not necessarily entail an increase in social inequality and exclusion, that are relative concepts. Indeed, while we might all be worse off in a less cohesive society (where nobody volunteers anymore because of car-related time poverty) this does not mean that, in such a society, more people would experience social exclusion. In that sense, I argue that the literature on time-related problematic car ownership would benefit from a clearer distinction between these two concerns.

2.2.4. Oil vulnerability

This last form of car-related transport disadvantage is both unique and similar to one of the above mentioned types. It is unique in that it refers to people who are not necessarily experiencing transport disadvantage now, but are likely to do it in the future in the event of increasing fuel prices. Indeed, as illustrated above (§1.2.2), the peak oil phenomenon makes it very likely that fuel prices will be considerably higher in the future: accordingly, an increasing proportion of the population is likely to face affordability problems in running their cars.

In that sense, even though oil vulnerability refers to a potential rather than actual situation, there is arguably a great degree of overlap between this concept and that of car-related economic stress (§2.2.2). Indeed, households who experience car-related economic stress today are even more at risk in the event of a sudden spike in oil prices. Therefore, it is no chance that research efforts on 'forced car ownership' and 'oil vulnerability' have intensified following the increase in oil prices in the first decade of the 21st century (see Fig. 2, Chapter 1), that has made the problem more visible.

The most significant research effort on this topic has been carried out by scholars at Griffith University in Brisbane (Australia) (Dodson & Sipe, 2006; 2007; 2008a; 2008b). In a first study, Dodson and Sipe (2007), using Australian Census data, have developed a 'vulnerability index for petrol expense rises' (VIPER), aimed at identifying the areas where people would suffer the most from fuel price hikes. The index covers two dimensions: economic resources (assessed through a socioeconomic index for areas) and car dependence (assessed through the proportion of households with two or more cars and the modal share of the car for the journey to work in the area). The assumption here is that households who have low income and live in car dependent areas would be the worst hit by petrol expense rises, because they would have no choice but to cut spending for travel and/or for other essential areas of expenditure. By contrast, high-income households living in areas where alternatives to the car exist would be able to choose whether to pay the additional costs of car driving or switch to other modes of transport. In both cases, they are less likely to experience social exclusion as a result. In a nutshell then, as Dodson and Sipe argue, in a world with oil prices substantially higher than today, "a household's ability to choose viable alternative modes will soon shape its social and economic status" (2008a, p. 61).

The empirical findings of this first study (Dodson & Sipe, 2007) show that a substantial proportion of the population in Australian metropolitan areas is vulnerable to petrol expense rises, particularly in Melbourne where in 2001 slightly more than 50% of the population (1.82 million people) lived in areas that scored high on the VIPER index (p. 55). Moreover, the study results show that "low socioeconomic status and high car dependence are strongly co-located in Australian cities" (p. 57): accordingly, the authors conclude that the impacts of rising fuel costs are likely to fall disproportionately on lower socioeconomic suburban groups in outer suburban areas, where housing is cheaper but both socioeconomic vulnerability and dependence on the car are highest. By contrast, high-income households tend to live in central areas, where there are more alternatives to car travel, thus reducing their oil vulnerability.

In this context, it is important to acknowledge that fuel price hikes would bring about more than a mere increase in the number of people affected by car-related economic stress. Indeed, as noted in the above, households generally trade-off costs and benefits when deciding where to live, whether or not to own a car and how much to use it. The outcome of this decision process can be car-related economic stress, either because households overlooked the scale of the problem (Currie & Delbosc, 2011c), or because they are willing to experience transport disadvantage in exchange for other benefits such as lower housing costs (Polacchini & Orfeuil, 1999) or access to employment (Blumenberg & Manville, 2004). However, households experiencing car-related economic stress in a context of stable prices should always be considered as having at least some agency. By contrast, fuel price rises change the structural constraints that households have to face: so, for example, an household might have chosen residential location so as to achieve a good balance between housing, transport and other expenses. A substantial increase in the price of fuel can alter this fragile equilibrium, and households may struggle to cope with an unanticipated situation: this is a defining feature of 'oil vulnerability'.

The research team led by Currie (2011a) has studied how Victorian households have coped with the fuel price rises that have taken place in the first decade of the 21st century, finding that nearly half of respondents had changed their travel habits as a result (Currie & Delbosc, 2011b): in this context, the most common 'coping strategies' were reducing the number of car trips, trip chaining and travelling less overall (p. 139). Similarly, Dodson and Sipe (2006), reviewing 'anecdotal reports' on the impacts of rising fuel costs on household travel patterns have found evidence that "households are cutting back on expenditures for non-essential items and trying to use their motor vehicle less" (p. 12). In a subsequent report, they quote findings of opinion polls showing that in 2006 11 per cent of Australian households were cutting down on food in order to cope with higher fuel prices (2008b). Similarly, in the UK, the Sustainable Development Commission has argued that rising oil prices suggest that "growing numbers of people will find it more and more difficult to access essential services and educational and employment opportunities" (2011). These findings highlight how rising fuel prices can have a negative impact on social inclusion for households with high levels of oil vulnerability, at least in the short term. In the longer term, as shown by Motte et al. (2010), moving to areas with better public transport provision is a valid strategy to 'escape car dependence' for suburban low-income households.

Subsequent studies by Dodson and Sipe (2006; 2008b) have moved from the premise that the economic stress resulting from rising fuel prices is compounded by parallel increases in housing costs. With reference to the Australian case, they observe that rising oil prices have had an inflactionary effect, and this in turn has promted the Reserve Bank of Australia to increase interest rates substantially. This 'compounding pressure' is likely to have increased the financial stress of households with variable mortgage rates (2008b, p. 6). To better account for this process, Dodson and Sipe (2006) have put forward an updated version of the VIPER index, the 'vulnerability assessment for mortgage, petrol and inflation risks and expenditure' (VAMPIRE). This new index covers the same two dimension of the VIPER (income and car dependence), with the addition of an indicator of exposure to mortgages (assessed through the proportion of dwelling that are being purchased in the area). On the basis of their findings for the year 2001, the authors conclude that "the VAMPIRE represents a different, albeit more spatially extensive, phenomenon than the VIPER" (2006, p. 29). However, both indexes show that, generallly speaking, low-income peri-urban areas are the most vulnerable; accordingly, the authors conclude that:

> "the distribution of oil and mortgage vulnerability is highly inequitable because the impacts of higher fuel and home purchase are borne most greatly by those in outer suburban tracts. As a result the households that will face the greatest adaptive task in coping with higher transport and housing costs are among those with the least resources and weakest acces local infrastructure that could assist them in the adjustment process. Under current conditions (..) higher fuel prices and higher mortgage interest rates are a highly regressive phenomenon within Australian cities" (Dodson & Sipe, 2008b, p. 37)

A further study (2008b) has updated the results for the VAMPIRE index using Census Data for the year 2006, showing that virtually all Australian metropolitan areas became more oil and mortgage vulnerable between 2001 and 2006, with very vulnerable zones in the outer suburbs "joined by increasingly vulnerable neighbouring middle suburban areas", reflecting "the inward encroachment of increasing oil and mortgage vulnerability inwards" (p. 36).

Despite repeated calls by Dodson and Sipe, to the knowledge of this author only a few studies have focused on car-related oil vulnerability outside Australia. In this context, alternative methods for assessing vulnerability have been proposed: Verry and Vanco (2009) for example, define as vulnerable households those who own cars and currently spend more than 18 per cent of their income for travel. By contrast, Lovelace, in a recent study focused on the vulnerability of commuter patterns to oil shortages in Yorkshire (2012), has tested different measures of vulnerability and concluded that the most satisfactory option is a composite index taking into account distance from employment, the proportion of trips made by car, public transport service and the percentage of active transport trips.

While oil prices keep rising, it is likely that oil vulnerabilty will attract more attention in the future. In this context, a few observations are relevant. Firstly, this issue provides a concrete illustration of why environental problems are nothing but the social problems of the future: in other words, one of the reasons why resource depletion should be of concern to social scientists is that it will have a disproportionate impact on some sectors of society. In that sense, the problem of car-related oil vulnerability highlights the convergence between the environmental and the social agenda in the field of transport. On the other hand, however, the findings of the studies cited above point at a latent tension between concerns for transport disadvantage and (certain) policies aimed at reducing the environmental impact of transport (more on this below, §2.4.7). Indeed, while such studies show that the impacts of rises in the cost of motoring would be unevenly distributed and socially regressive, this conclusion is quite independent of the *cause* of such rises. In that sense the logic of Dodson and Sipe's analysis could be extended to the case of increases in the costs of car travel induced by policy measures (such as fuel taxes, road pricing, etc.) aimed at reducing car dependence and its negative effects (see §1.6.4). Moreover, increases in the cost of motoring might also result from the introduction of alternative fuels or technologies (Schäfer et al., 2009). Finally, it has to be observed that most studies discussed in this section move from the assumption that, while the cost of motoring will rise, the cost of alternative modes of transport will be unchanged. However, this assumption is questionable: in Germany, for example, Hunsicker and Sommer (2009) have recently ascertained alternative scenarios for cost increases for cars and public transport, observing that, while the cost of motoring is likely to go up by 60% in the next 25 years, forecasting public transport costs is much more complex, given the wide range of determinants. They conclude that while "at best, public transport ticket prices will increase less than the cost of using private cars, (..) different scenarios may still emerge", notably as a result of austerity measures enacted in response to the recent financial crisis (p. 367). Indeed, the UK case study shows how the cost of public transport has increased much faster than the cost of motoring in recent decades (SEU, 2003). In the current research literature on oil vulnerability, however, there is little recognition of the possibility of rises in public transport costs.

2.3. Motorisation, urban structure and car related transport disadvantage

In the previous sections, I have given little attention to the spatial dimension of transport disadvantage. This has been deliberate: given the importance of the interrelationships between transport disadvantage and urban structure, in this section I focus exclusively on this issue. In doing that, I first deal with the relationships between motorisation, urban structure and transport disadvantage in historical perspective (§2.3.1, §2.3.2), and then with the issue of rural transport disadvantage (§2.3.3). In the last section (§2.3.4), I expand on the relationship between transport disadvantage and the built environment in a synchronic perspective.

2.3.1. Motorisation, urban structure and transport disadvantage in historical perspective

As illustrated in the previous chapter (cfr. §1.5.1) it is generally accepted that, in the last two centuries, motorisation and the related changes in travel patterns have gone hand in hand with changes in land-use patterns, as the destinations of activities have spread out in space. The result of this development is a more mobile society, and one where the ability to cover great distances and access to motorised transport are essential (Knowles, 2006). As argued by Farber and Páez (2011a), land-use and transport are:

> "intimately linked in a cycle of reinforced urban expansion and development of automobile-oriented transport and land-use infrastructure. Automobility makes far-off places reachable, attractive, and therefore developable. These areas are then only feasibly reached by automobiles, therefore enticing, or rather, inducing the adoption of the automobile by residents, and the promotion of automobile infrastructure" (Farber & Páez, 2011a, p. 790)

In the remainder of this section, I will show the relationships between this historical development and the different forms of car-related transport disadvantage illustrated above (§2.2). In this context, my goal is to highlight how such forms of transport disadvantage have emerged as result of the processes of increasing motorisation and land-use change.

To illustrate this dynamic, it is useful to refer to the macro- social understanding of 'car dependence' put forward in the previous chapter (§1.4): there, it was argued that car dependence is best conceived as a self-reinforcing, path dependent process resulting in incresing levels of car ownership and use. The works of scholars such as Newman and Kenworthy (§1.4.2) show that there is a crucial spatial dimension to this process, as increasing motorisation brings about changes in land-use patterns, which in turn bring about increasing levels of motorisation. In the context of this chapter, it is interesting to observe that transport disadvantage is a crucial intervening factor, as illustrated in Fig. 2.6. Over time, increasing car ownership and use (also determined by exogenous factors such as technological diffusion and increasing income) have resulted in more dispersed settlement patterns and in the separation of land uses, often actively promoted by automobile oriented transport planning. This brings about a decline in the quantity of services in the local area: while on one hand this results in increasing distance travelled, it also tends to reduce accessibility levels for non-car users. This in turn results in an increased pressure to own a car, despite the financial burden associated with it, notably for low-income households. Once more people adopt car-oriented travel patterns, this results in land-use change, thus fuelling the vicious cycle illustrated in Fig. 2.6. This illustrates how the spatial changes associated with increasing car dependence are strongly related to an increase in both car deprivation and car-related economic stress, to adopt the terminology proposed in the previous section (§2.2).

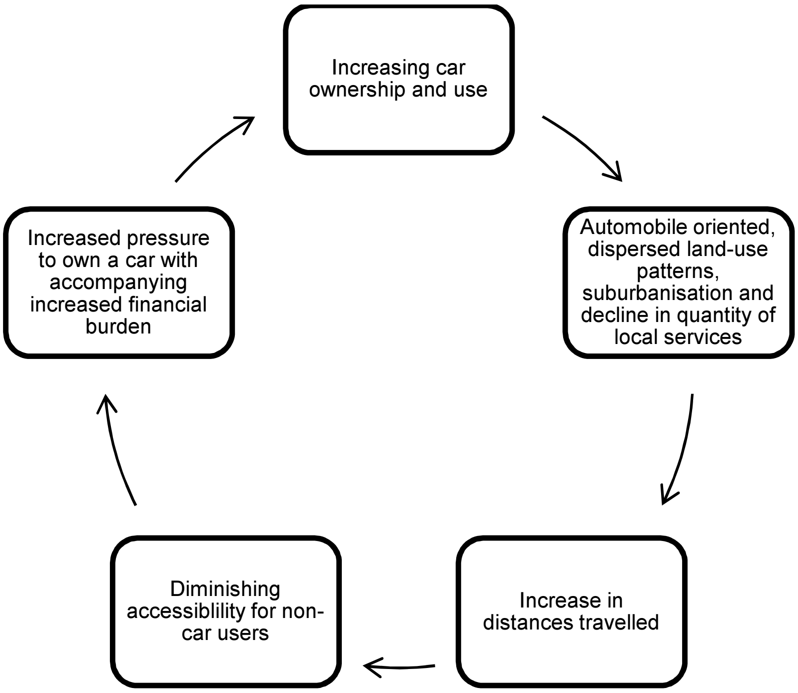

Fig. 2.6 – The cycle of car dependence, spatial dimension. Source: adapted from Clifton & Lucas (2004, p. 16), Litman (2003, p. 8)

As argued by the British Social Exclusion Unit:

> “over the last 50 years the need to travel has become greater and more complex as society became organised around the car and average distances to work, learning, hospitals and shops increased. (..) While the majority of people have successfully adapted to the rising need to travel through greater car use, for those without a car the ability to travel has failed to keep pace in a number of respects” (SEU, 2003, p. 21)

While the cycle of car dependence is a compelling framework to illustrate the relationships between urban structure change and car-related transport disadvantage, it would be wrong to see the development of car-dependent suburban areas merely as a result of this self-reinforcing system. In fact, from an historical perspective, other factors have been at work. As argued by Gonzalez (2008) with reference to the American context, sprawl and car dependence have been actively promoted by public authorities in order to push forward the interests of economic elites and producer groups, who benefited from the resulting increase in the demand for automobiles, consumer durables and energy consumption (pp. 166-167). On the other hand, it should not be forgotten that suburbanization has also been considered as a way to alleviate other social problems of industrial 20th century cities. As argued by Dodson (2007) with reference to the Australian case:

> “from a transport disadvantage perspective the early Australian city provided what would today be considered relatively good accessibiliy for most residents, with all but a few trips made on foot. The disdvantage of this arrangement however was that housing prices were often high relative to household incomes, while quality was low” (Dodson, 2007, p. 11.2)

Accordingly, suburbanization was widely perceived at the time as a way to solve this major social disadvantage problem:

> "Housing shortages during the Great Depression to the end of the war had generated high levels of social disadvantage. Post-war planning sought a major increase in the supply and quality of housing in Australia to reduce the social disadvantage caused by housing shortages (..) Much of this new housing was to be provided by an expansion of home ownership in the suburbs" (Dodson, 2007, p. 11.2)

In a nutshell then, in many industrialised countries increasing suburbanization and car dependence have also been a way to alleviate a 'social emergency' related to housing cost and quality (see also Kesteloot, 2005). Indeed, much urban theory of the 20th century has built on the premise that the 'social pathologies' of the industrial city had to be cured, and in this context the kind of suburban development afforded by new transport technologies has often been seen as a solution (Choay, 1965). With hindsight, however, it is clear that this has resulted in new forms of social disadvantage, namely an increasing relevance of transport-related social exclusion (Dodson, 2007, p. 11.3)

In this context, it is important to note that all four forms of car-related transport disadvantage can be considered as an outcome of this historical coevolution between transport and land-use. It is quite straightforward to understand how, in an increasingly motorised society, lack of car access gradually becomes a factor of disadvantage; by contrast, the other forms of car-related transport disadvantage require a more detailed explanation. With regard to car-related economic stress, there is considerable research evidence to suggest that low income households are often "forced by residential housing markets to 'trade-off' outer suburban transport accessibility against other objectives such as home ownership" (Dodson, 2007, p. 11.4); accordingly, while a greater proportion of the population can afford suitable housing today, "achieving this goal clearly comes at the risk of significant transport disadvantage for some groups" (p. 11.5). In that sense, car-related economic stress has arisen historically as a result of the trends towards increasing motorisation and suburbanisation.

Given the strong similarity between car-related economic stress and oil vulnerability, the same applies for the latter. Indeed, car-dependent suburban development is inherently based on the availability of cheap energy, as it was generally the case in the 20th century. If, as it seems likely, fuel prices will go up considerably in the future, this will result in an aggravation of car-related economic stress in these areas, with knock-on effects in terms of social exclusion (Dodson & Sipe, 2008a). Indeed, the research work conducted by Dodson and Sipe on oil vulnerability in Australian cities (2008a) has shown a contrast between high vulnerability areas in the middle and outer suburbs (both more car dependent and poorer) and minimal and low vulnerability areas in inner cities, where a wealthier population has better access to public transport and services and opportunities in the local area. Similarly, the work of Verry and Vanco (2009) on French cities shows that oil vulnerability varies according to the urban structure of the metropolis: indeed, their study shows that vulnerability is considerably higher in the metropolitan area of Marseille than in Lille, because of the more dispersed structure of the former. To sum up, then, the twin processes of motorisation and suburbanization, by creating the need for longer travel distances and reliance on cheap fuel, have created the premises for the oil vulnerability concerns of today. In that sense, as it has been observed for fuel poverty, the issue of oil vulnerability points at "society's failure to plan for an age of high-cost fuels" (Boardman, 2010, p. 18). In a future perspective, this calls for better taking into account possible fuel price rises in urban planning (Krumdieck et al., 2010); as Næss (2006) argues:

> "…precisely because it takes a long time to change the built environment it is important to avoid creating a future pattern of development dependent – perhaps to an even higher degree than today – on ample supply of cheap energy. Such a structure will be highly vulnerable to any future limitation on energy use (as well as) to failing supply stability" (Næss, 2006, p. 5)

Finally, from an historical perspective, also car-related time poverty can be seen as the inadvertent outcome of a self-reinforcing dynamic between motorisation and more dispersed land-use patterns. Farber and Páez (2011a) have provided a formal description of this development, by drawing on time-geographic concepts.

They argue that, while on the short term and at the individual level the car leads to faster travel speeds, an expansion of the person's space time prism and thus greater accessibility, on the longer term and at the macro level, cities expand in response to faster travel speeds and this tends to offset any accessibility gain achieved with car access. To understand how this happens, it is necessary to take into account the time dimension of access: indeed, while car drivers are able to reach more distant locations, in a car-oriented city they still have the same amount of time to perform activities. In that sense, "greater spatial accessibility (..) may in fact not be accompanied by a sufficient amount of free time to make participation in various activity possible" (p. 784). On the whole, Farber and Páez aim to demonstrate how, at the collective level, there are no accessibility benefits associated with increasing mobility, because the self-reinforcing cycle of increasing motorisation and more dispersed land-use patterns is ultimately self-defeating and "running to stay place" (2011a). Indeed, this process can even result in lower accessibility levels, because the phenomenon of congestion (widespread in car-oriented cities) can give rise to time poverty problems: people might miss out on participating in discretionary, leisure activities, because they spend too much time commuting (2011a). In that sense, the spatial changes brought about by the macro-social process of car dependence, as well as the inability of infrastructure provision to keep pace with increasing car use, should be considered as the cause for the emergence of car-related time poverty in contemporary cities.

2.3.2. Changing urban socio-spatial configurations and transport disadvantage

In the previous section, I have focused on the evolution of urban structure in contemporary cities, with little attention for the patterns of spatial distribution of different social groups in urban areas. However, the historical evolution of urban social morphology has to be taken into account, if contemporary forms of transport disadvantage are to be understood.

Indeed, the recent surge in interest for transport disadvantage might be considered as the last episode of a growing concern in urban studies for socio-spatial differentiation in cities. Several popular research themes in the urban sciences of the last few decades such as the global city (Sassen, 2001; Hamnett, 1994), urban segregation and the related neighbourhood effects (Musterd & Ostendorf, 1998; 2005; van Kempen, 2005) and gentrification (Slater, 2006; Simon, 2005) are concerned with the question of whether contemporary urban areas are becoming more unequal, and whether there is a spatial dimension to this process. In this context, the relevance of transport has only recently been taken into account. As observed by Dodson and colleagues (2004):

> "there is a substantial scholarly literature concerning patterns and dynamics of socio-economic disadvantage and advantage within cities. The processes of urban economic and social change that impact upon lower socio-economic status groups have been the focus of much research and analysis. (..) One aspect (..) that has not been comprehensively addressed through research is that of transportation. The extent to which different social groups are able to negotiate urban space to access goods, services and socio-economic opportunities remains underdeveloped as a research consideration" (Dodson et al., 2004, p.1)

In this perspective, the main assumption is that, as a result of global economic change, disadvantaged groups are increasingly concentrated in specific areas within cities. Urban spatial segregation can, in turn, compound their inability to participate in mainstream society. In this context, "transportation systems have a role in mediating these dynamics" (Dodson et al., 2004, p.48): indeed, if disdavantaged areas are poorly served by public transport, lack of car access (due to low incomes) is likely to result in transport disadvantage.

As far as urban social morphology is concerned, any generalization is problematic. Indeed, while the trend towards suburbanization has been observed for all cities of developed countries (even if to varying degrees, with North American and Australian cities considerably more dispersed than their European and Asian counterpars, cfr. Newman & Kenworthy, 1999), the urban socio-spatial configurations are often very country-, region- or even city-specific (Kesteloot, 2005). Differences between countries might be explained by the fact that different 'models of capitalism' have an impact on urban social morphology, through mediating factors such as welfare, housing and land-use policies. Therefore, it is only possible to describe ideal-typical cities, specific to certain world regions.

With regard to the American city, starting around mid-century, suburbanization has led to the flight of the white middle classes to car-dependent suburban areas, while low-income minorities have remained in decaying inner cities; later on, retail and service jobs have also been decentralised to the suburbs, and this to a greater extent than in other countries. As a result:

> "unlike most European, Canadian and Australasian cities, US cities *typically contain a disadvantaged core region – with low quality housing stock, and limited employment opportunity – surrounded by more affluent middle and outer suburbs*. Combined with these housing and labour market pattern are ethno-spatial arrangements that reflect the strong racial divisions in US societies. Such divisions have resulted in concentrations of disadvantaged minority groups in the inner areas of many US cities" (Dodson et al., 2004, p.13, emphasis added)

This situation gives rise to particular problems, that have been studied under the label of "spatial mismatch". This term describes:

> "a broad set of geographical barriers to employment that stem from a disparity, or mismatch, between where people live and where appropriate job opportunities are located. A more specific form of spatial mismatch, the spatial mismatch hypothesis, argues that the combined effects of residential segregation and economic restructuring limit geographical access to employment opportunities for black, inner city residents" (McLafferty, 2001, p. 14807-14808)

In a nutshell, in the American context, the spatial mismatch hypothesis assumes that, historically, the changing spatial distribution of social groups and jobs within urban areas has resulted in increasing distances between low-income minority workers living in inner cities and suburban employment opportunities. This, in turn, explains part of the higher unemployment rates for this group: in that sense, the spatial mismatch hypothesis is equivalent to arguing that there is a spatial dimension to the disadvantage of low-income minority households in US cities.

This has been contested by some scholars (Taylor & Ong, 1995; Ong & Miller, 2005; Blumenberg & Manville, 2004), who have argued that suburbanization has increased the distance to employment for all metropolitan residents, including suburban residents. Therefore, the key to explain higher levels of unemployment among inner city minority workers is lower levels of car ownership, rather than the greater distance to jobs. Indeed, accessing employment opportunities in the suburbs by public transport ('reverse commuting') is problematic in a car-dependent urban structure. This argument suggests that the problem is not so much the 'spatial mismatch' but the 'automobile' (Taylor & Ong, 1995) or 'transportation mismatch' (Ong & Miller, 2005). Interestingly, this is equivalent to denying that there is a spatial dimension to the discrimination of low-income inner city residents, and arguing that the transport dimension is the crucial factor at play.

More recently, scholars outside the US have investigated whether the concept of 'spatial mismatch' is a good framework to analyze the effects of urban socio-spatial change in other parts of the world. With reference to the Australian context, Dodson (2005) has explored whether there is a spatial mismatch between locations of greater housing affordability and locations of employment opportunity in Melbourne, concluding that, while unemployment is concentrated in outer suburban locations (notably declining industrial areas), spatial mismatch is unlikely to be a relevant factor, since suburbanization has increased the number of employment opportunities in these areas. In that sense, the historical evolution of Australian cities (where middle and upper classes have moved back to central cities since the 1970s, Dodson 2007; Dodson & Sipe, 2008a) has resulted in an socio-spatial configuration that appears to be more spatially equitable than that of the racially divided American city.

In the European context, Fol (2009) discusses how post-industrial change has transformed working-class neighbourhoods in French cities, where traditionally the proximity between employment and residence resulted in short commutes and small activity spaces for the inhabitants. This was often the result of social housing policies aimed at providing affordable housing in proximity to major employment centres. Starting from the 1970s, as a result of economic restructuring, low-skilled jobs have dispersed across wider areas, and this has increased commuting distances for the residents of working-class neighbourhoods. In this context, an increasing number of studies has focused on the lack of mobility of low-income households living in these areas, and how this impacts negatively on their social inclusion, drawing on the concept of spatial mismatch and putting forward the hypothesis that French cities are developing 'american-style' ghettos. *Contra* this hypothesis Fol (2009) argues, on the basis of a qualitative comparative study, that the mobility practices of low-income households in France are characterised by 'local dependence', thanks to the greater availability of services and public transport in the local area, which offsets the lower levels of car ownership in working class neighbourhoods. This is the opposite of the 'car dependence' model (where lack of mobility necessarily entails social disadvantage) epytomised by the situation of cities in the US and the UK (Fol, 2009).

This work resonates with that of other European urban scholars (Les Galès, 2002; Kazepov, 2005a), who have highlighted how the social morphology of European city type is profoundly different from that of its American counterpart. The reason for this is ultimately higher levels of public expenditure in European cities, that have three kinds of effects: firstly, they imply "a relatively high share of employees in the public sector, who make the city's economy – in contrast to US cities – less dependent on market forces" (Kazepov, 2005b, p. 13). Secondly, they are also associated with a greater supply of public services and infrastructure, such as public transport (*ibidem*). Finally, public landownership, regulation and the tradition of town planning are stronger, and have successfully limited the impacts of market-led urban development (Häusserman & Haila, 2005). For example, regulation of housing markets and social housing programs are common in most European municipalities (Les Galès, 2002; Murie, 2005). Overall, a greater level of 'decommodification' in European cities has resulted in lower levels of socio-spatial segregation, as compared to the American city-type (Kazepov, 2005b; Murie, 2005; van Kempen, 2005). Accordingly, while problems of social exclusion exist in European cities, the spatial dimension of disadvantage seems much less important than in the US[33] (Musterd & Ostendorf, 2005).

However, it is important to acknowledge that public policies have not always resulted in a reduction of spatial and transport-related disadvantage. For example, Power argues that

> "the framework of urban planning, housing policy and and welfare systems within which low income neighbourhoods have evolved over the twentieth century has taken little account of transport connections or long-run economic viability. (..) Modern, subsidised estates, invariably built by social landlords, creating at least thirty million high rise dwellings in Europe, were built without adequate funding for the transport connections that would make them work" (Power, 2012, p. 40, 42)

As a result, in Europe, living in a social housing estate is a factor that can be conducive to transport disadvantage, for reasons other than simple market-driven dynamics (Power, 2012). This is of course compounded when estates are located in outer areas.

Another defining feature of European cities is their long history. Indeed, most important European cities of today were already major centers in the Middle ages. Accordingly, 'historic city centres" often correspond to the perimeter of the pre-existing, preindustrial city (Les Galès, 2002). Starting with the industrial revolution "the socio-spatial history of European cities has been characterized by tensions between centrifugal and centripetal forces that (..) can be termed suburbanization and gentrification" (Kesteloot, 2005, p. 126). In that sense, while in some phases the middle classes have tended to leave the city centre (suburbanization), at other times they have been attracted back to the inner city (gentrification). From an historical perspective, as Kesteloot argues, "the persistence of past socio-spatial configurations, their change over time and the appearance of new configurations *result in a growing complexity of the urban socio-spatial structure*" (Kesteloot, 2005, p. 132, emphasis added). Similarly, from a synchronic perspective, this results in a

[33] In this context, several authors have highlighted that the 'liberal' model of the UK is an intermediate case between the US and mainland Europe (see for example Les Galès, 2002).

"*complex and historically rooted mosaic, which varies across cities*, regions and countries" (Kazepov, 2005b, p. 21, emphasis added). As Kesteloot observes:

> "Most European cities will (..) display a dominance of center-periphery contrasts. North and south of the European core, including its south end with relatively late industrialization, one still finds a significant presence of the upper-and middle-income classes in the inner cities. Despite suburbanization, cities such as Stockholm (..) or Milan (..) still present a broadly concentric socio-spatial structure, with the rich residing in the center and the poor in the periphery. (..) In Belgium (..) cities look very like US ones, with immigrants in the former nineteenth century working-class areas and the middle class sprawled in the suburbs. (..) In some cases one can find rich and poor configurations in both the center and the periphery" (Kesteloot, 2005, p. 136)

Overall then, the socio-spatial configurations of European cities are more varied than for the American and the Australian city type, at least with respect to the residential location of different classes. However, one common trait of European cities is the enduring symbolic and economic importance of the city centre. As Næss argues, this is also related to the long history of European cities:

> "Most European cities still have a higher concentrations of workplaces, retail, public agencies, cultural events and leisure facilities in the historical urban centre and its immediate surroundings than in the peripheral parts of the urban area. (..) (This) is partially a result of the location preferences of previous periods. (..) Enterprises and institutions established 100 or 200 years ago were to a higher extent than today compelled to choose a central location, because they would be otherwise too difficult to access (..). This can in itself explain why the urban core often has a concentration of historical buildings and institutions. In many cases, important symbolic value is attached to these buildings. (..) The established, material structures thus represent an inertia tending to sustain the importance of the inner city, also in the present situation where mass automobility has reduced the need to locate workplaces and services at locations easily accessible by public or non-motorized modes of transport" (Næss, 2006, p. 23-24)

Similarly, as argued by Martinotti, the medieval or Roman kernel of many European cities "contains portions of land that are not marketable (and) this provided substantial stability, attraction for the elites and overall ballast for the functions of the city core" (Martinotti, 2005, p. 95). Overall then, workplaces and services are generally more concentrated in the city core in European than in American or Australian cities (Colleoni, 2011; Borlini & Memo, 2009). While this is beneficial to the poor when they are concentrated in the inner city (Kesteloot, 2005), it can give rise to problems of transport disadvantage for low-income households when they are pushed to outer suburbs by increasing housing prices in the city centre (Polacchini & Orfeuil, 1999). For example, in the case of Paris, Beaucire and Saint-Gérand have observed that "nearly 60 per cent of Paris area employment is found 10km radius from the city centre, whereas only 40 per cent of the working population lives there" (2003, p. 111). As a result:

> "better-off social groups, more or less clustered in the Paris area, enjoy good access to a spatially extensive labour market. Underprivileged groups are far more scattered and, despite the efficiency of the public transport system, have less access to that system and, hence, to the labour market" (Wenglenski & Orfeuil, 2003, p. 116)

In a nutshell then, being a low-income suburban resident is perhaps more dangerous in Europe, where many jobs and services are still clustered in the urban core, than in the American or Australian context. However, it must be remembered that residential suburbanization has been less intense in European cities, that are still considerably more compact than their American and Australian counterparts (Newman & Kenworthy, 1999). Moreover, middle-sized cities (from 200,000 to 2 million inhabitants) are the dominant form of city in Europe (Les Galès, 2002): as a result, the distance to the city centre is often quite short, even for residents of suburban areas.

2.3.3. *What about rural areas?*

The urban studies literature discussed in the previous sections (§0, §2.3.2) pays virtually no attention to rural areas, reflecting an entrenched division of labour between urban and rural disciplines. However, in transport and social exclusion research, the issue of rural transport is generally considered as crucial (Banister, 2009). Indeed, many concepts (such as accessibility, forced car ownership, etc.) have been originally developed with reference to rural areas (Farrington & Farrington, 2005). As of today, scholars agree that "access to health care, education, work, and other services (..) for people living and working in rural areas is a key issue around the world" (Velaga et al., 2012, p.102).

From an historical perspective, how can rural transport disadvantage be explained? Two kinds of answers are possible. Firstly, from a sociological perspective, scholars have acknowledged that in the last decades transport and communication technologies have gradually reduced differences between the urban and rural way of life. Indeed, while Wirth (1938) described urbanism as a way of life defined by the size and density of the settlement and the heterogeneity of its inhabitants, contemporary urban sociologists have argued that the urban / rural dichotomy is less pertinent, at least in terms of mode of life. As Häusserman & Haila argue:

> "the contrast that Simmel made between big and small cities (..) soon lost its validity and in the modern world communication technologies spread urban culture around the human landscape. "The urban" was no longer bound to a specific geographic type of space – dense and heterogeneous" (Häusserman & Haila, 2005, p. 45)

Similarly, Fol argues:

> "while density was a necessary condition for the intensity of social interactions, the increase in travel speed allows people to have the same potential for contacts allowed by density. Automobility is the main driver of this process. Every person builds its own social and physical geography, increasingly independent from residential location" (Fol, 2009, p. 60, own translation)

In a nutshell then, while the 'central place theory' put forward by Christaller (1933) assumed that a more peripheral location and smaller settlement size necessarily corresponded to less specialised services, the increasing speed and flexibility brought about by motorisation increasingly put this principle into question. As a result, it is increasingly possible – and expected – to live in an 'urban' way in rural areas. However, this possibility is dependent on the ability to cover great distances – which generally means owning a car and the economic resources necessary to running it and maintaining it. In that sense, the expansion of the activity spaces of rural residents has its downside, namely an increase of car-related transport disadvantage.

A second way of interpreting the historical emergence of transport disadvantage in rural areas is to take into account the changes that increasing motorisation has brought about in the spatial distribution of activities and services. Indeed, as Farrington and Farrington argue, 'accessibility' was originally "a rural idea":

> "particularly, though not exclusively, based on the recognition of a post 1950s *rural* Britain where bus and rail services, and other public service facilities such as schools and hospitals, were in decline, leaving some groups in rural society with fewer opportunities to access opportunities and activities, despite an overall increase in car ownership and car-based commuting" (Farrington & Farrington, 2005, p. 2)

To sum up then, increasing motorisation in rural areas has deeply transformed both the rural way of life and the spatial distribution of activities. The outcome is an increasing dependence on the automobile to participate in the activities that people consider essential for living a decent life. In that sense, this historical process has paved the way for the rise of car-related transport disadvantage. As of today, rural areas are generally considered as those where car dependence and transport disadvantage are most severe (Gray et al., 2001; 2006; Gray, 2003; McDonagh, 2006; Owen et al., 2012; Smith et al., 2012).

2.3.4. Car-related transport disadvantage across different types of area

In the previous sections (§2.3.1-§2.3.3) I have shown how in the last century car-related transport disadvantage has emerged as a result of motorisation and the associated changes in urban structure and social morphology. In this section, by contrast, I expand on the relationship between transport disadvantage and the built environment *in a synchronic perspective*. In this context, my goal is to show how the intensity of the different forms of car-related transport disadvantage varies systematically between different types of area.

A caveat to this discussion is that it would be wrong to think of car-related transport disadvantage as inherently clustered in certain types of area. Indeed, as argued by Hine and Grieco (2003) there are both 'scatters' and 'clusters' of transport disadvantage. As illustrated above (§2.1.3), this is due to the fact that transport disadvantage emerges from the interaction of several factors (cfr. Fig. 2.3), only some of which have a spatial dimension. So for example, when transport disadvantage is mostly due to individual characteristics (such as disability or old age resulting in mobility difficulties), it is likely to be found everywhere, regardless of the density of the built environment and of the social status of the area (Hine & Mitchell, 2003, p. 3). In this context, Lucas and Markovich have criticised studies that "concentrate on geographical or spatial-based exclusion, such as that experienced by suburban or rural communities" (2011, p. 226), because:

> "in doing so (they) sometimes entirely overlook the 'poverty' dimension of the social exclusion policy agenda (..), which tends to undermine, rather than enhance, the previously unique contribution of the UK research to social policy understandings of the role of transport" (Lucas & Markovich, 2011, p. 226)

There is however considerable research evidence to demonstrate that transport disadvantage is more severe in certain contexts, notably suburban and rural areas. For example, Delbosc and Currie (2011c) have studied the impacts of transport disadvantage on social exclusion and well-being across different types of area in Victoria, Australia, exploring the hypothesis that these are greater in remote than in accessible urban areas. Although they do not find significant differences between types of areas in subjective, self-reported measures of transport disadvantage, they are able to demonstrate that high levels of transport disadvantage are more strongly correlated with low levels of well-being in rural areas. As they argue:

> "this means that even though regional residents did not always report higher levels of transport disadvantage, those who *do* experience it are likely to experience worse well-being outcomes than people in urban areas. Conversely if residents of urban areas experience transport disadvantage this is less likely to have a major impact on their well-being" (Delbosc & Currie, 2011c, p. 1136)

To sum up, then, even though transport disadvantage is found in every type of area, the *number* of people that experience it and the *intensity* of disadvantage (in terms of negative impacts) are likely to vary systematically across different types of area. In the remainder of this section, I illustrate this for the different forms of car-related transport disadvantage put forward in §2.2. In doing so, I refer exclusively to the European city type described in §2.3.2. There are two reasons for this: first, it allows me to simplify the discussion. Second, the empirical work presented in this thesis is focused on two European case studies.

Tab. 2.1 further simplifies the picture by assuming the existence of only two types of area, defined by population density and location within the urban area: a high-density historic city centre and a low-density suburban area. These ideal-types should be considered as polar extremes on a continuum, with most European city neighbourhoods located somewhere between these poles. For the purpose of this (deliberately simplistic) discussion, it can be assumed that rural areas are very similar to low-density suburban areas, as far as car-related transport disadvantage is concerned. This assumption is justified on the basis of the similar degree of population density and the peripheral location with respect to city centres. Furthermore, the findings of transport and social exclusion research have shown similarities in how the problem manifests itself in these two types of area. Another assumption in Tab. 2.1 is that employment opportunities and services are quite concentrated in and around the city centre – a common trait in the European city type, as illustrated above (§2.3.2).

	High density historic city centre	**Low-density suburban area**
Car deprivation	More people affected Minimum intensity	Less people affected Maximum intensity
Car-related economic stress & Oil vulnerability	Less people affected Minimum intensity	More people affected Maximum intensity
Car-related time poverty	Less people affected Minimum intensity	More people affected Maximum intensity

Tab. 2.1 – Forms of car-related transport disadvantage across different types of area in the European urban structure. Source: own elaboration.

With regard to car deprivation, existing research shows that lack of car access is more of a problem in low-density suburban areas (where modal alternatives are often virtually absent) than in historic city centres, where public transport provision, walkability and cyclability are better. Even more importantly, higher population density and the concentration of jobs and services in the city centre tend to reduce distances to key destinations, thus making the car less of a necessity in central areas. The opposite is true in low-density suburban areas, where the intensity of car deprivation is at its peak. However, the opposite is true for the number of people that experience this kind of transport disadvantage. Indeed, the greater need for automobility in peripheral areas results in higher car ownership rates: as a result, less people lack access to a car, even though those who do are arguably in a very difficult situation. As Delbosc and Currie argue with reference to Australian rural areas, “transport disadvantage may be minimal for households with car access but the small proportion of households without a car are likely to suffer much greater deprivation than their urban counterparts” (2011c, p. 1131). By contrast, even though lack of car access in central areas arguably corresponds to only a minor disadvantage, much more people experience it, given the lower car ownership rates. In a nutshell then, car deprivation has a peculiar relationship with population density: the lower the density, the lower the chance to find individuals without access to cars, but the higher the likelihood that this results in serious disadvantage.

This pattern is typical of car deprivation, and is not generalizable to other forms of car-related transport disadvantage. Indeed, existing research shows that car-related economic stress and oil vulnerability are experienced by *more* people in low-density suburban areas (where car ownership and use are higher) (Polacchini & Orfeuil, 1999; Dodson & Sipe, 2007). Also the intensity of car-related economic stress is higher, given the relative lack of modal alternatives, resulting in price inelasticity in the demand for car travel (Dargay, 2002), and the longer distances to key destinations, resulting in higher expenditures for transport, all other factors equal. The opposite is true for high density city centres, where car-related economic stress is both less intense and experienced by less people (the same applies to oil vulnerability).

Finally, car-related time poverty affects mostly the residents of low-density suburban areas, as compared to people living in walkable compact urban areas (Farber & Páez, 2011a). Similarly, it is reasonable to assume that the intensity of car-related time poverty would be lower in historic city centres. Indeed, car-related time poverty is the result of the combination between the great amount of time required for commuting and the travel time required to access leisure activities. While commuting time might be excessive also for inner-city residents (even though they are less likely to have to cover great distances, given the concentration of employment opportunities in the urban core in Europe), the accessibility of leisure activities is likely to be much better. Overall then, they are both less likely to experience car-related time poverty and, when they do, it is arguably less intense[34].

To sum up, then, all four forms of car-related transport disadvantage – with the partial exception of car deprivation – are assumed to have a negative relationship with population density and distance to the city centre. To put it simply, in low-density peripheral areas both living with and without a car are more likely to be associated with transport disadvantage: indeed here we find more people struggling to cope with motoring costs, more people vulnerable to increases in fuel prices and more people who are time poor because of lengthy car commutes. Even though we find less people lacking access to a car, those who do are more likely to suffer the negative impacts of car deprivation.

However, an important feature of this deliberately simplistic scheme is the assumption that there are no systematic social differences (in terms of income, social status, etc.) between residents in the two types of areas. This is unlikely to be true – even in the case of European cities, where residential location is determined to a lesser extent by the housing market, as compared to American and Australian cities (see §2.3.2). In that sense, it is crucial to acknowledge that urban socio-spatial configurations can either compound or reduce the spatial patterning of car-related transport disadvantage illustrated in Tab. 2.1.

In the following, I illustrate the relevance of urban socio-spatial configurations for all four forms of car-related transport disadvantage. For the sake of simplicity, I assume that only two ideal-typically opposed urban socio-spatial configurations exist, as illustrated in Fig. 2.7. Using the terminology put forward by Kesteloot (2005), city-type A is the 'dramatic city', where both employment and services and lower classes are concentrated in the urban core, while middle and upper classes live in the suburbs. City-type B is a 'topologic city' with a concentric socio-spatial structure, where middle and upper classes live in the urban core, while the poor are concentrated in the suburbs.

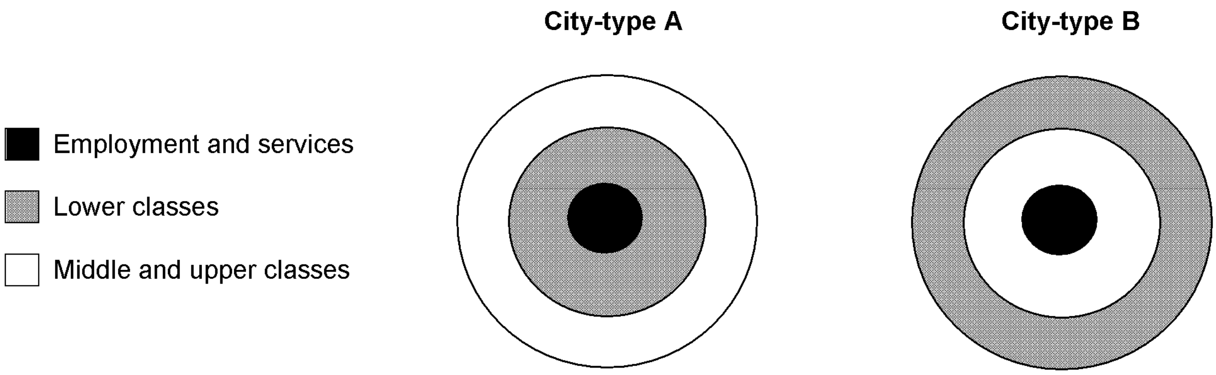

Fig. 2.7 – Ideal-typical urban socio-spatial configurations for the European city-type. Source: adapted from Kesteloot (2005)

With regard to car deprivation, the urban socio-spatial configuration B tends to compound the spatial patterning illustrated in Tab. 2.1: indeed, the problem of car deprivation would be even worse in low-density suburban areas, because many low-income people would not be able to afford a car, despite the fact that it is virtually a necessity in these areas. By contrast, car deprivation would be residual in the urban core, because everyone who needs a car would be able to afford it. The opposite urban socio-spatial configuration (city-type A) would instead result in a mitigation of the spatial patterning of car deprivation: indeed, suburban residents would be able to offset the greater need for automobility with higher levels of car ownership, given

[34] It must be noted however, that inner city residents are arguably more likely to experience time poverty as a result of long commutes by alternative modes (walking, cycling, public transport). In this context, however, this form of transport disadvantage is subsumed under the category of 'car deprivation'. This observation helps explain why – as argued above – car deprivation affects a greater number of people in central areas, even though the intensity of disadvantage is lower.

their higher economic status. By contrast, the consequences of low car ownership rates among the poor in the city centre would be mitigated by the higher accessibility with alternative modes[35].

The same applies to car-related economic stress and oil vulnerability. Indeed, in city-type B, housing prices push low-income households to suburban areas, where they have to struggle with higher motoring costs and greater vulnerability to increases in fuel prices, and this is only compounded by low economic status. By contrast, the middle and upper classes concentrated in the urban core are doubly advantaged: they do not need to spend so much for car travel, and they have higher income. In that sense, urban socio-spatial configuration B compounds the spatial patterning of car-related stress and oil vulnerability. The opposite is true for the 'dramatic city' model (A), where centrally-located lower classes are less exposed to car-related financial stress and fuel price increases, while the suburban middle and upper classes are able to offset these problems with higher income. Overall, urban socio-spatial configuration A mitigates the spatial patterning of three forms out of four of car-related transport disadvantage. The relevance of the different social morphologies of cities in this context is reflected in the findings of Verry and Vanco (2009): in a study focused on oil vulnerability (defined as spending more than 20% of income on motoring), they have been able to show that the problem is more serious in Marseille (a city with sprawling, low-income suburbs) than in Lille (where suburbs are both more compact and wealthier). Similarly, the works of Dodson and Sipe have consistently shown that "low socioeconomic status and high car dependence are strongly co-located in Australian cities" (2007, p. 57): this implies that the urban socio-spatial configuration typical of Australia (middle and upper classes in the urban core, lower classes in cheap housing areas in the urban fringe) is compounding the spatial patterning of car-related economic stress and oil vulnerability.

In a sense, this discussion mirrors what has been observed in studies on fuel poverty (§2.2.2), where Boardman has observed that:

> "if the amount of money that is affordable is fixed (..) and there is a defined standard of energy services to be obtained, then the only way these can be brought together is through the energy efficiency of the home and the equipment inside. This means that the lower the income of the household, the more energy efficient the property has to be to ensure that they are not in fuel poverty. *Although counter-intuitive, the poorest people should have the most energy-efficient homes.* This is certainly not the situation in 2009" (Boardman, 2010, p. 35-36, emphasis added)

If we substitute the notion of "fuel efficient cities" put forward by Newman and Kenworthy (1988) for the notion of "energy efficiency", it is apparent that the problems are similar. Given the spatial patterning of car-related economic stress, the poorest people should live in the most 'fuel-efficient' (i.e. compact) areas: this happens in city-type A, but not in B.

The exception in this context is car-related time poverty. Indeed, as illustrated in §2.2.3, this form of transport disadvantage tends to affect more the working middle classes, given that their workplaces are on average more distant from home. In that sense, urban socio-spatial configuration B would arguably help to mitigate the spatial patterning of car-related time poverty, by reducing the length of the commute for middle-upper classes. Low income workers in suburban areas would arguably be less likely to experience time poverty, because of shorter commutes to local workplaces. By contrast, city-type A compounds the spatial patterning, because the concentration of middle and upper classes in the suburbs results in a further increase in commuting distances, with knock-on effects in terms of participation in leisure activities.

To sum up, then, urban socio-spatial configurations should not be overlooked when studying transport disadvantage. Indeed, while all forms of car-related transport disadvantage show some degree of spatial

[35] This conclusion arises from the assumption that in European cities jobs and services are not strongly suburbanised. When the opposite happens, like in the typical US city, the concentration of lower classes in the city centre results in spatial mismatch and car deprivation (see §2.2.1).

patterning (being generally worse in low-density suburban areas), urban socio-spatial configurations can either compound or reduce it[36].

2.4. Policies to tackle transport disadvantage

In this section, I review the policies that have been proposed and implemented in many countries in order to tackle transport disadvantage (§2.4.1–§2.4.6). At the end of this review (§2.4.7), I discuss the latent tension between these policies and the measures aimed at reducing the environmental impact of transport, reviewed in the previous chapter (§1.6). This is aimed at bringing together the two strands of research, by making explicit the connection between them at the policy level.

2.4.1. Changing transport decision making

In the context of transport and social exclusion research, scholars and policy makers have argued that the characteristics of transport decision-making tend to produce situations of transport disadvantage. Indeed, as argued by Hine and Mitchell, "transport planning has traditionally been concerned with approaches that downplay the importance of social impacts of transport infrastructure" (2001, p. 320). In turn, these approaches inadvertently result in transport-related social exclusion (Markovich & Lucas, 2011; Jones & Lucas, 2012; Litman & Brenman, 2012). In the last decades, similar criticism has been directed at transport planning for its inability to take into account the environmental impacts of transport. However, as Martens (2006) observes:

> "transport modelling and cost-benefit analysis (..) have been adapted substantially to cope with the challenges posed by the goal of sustainable development. However, the changes have primarily focused on the negative environmental impacts of the transport sector. Hardly any attention has been paid to another key dimension of sustainable development: social justice" (Martens, 2006, p. 1)

In this context, a typical example is cost and benefit analysis (CBA), that can be defined as the procedure whereby "quantified effects are assigned a monetary value and included in overall economic appraisal of the total value of the project in monetary terms" (Geurs et al., 2009, p. 80). CBA is frequently used for evaluating transport projects and assisting decision-making, and has been criticized for inherently working to the advantage of higher-income, motorised population groups (Martens, 2006, p. 10). More broadly speaking, it has been argued that "current policy and planning biases (..) in various and often subtle ways tend to favor mobility over accessibility and automobile travel over other transport modes" (Litman & Brenman, 2012, p. 2).

To counter this bias, scholars and policy makers have proposed different ways to adapt transport decision making, taking into account its social impacts so as to promote transport projects that help reducing transport-related social exclusion. For example, as illustrated previously in this chapter (§2.1.3, §2.1.4), Australian researchers (Currie et al., 2007; Currie, 2011a) have attempted to produce measurements of the social impacts of transport, in order to feed them into existing transport-decision making tools such as CBA (Stanley & Hensher, 2011; Stanley & Stanley, 2011). This move allows the appraisal of the value of policy measures (such as public transport improvements) meant to tackle transport-related social exclusion. Moreover, it also helps showing that "individual benefits of reduced social exclusion to the people involved are likely to be many times greater in ultimate value than those derived from transport initiatives that focus on people who are already included" (Stanley & Stanley, 2007a, p. 13.15). This, in turn, is likely to result in the prioritization of targeted, 'social transit' improvements over 'mass transit' improvements (see §2.4.3 below). Overall, this shows that:

[36] In the empirical work of this thesis, it is not possible to take into account of the effect of urban socio-spatial configurations, because I use national travel survey data that allow only to distinguish different 'types' of area.

> "the traditional economic cost-benefit approach to transport policy becomes much closer to a social policy approach when the research results about the value of improved trip making, as it affects risks of social exclusion, are incorporated in the analysis" (Stanley & Stanley, 2011, p. 277)

While integrating social impacts into CBA is a possible way to correct biased transport decision-making processes, it is not necessarily the only one. Indeed, in recent years an increasing number of authors has proposed corrections or alternatives to existing tools (Martens, 2006; Martens et al., 2012; Geurs et al., 2009; Litman, 2012) In this section, it is impossible to provide a review of these studies. However, it is important to acknowledge that current transport decision-making tools tend to worsen the problems of transport disadvantage: solving them in turn requires the use of improved or alternative procedures. In this context, the role of quantitative empirical research on transport disadvantage is crucial.

However, transport disadvantage arises not only from biased transport planning *tools*, but is also the result of particular *institutional arrangements*. In the UK, this idea has inspired a new framework of 'accessibility planning' (AP) (SEU, 2003). This approach moves from the premise that, if past policies have contributed to the rise of transport-related social exclusion, this is also because of an institutional problem, namely that historically, "no single public body has had overall responsibility for accessibility" (p. 39). Therefore, the solution is to "ensure that there is a clear responsibility and accountability for identifying accessibility problems and deciding how to tackle them. In practice, in the UK AP has three main goals:

> "to ensure that there is a clear process and responsibility for identifying groups or areas with accessibility problems; (to ensure that) in developing and delivering their Local Transport Plans, authorities have improved information on barriers to accessibility and the areas where accessibility is poorest; and (to ensure that) local authorities work with other agencies to consider a wide range of solutions to accessibility problems including changes to the location and delivery of services and measures against crime around transport, as well as improved mainstream and specialist transport" (SEU, 2003, p. 61-62)

Therefore, the responsibility to lead the process of AP is assigned to local transport authorities, that are encouraged to involve local planning authorities and other agencies in 'Local Strategic Partnerships' (SEU, p. 62). In that sense, AP is a paradigmatic example of a place-based approach in the context of the "place versus function dilemma" (Stanley & Stanley, 2011, p. 281-282). In the words of Stanley and Stanley:

> "government administration (..) has traditionally been structured on functional lines, with separate transport agencies and land-use agencies and also separate agencies with functional responsibilityies to deliver many of the other services to which people require access (e.g. education, health, and medical services). Place-based approaches to tackle needs related to transport disadvantage seek to bring relevant functional agencies together to work in a place-based mode with local communities, to identify the most suitable combinations of transport, land use an outreach solutions" (Stanley & Stanley, 2011, p. 281)

The accessibility planning approach has had great resonance across the world, and its adoption has been proposed by scholars in countries such as Australia (Stanley & Stanley, 2007; Lucas & Currie, 2012) and Italy (Borlini & Memo, 2009).

Also, several scholars and policy makers have argued that allowing the general public (and notably disadvantaged groups) to participate to transport decision-making would improve the outcome of the process in terms of social equity and transport disadvantage[37]. Indeed, Lucas argues that in the transport domain, low-income communities not only "are disproportionately denied the benefits of public resources", but also "full and fair participation in the decision-making process" (2004d, p. 297). To adopt the terminology proposed by Walker (2012), there is an issue of 'procedural justice', whereby lack of participation results in

[37] More broadly speaking, the issue of participation in sustainable transport policy making is attracting increasing research attention (Cucca, 2009).

distributive injustice with regard to access to services and opportunities. In the US, starting from the 1990s this idea has inspired Community impact assessment (CIA) analysis, that can be defined as:

> "an approach that a number of agencies (..) have adopted in recent years to ensure the voices of local people are heard during the transportation planning and implementation phases of projects. It includes such approaches as community profiling, meaningful community involvement, consensus building, decision making, education, training and implementation" (Morris, 2004, p. 197)

In the context of CIA, public involvement exercices are carried out, with the expliciting goal of encouraging the participation of "traditionally underserved populations" (Kennedy, 2004, p. 164). Also outside the US, the importance of involving the general public in transport decision-making has been acknowledged. For example, Merseytravel, the Public Transport Authority of the Liverpool city region, has sought to adress the transport and social exclusion agenda, by adopting a participative approach, with a commitment "to fully engage and consult with the local community and to attempt to meet their aspirations" (Grant, 2004, p. 67). More in general, in the UK the Social Exclusion Unit has identified public consultation and participation as a key to the progress of the transport and social exclusion agenda (Lucas , 2004b, p. 148). Some authors have gone even further, arguing that, since some population groups (such as women) are more likely to experience transport disadvantage because of their special needs, public involvement exercices should target them directly (Ortoleva & Brenman, 2004; Turner & Grieco, 2006).

While including disadvantaged groups in the decision-making process is a good antidote to the biases of current transport planning tools, their participation might be difficult to achieve. Indeed, as Lucas and Currie argue:

> "people who are experiencing social exclusion are likely to be disengaged from the formal political process and institutional structures of the society in which they live and so are unlikely to be directly involved in formal transport decision-making and are likely to feel alienated and disempowered by the whole decision-making process" (Lucas & Currie, 2012, p. 155)

Therefore, public participation techniques "need to be adapted if they are to secure the participation of disadvantaged groups and low-income and minority communities" (Lucas, 2004c, p. 286). This, in turn, is essential if their transport disadvantage problems are to be addressed.

2.4.2. Changing land-use and urban planning

The need to cover increasingly long distances in order to access essential services and opportunities is at the root of transport disadvantage (see §2.3). Therefore, a possible solution is to try and reduce these distances, by promoting new approaches to urban planning and land-use. In this context, compact, mixed-use and public transport oriented urban developments have been advocated. As Stanley and Stanley argue:

> "land use improvements that aim to tackle transport disadvantage generally seek to improve people's access to activities through better structuring of land uses, to reduce the need to travel. For example, mixing of land uses may reduce the travel distances/costs for some people to accomplish some activities (as compared to land use arrangements that separate different kinds of activities)" (Stanley & Stanley, 2011, p. 280)

Moreover, modal alternatives to the car are more competitive over shorter distances: as a result, the need to own and use cars is reduced in compact and mixed-use areas, and this reduces all forms of car-related transport disadvantage (§2.2). In addition, this might also reduce the negative environmental externalities of transport, as noted in the previous chapter (§1.6.3).

However, as noted above (§1.6.3) this agenda has wide-ranging institutional and organisational implications, because it requires a greater level of coordination between transport and land-use policies (Kaufmann & Sager, 2006; Gallez & Kaufmann, 2010). Moreover, the need for coordination is not limited to these sectors, nor to the local level: as shown in Britain by the Social Exclusion Unit (SEU, 2003), the location decisions of a number of key public services (for example, health care services) have for long been taken with little (if any) concern for their accessibility by modes alternative to the car. As observed by Lucas:

> "while the problem is usually described in term of land-use planning, solutions are rarely within the power of local authority land-use planners to effect. Many planning decisions are taken out of their hands by the private sector and other more powerful public sector agencies with an influence over location decisions, such as the health and education sectors. These do not include transport and accessibility as essential criteria in their location assessments. As such, planners are regularly forced to bow to the pressures of other more compelling considerations, such as private profit, job creation and value for money" (Lucas, 2006, p. 802)

Accordingly, providers of public and private services also need to be involved in coordination processes, if the trend towards increasing intensity of car-related transport disadvantage is to be reversed. In the UK, accessibility planning (see §2.4.1 above) includes also the goal of bringing together spatial planning and transport planning in order to improve accessibility. Notably, AP moves from the premise that in the past "services have been developed with insufficient attention to accessibility" (SEU, 2003, p. 3) and that "accessibility (should) be given greater weight in land-use planning decisions" (p. 5).

Overall, there are several limits to land use solutions to the problems of transport disadvantage:

- firstly, as noted in the previous chapter (§1.6.3), changing the built environment is inherently a long term strategy, unlikely to make a difference in the short term. Therefore, it is unlikely to be the sole solution to transport disadvantage problems, and it needs to be complemented by other short-term, transport-based strategies (see §2.4.3, §2.4.4)
- secondly, as noted above (§1.6.3), the implementation of changes in land-use policies is likely to meet considerable institutional and organisational resistance, because of path dependencies in transport and urban planning policies (Newman & Kenworthy, 1999; Pflieger et al., 2009)
- thirdly, place-based approaches may not adequately address forms of transport disadvantage that are inherently 'scattered', rather than 'clustered' (Hine & Grieco, 2003; Hine & Mitchell, 2003, p. 120)
- finally, as acknowledged by Lucas if "land-use developments continue to be located in places that people without cars find difficult to reach" (2004b, p. 148) this is not just the result of lack of coordination between land use, transport planning and other agencies. Importantly, the problem is also that "these decisions are often out of the hands of planners themselves, who are regularly forced to bow to the pressures of other more powerful interests such as private profit, job creation and cost-efficiency savings" *(ibidem*). If this is true, bringing about real change in patterns of land use will require more than just encouraging integrated planning at the local level: arguably, it will be necessary to counteract the vested interests that stand in the way of radical change in this domain (Schwedes, 2011a; 2011b).

Overall, land-use solutions to transport disadvantage are difficult to deliver, and are effective only over the long term. Therefore, scholars and policy makers generally agree that this strategy is hardly sufficient, and that more short-term measures are needed. These are reviewed in the following sections (§2.4.3-§2.4.6).

2.4.3. Improving modal alternatives

As illustrated above (§2.2) many forms of transport disadvantage derive from the increasing need to own and use cars. Therefore, an obvious solution to such problems is to improve the performance of alternative modes of transport. This section reviews this strategy, focusing mostly on public transport improvements. Indeed, as Lucas observes, "currently, the policy agenda places heavy emphasis on the public transport network" to provide access to goods and services (2004d, p. 293). The reason for this is that in industrialised countries, the introduction of motorised modes of transport, increasing motorisation and associated land use changes have resulted in increasing distances between residences, services and opportunities. These in turn are not easy to cover by non-motorised transport modes such as walking and cycling. However, improvements to 'slow' transport modes can be a valuable solution in some contexts: this will be discussed at the end of this section.

To adopt the terminology proposed in this chapter (§2.2), public transport improvements reduce the intensity of car deprivation, car-related economic stress and oil vulnerability. First of all, scholars and policy makers often point out that improvements to mainstream public transport services are crucial to reduce transport disadvantage. Broadly speaking, this means supply increases, from a spatial perspective (network coverage, better route penetration, etc.), as well as from a temporal point of view (higher service frequencies, longer operating hours, etc.). Quality improvements (substition of bus services with rail-based public transport, Bus Rapit Transit systems, bus priority measures such as segregated lanes, etc.) are also often advocated for the same purpose. Improvements to public transport vehicles in terms of accessibility, comfort and safety are particularly important for transport disadvantaged groups such as older people (Hensher, 2007). Finally, providing better information is also considered as crucial (Cass et al., 2003, p.23), given the lack of skills and competences of some transport disadvantaged (cfr. §2.1.3).

A recent report by Lucas, Tyler et al. (2008) has provided evidence about the value of providing new public transport in deprived areas: based on findings for four British case studies, the authors demonstrate that increased public transport supply resulted in more travel, better access to work, more social capital and expanded travel horizons for residents. Moreover, additional public transport brought huge cost savings to service users, as well as wider social benefits, as "new services have created the opportunity for people to undertake wholly new activities through improved accessibility" (p. xiii), thus generating new trips previously suppressed. Similarly, Australian researchers have used structural equation modelling and CBA to impute the value of the additional trips that transport disadvantaged people would be allowed to make if a new public transport service was implemented, showing that the reduction of social exclusion is the major single benefit of public transport services (Stanley & Hensher, 2011).

With regard to the cost of public transport, reducing fares is considered not only as a way to increase ridership and encourage modal shift (see §1.6.2), but also as a solution to some forms of transport disadvantage. Indeed, the cost of public transport is a cause for concern in transport and social exclusion research, notably in countries where this has increased considerably over the years, such as the UK (SEU, 2003). Internationally, attempts to address this issue have taken three main forms:

- offering discounted or free fares to groups deemed to be disadvantaged is by far the most common measure. For example in Britain the SEU report indicated "concessionary fares for particular client groups or journeys" as a valuable policy instrument to make travel more affordable[38] (2003, p. 6). Similarly, in France, local authorities have implemented "special pricing policies designed to help the most disadvantaged groups" for several years (Diaz Olvera et al., 2004, p.153). In this context, the targeted categories generally include some of the following: pensioners, disabled, jobseekers, lone parents, workers on low-income, war veterans, children and students (Hine & Mitchell, 2003; SEU, 2003; Diaz Olvera et al., 2004; Serebrisky et al., 2009; Morris & Kinnear, 2011). The same result is sometimes achieved with demand-side subsidies such as transport vouchers and direct transfers using the welfare system (Serebrisky et al., 2009)
- a progressive pricing policy according to household income is a more radical solution to the affordability problems of low-income households. This has been proposed for example in France (Diaz Olvera et al., 2004)
- supply-side subsidies to public transport allow to reduce fares, and are very common in developed countries (Serebrisky et al., 2009). An extreme case of subsidization is the so-called "free public transport" concept, which actually refers to a system that is entirely funded from general taxation. Even though it has been rarely implemented on a large scale (Steenberghen et al., 2006), free public transport has been proposed as a way to ensure equality of opportunity in terms of accessibility (Piratenpartei Berlin, 2011)

[38] In the British context, 'concessionary fares' means that "local authorities reimburse operators for offering discounted fares to particular groups" (SEU, 2003, p. 44).

Overall, improving mainstream public transport services is considered as an effective way of tackling transport disadvantage. However, there are two main limitations to this approach. Firstly, as argued in the previous chapter (§1.6.2) providing convenient public transport in low density car-oriented areas is extremely challenging, as well as expensive for the public purse (especially if subsidized services with low fares are to be provided). In that sense, where land-use patterns are car dependent, improving modal alternatives can be ineffective as a way to tackle transport disadvantage. Secondly, as argued by Betts, the choice "to expand 'mainstream' transport services rather than provide targeted services (..) is based on the premise that disadvantage is experienced broadly and solutions need to be broad and inclusive" (2007, p. 12.14). This is not necessarily true, given the complex nature of transport disadvantage (cfr. §2.1.3). Indeed, particular groups of transport disadvantaged (such as disabled people) might benefit more from targeted service (such as a dedicated minibus) rather than from marginal improvements to the existing bus network. In that sense, as Lucas argues

> "if properly designed and delivered, public transport can provide a part of (the) solution (to the problem of transport-related social exclusion), but it is most likely that *other forms of more flexible (and often informal) transport services will be needed to complement* these mainstream services" (Lucas, 2012, p. 112, emphasis added)

In the UK, these form of complementary transport services have been studied under the label of 'community transport'[39]. This term describes a "wide variety of community ad voluntary-run and owned transport services" (Jones, 2004, p. 119) that are "usually provided for specific groups of people with particular needs or accessibility difficulties" (Stanley & Stanley, 2007a, p. 13.10). The aim of these schemes is to provide inclusive transport services by increasing access to essential services and opportunities (such as health, education and employment) (Jones, 2004). While some community transport schemes offer access to private vehicles such as cars and scooters (cfr. §2.4.4), 'public' community transport schemes generally take the form of 'flexible transport services' (§2.4.3) such as group hire bus services or demand responsive services (Hine & Mitchell, 2003, p. 24). Typical examples in this context are: door to door services for disabled; minibus services for jobseekers and parents of young children in deprived areas; dedicated services to take people to healthcare facilities (Jones, 2004).

Overall, there are three fundamental differences between 'mainstream' public transport and the flexible public transport services provided by 'community transport' initiatives:

- the *flexibility* of services. From a temporal point of view, instead of running on fixed schedules, community transport schemes generally provide demand reponsive services ('dial-a-ride'), often using ICTs (Velaga et al., 2012). From a spatial point of view, they provide door-to-door service, rather than following a set route. This flexibility makes them better suited for people with particular needs that are not well served by traditional public transport. It also makes them more suited to low-density, car dependent areas where traditional public transport is not convenient (see above). For these reasons, flexible public transport services have been proposed as solutions to the problems of the disadvantaged since the 1970s (Paaswell & Recker, 1976; Hine & Mitchell, 2003, p. 25; Kemming & Borbach, 2003)
- instead of being available for general use, 'community transport' is generally *targeted* at specific population groups. Also, it is often targeted at specific access needs (e.g. access to employment, to health care services, etc.). This is an asset because it focuses on groups and needs that are not satisfied by mainstream public transport services
- as the name indicates, 'community transport' is generally *provided by grassroot initiatives*. As argued by Stanley and Stanley, often it is the "result of an initiative by a non-transport sector, which recognises that transport is a basic requirement to enjoy the services provided by that sector" and therefore "it can be seen as a *response to policy failure* on the part of the transport sector in meeting the transport needs of some groups of people" (Stanley & Stanley, 2007, p. 13.10, emphasis added). In that sense, ideal-typical 'community transport' consists of specialist services, provided by the

[39] While the term 'community transport' is used in the UK and Australia, the term 'paratransit' is used in the US (Stanley & Stanley, 2007a, p. 13.10).

voluntary sector "to address those gaps in provision not filled by mainstream transport providers" (Hine & Mitchell, 2003, p. 24). However, it must be acknowledged that flexible public transport initiatives may also be initiated by local public institutions, such as job agencies in France (Le Breton, 2004b) and the US (Cervero, 2004a) or local authorities in Denmark (SEU, 2003, p. 51) and France (Fol, 2009). The common trait here is the local, small scale nature of the schemes implemented, at least in an initial phase. Arguably, while the grassroot nature of these programmmes is a major strength of community transport, as it enables it to detect provision gaps, it is also one of its major weaknesses, because of the resulting uncertainties in funding (Jones , 2004, p. 141; Access Exchange International, 2012)

	Mass transit	**Social transit**	**Source**
Goals	*Modal shift: diverting trips from more polluting transport modes to alternatives*	*Generating more travel: satisfying suppressed demand or diverting trips from walking to faster modes*	
	patronage goals: "maximize patronage of all types" in order to achieve environmental benefits (through vehicle trip reduction) and maximizing financial return or efficiency (thus minimizing subsidy)	coverage goals: "provision of service despite low patronage – to achieve social inclusion objectives (..) such as accessibility for persons who cannot drive"; provision of an "equitable" service that meets the "social needs of disadvantaged populations"	(Walker, 2008, p. 436-437)
	Economic and environmental benefits	"(to) improve mobility opportunities so as to reduce the risk that people are socially excluded"	(Stanley & Stanley, 2007, p. 288-289)
	Improving "the efficiency of public transport in transport markets that support high-volume operations"; addressing the demands of peak period travelers	"serving markets that are not well addressed by the mass transit agenda, principally to achieve social inclusion objectives"; addressing the demands of the socially disadvantaged	(Morris & Kinnear, 2011, pp. 260, 270)
	"encouraging car users to opt for public transport"	"meeting the mobility needs of the carless population"	(Pflieger et al., 2007)
Characteristics of service	"Frequent all-day service in dense and walkable areas"; "frequent all-day connections between major activity centres"; "peak-period service in commute markets"	"Devoted to low-density areas"; "infrequent because services are spread out over the largest possible area"; "circuitous (..) because covering an area is more important than speed"	(Walker, 2008, p. 437-438)
Examples	Rapid transit commuter routes; high-speed commuter rail links; BRT; tramways	New fixed-route services in deprived areas; specialist services; demand-responsive services	

Tab. 2.2 – Public transport improvements with 'mass transit' and 'social transit' purposes: goals and examples. Source: own elaboration, adapted from Pflieger et al. (2007), Walker (2008), Stanley and Stanley (2007; 2011), Morris and Kinnear (2011).

At a superficial look, public transport improvements may seem a win-win solution, that achieves reductions in the environmental impacts of transport (by encouraging modal shift), while at the same time tackling transport disadvantage. However, a closer look at the public transport improvements motivated by the environmental imperative (§1.6.2) and by transport disadvantaged concerns (reviewed in this section), reveals that the two do not completely overlap. In fact, there even seems to be a conflict between the two agendas. As Pflieger et al. argue:

> "today, public transport policies in most industrialized countries are under enormous pressure to satisfy often contradictory demands: meeting the mobility needs of the carless population while encouraging car users to opt for public transport. In such instances, the divergence between objectives and means can be considerable" (Pflieger et al., 2007)

This opposition is illustrated in Tab. 2.2, which adopts the terminology proposed by Stanley and Stanley (2011, p. 289-290), who argue that "public transport services and service-level improvements can be largely classified as being for either 'mass transit' or 'social transit' purposes" (2011, p. 289-290). The same distinction has been discussed by other scholars in recent years (Pflieger et al., 2007; Betts, 2007; Walker, 2008; Morris & Kinnear, 2011), albeit with different terminologies, as illustrated in Tab. 2.2.

Accordingly, scholars of transport and social exclusion often complain that too much attention is given to the first approach, much to the detriment of the second. For example Lucas, reviewing the UK experience (2004b), points at "under-resourcing and competing funding priorities" as one of the "significant barriers and risks that could undermine the delivering of the new (transport and social exclusion) agenda" (2004b, pp. 145-146), arguing that "current policies to improve public transport services primarily do so with the aim of encouraging modal shift from cars. This (..) fails to benefit the travel poor" (p. 147). Similarly, Hine and Mitchell observe:

> "a fear is that current policy (..) will be more effective in dealing with the modal shift question rather than with povery reduction and creating transport opportunities for socially excluded groups. (..) Policy tools that (..) encourage modal shift (..) may also inadvertently promote a realignment of public transport services on corridors away from and towards the edge of areas where socially excluded groups reside" (Hine & Mitchell, 2003, p. 4)

Overall, Morris and Kinnear, with reference to the Australian experience, have argued that there is a need to:

> "recognize that there are two equally valid and parallel, but sometimes conflicting agendas for providing public transport services. (..) Balancing the competing demands of peak period travellers and those of the socially disadvantaged gives rise to a *fundamental tension in transport policy and planning*" (Morris & Kinnear, 2011, p. 260, 270, emphasis added)

To conclude this section, it is important to note that also improvements to non-motorised modes of transport can help tackling transport disadvantage, insofar as they reduce the need to use other modes of transport (car, public transport). A particular advantage of walking and cycling is "their generally low barriers to entry", that can be supported by "policy measures that make it easier and safer to utilise (them)" (Stanley & Stanley, 2011, p. 280). Accordingly, the British Social Exclusion Unit lists "improving road safety for pedestrian and cyclists" as one of the strategies to reduce transport disadvantage (2003, p. 93) and so do Hine and Mitchell (2003, p. 127) and Orfeuil (2003, p. 22). Similarly, Litman argues that improving walkability contributes to achieving a variety of accessibility and equity-related objectives (2010b). However, it should be kept in mind that improvements to walking and cycling can alleviate transport-related social exclusion only in contexts where distances between residences, jobs, services and opportunities are not too great. In all other contexts (such as low-density peri-urban and rural areas), improvements to public transport and/or promoting access to car use will be necessary.

2.4.4. Promoting car ownership and use

A common claim in transport and social exclusion literature is that improvements to modal alternatives are not always sufficient to provide access to essential services and opportunities: accordingly, actively promoting the car ownership and use of carless individuals is often proposed as a solution to transport disadvantage.

As noted above (§2.2.1), this argument this argument is particularly common in the US – unsurprisingly, given that it is the most car dependent society in the world. In this context, researchers who have studied transport and the welfare-to-work transition broadly agree that car availabilty is an essential precondition for job access (Blumenberg & Manville, 2004). For example, Taylor and Ong have argued that their findings on race, residence and commuting point "to policies to help carless job-seekers get access to automobiles" (1995, p. 1471). Similarly, Raphael and Stoll conclude that "policies geared towards fostering greater auto access should most definitely be considered in any comparative benefit-cost analysis of policy initiatives designed to alleviate the spatial concentration of joblessness" (2001, p. 145).

In Australia, Lucas and Currie (2012) have argued that, given the dispersed spatial structure of settlements outside of inner cities, Australian policy-makers should explore the transferrability of American programmes aimed subsidizing car access, rather than adopting the public transport focus of the UK, if they aim at tackling transport disadvantage. However, even in the UK there have been repeated calls for policy measures that improve access to cars among transport disadvantaged groups. For example, Lucas et al. (2001) have denounced the "policy ignorance of the car as a basic need for some low-income groups (..) and in some areas (..)" (p. vi). Accordingly, Lucas has argued that "unless there are significant improvements to the public transport network and road safety in deprived areas, many people will need to drive cars in order to secure social inclusion" (2004b, pp. 149-150). Similarly, a report by the Joseph Rowentree Foundation on rural exclusion (Shucksmith, 2000) has urged the British government to "give help with car ownership" (Joseph Rowntree Foundation, 2000).

Also in France there have been repeated calls for the implementation of aids to car ownership and use. For example, transport scholar Mignot has argued that "the analysis of travel inequalities inevitably leads to the question of car access and use. (..) If public powers aim to reduce travel inequalities (..) it is necessary to help poor households to have access to cars" (2004, p. 131, own translation). This conclusion seems to be shared by policy makers, with the then prime minister Jean-Pierre Raffarin going as far as to argue that "a driver's license, just like proper housing or a job, is an essential factor in social integration, insofar as it represents the principal means of autonomous travel for our citizens" (Bertrand, 2005, p. 3, quoted in Fol et al., 2007, p.811).

In all these countries, a variety of measures to promote car ownership and use have been considered and/or implemented at the local level (notably in sparsely populated areas), and sometimes incorporated into national programs; overall, they are mostly focused on work-related travel needs (Fol, et al., 2007; Fol, 2009). In the US, auto programs have existed since the 1980s (Fol, 2009, p. 194) and have mostly taken the form of low-interest 'car loans' to subsidize vehicle acquisition (Cervero & Tsai, 2002; Cervero, 2004a; Lucas & Nicholson, 2003; Blumenberg & Smart, 2011). In France, since the 1990s, social benefits aimed at facilitating the welfare to work transition can be claimed in order to cover travel expenses related to car trips; other forms of auto-programs in France include short-term loans of vehicles and subsidised driving lessons (Le Breton, 2004b; Fol et al., 2007; Fol, 2009, p. 198-203). This latter initiative has been scaled up to the national level, with the drafting of a national plan to provide help with obtaining a driver's licence in 2005 (Bertrand, 2005). More recently, Motte-Baumvol et al. have reported that "when France was confronted with a significant increase in petrol prices in 2008, the solutions proposed (included) the creation of a transport voucher for car mobility (which was never actually implemented)" (2010, p. 14). "Mobility vouchers", expendable for public transport, taxis, but also for fuel, have recently been discussed also in Germany (Ahrend & Herget, 2012, p. 44). In the UK, auto-programs are less common than in France and the US (Fol et al., 2007), although the SEU report mentions the existence of car clubs, discounted leasing of cars, minor repair and maintenance grants, subsidised driving lessons and Wheels to Work schemes (2003).

As argued above, providing access to cars is often presented as a more effective solution to transport disadvantage than improving modal alternatives. However, despite their appeal, car-based strategies have several limitations, that prevent their diffusion (Fol et al., 2007):

- a first concern is the cost of these programs. Indeed, Fol and colleagues (2007), on the basis of a review of auto-programs for the poor in France, the US and the UK, conclude that they are simply "too costly to be generalized" (p. 813)

- moreover, auto-programs are unlikely to be a suitable solution for all transport disadvantaged. Indeed, as Lucas argues "a huge proportion of people experiencing transport poverty are too young, too old or simply unable to drive. For this reason alone, car-based strategies cannot be seen as the only solution" (2004d, p. 295). Moreover, to adopt the terminology proposed in this chapter (§2.2), they only address the problem of car deprivation, while they have no effect on car-related economic stress, oil vulnerability or car-related time poverty. In fact, they might even make them worse
- indeed, a widespread criticism of auto-programs is that, given the significant costs associated with car ownership and use (cfr. §2.2.2), encouraging car ownership is unlikely to solve the transport disadvantage problems of poor households. Indeed, as argued by Currie and Delbosc "there is a danger that such programs could place low-income groups in financial stress" (2011c, p. 205). However, such consequences are rarely taken into consideration by policy makers (Fol, 2009, p. 206). To adopt the terminology put forward in this chapter, auto-programs seem to move people from one form of transport disadvantage (car deprivation) to another (car-related economic stress)
- finally, the main reason why auto-programs are considered as a "highly controversial issue and one that generally does not sit easy with transport professionals" (Lucas, 2004d, p. 294) is that they go against the environmental imperative to reduce car use (Fol et al., 2007). Moreover, they would "risk destabilizing the mechanisms for funding public transit and weakening their social legitimacy" (Fol et al., 2007, p.802), thus further deteriorating the condition of carless people: to adopt the terminology put forward by Dupuy (1999a), car-based strategies would reinforce the "car dependence spiral" (Fol et al., 2007, p.814), thus aggravating the intensity of all forms of car-related disadvantage.

2.4.5. Virtual mobility

Some authors have discussed the implications of recent developments in Information and Communications Technologies (ICTs) for measures aimed at tackling transport disadvantage. For example Kenyon et al. (2002) argue that "the use of ICTs could enable a new, virtual mobility, enabling an Internet-based increase in accessibility as an alternative to an increase in physical mobility" (2002, p. 207): in this context, the authors mention job search online, as well as the role of ICTs in providing virtual access to 'bonding' social capital (*ibidem*). According to Grieco et al. (2000) there is great potential in innovations such as home banking and home shopping for tackling accessibility problems. Hine and Mitchell have argued that 'scattered' transport disadvantaged (see above) "can be better served through new information technologies where reservation systems can be used for demand responsive transport" (2003, p. 129). This latter example shows how 'virtual mobility' policies may interact with the provision of 'flexible' public transport (see §2.4.3). The British Sustainable Development Commission (2011, p. 55) has argued that universal broadband provision would allow home-working and 'work-hubs', reducing commuting costs considerably, thus addressing car-related economic stress, and public provision of technologies such as video-conferencing "could potentially enable public sector services such as health care to be delivered remotely (..), helping those who have limited transport options" (*ibidem*).

While there is certainly much scope for 'virtual mobility' solutions to transport disadvantage, this approach has a number of limitations. Firstly, as acknowledged by Kenyon et al. (2002), there is probably also a 'virtual mobility-related dimension' of social exclusion, as access to ICTs is uneven across the population. Therefore, there is a need to study how "transport poverty meets the digital divide" (Velaga, 2012): existing evidence shows that transport disadvantage problems are often compounded by lack of access of ICTs, as for example in rural communities where broadband supply coverage is rare (*ibidem*).

2.4.6. Education and training

As illustrated in §2.1.3, several scholars in transport and social exclusion research have highlighted the role of individual competences, skills and travel horizons in determining transport disadvantage (Dijst and Vidakovic 1997; SEU, 2003; Lucas, 2004b; Le Breton, 2004a; Kaufmann et al., 2004; Allemand, 2008; Borlini & Memo, 2009; MSFS, 2011). Accordingly, several policy measures have addressed the socio-cognitive dimension of transport disadvantage. These have mostly taken the form of education and training initiatives.

In the UK, the Social Exclusion Unit (2003) has listed "widening travel horizons" among the five key "measures that can help tackling accessibility problems": this implies "helping people know and understand the travel options available to them", notably through "travel and advice, personal travel plans and better travel information" (p. 6). For example, the SEU argued in favour of the generalisation of "mobility and indipendence training" programmes, aimed at overcoming the lack of skills and confidence that cause people to experience travel difficulties (p. 57). Similarly, the report argued that the *TravelSmart* technique, pioneered in Australia with the aim of reducing car use, could be adapted to the goal of reducing transport disadvantage:

> "similar 'individualised marketing' techniques could be aimed specifically at people on lower incomes from deprived communities. The aim would be to increase their use of public transport, walking and cycling, and so widen the number of services and job opportunities to which they have access" (SEU, 2003, p. 57)

Westwood (2004), reported how, in the municipality of Halton, the concept of 'personalised journey planning' (PJP) has been adapted to the goal of meeting the needs of the 'transport poor'. PJP is a technique aimed at enabling transport disadvantaged people to reach crucial opportunities (e.g. employment, education), by providing them with tailored travel advice. In the Halton case study, this measure proved successful, as 40% of PJP recipients "had gone on to access education, training or employment opportunities using the plan" (p. 78). Overall, according to Westwood, the Halton experience shows that "through a combination of personal contact, encouragement and advice that is specifically relevant to needs, (..) restricted travel horizons can be overcome" (p. 91). In recent years, PJP initiatives have been implemented in several towns in Great Britain (Kilby & Smith, 2012).

Also in France, many initiatives have tried to tackle the socio-cognitive dimension of transport disadvantage. For example, Le Breton (2004b) reports the experience of a municipality that has implemented a training programme addressing various travel difficulties, including orientation in space, public transport use, and learning to drive a moped (pp. 117-118). Other programs have targeted disadvantaged women who needed a driving licence in order to find employment (p. 132). In Paris, the local public transport operator (RATP) has organised "teaching mobility" workshops aimed at providing people with the basic skills (reading a public transport map, a timetable, etc.) required to travel by public transport (Allemand, 2008). In Australia, Morris and Kinnear (2011) have argued that, in order to facilitate the transition to driving cessation, there is a need to provide older people with "specific and individualised information" about existing public transport services exist and how to use them (p. 263).

2.4.7. The tension between environmental and social goals in the field of transport

In the previous sections (§2.4.1 – §2.4.6), different policy measures aimed at tackling transport disadvantage have been reviewed. Before concluding, it is important to observe that some, though by no means all, of them are detrimental to the goal of reducing the environmental impacts of transport. This is most obvious for measures aimed at promoting car ownership and use (§2.4.4), but it is also true for some kinds of improvement to modal alternatives (see below).

Accordingly, several transport and exclusion scholars have expressed concern that policy efforts to tackle transport disadvantage might be hampered by environmental concerns. This is for example one of the reasons why auto-programs are unlikely to develop on a large scale (Fol et al., 2007, cfr. §2.4.4). Similarly, competing funding priorities such as 'mass transit' programs aimed at achieving modal shift are one of the reasons why 'social transit' programs are chronically under-resourced (§2.4.3). This 'latent tension' between environmental and social goals in the domain of transport has been noted by several authors. For example, Currie concludes his recent volume on "New perspectives and methods in transport and social exclusion research" by arguing that:

> "it is now clear that increasing mobility is unsustainable due to its impacts on congestion and the environment and because the fuel resources that provide mobility are finite. Although reducing

mobility has been suggested as a new objective, it must be considered in the context of the *impacts restricted mobility can have on well-being*" (Currie, 2011c, p. 306, emphasis added)

Indeed, early research on transport and social exclusion in the UK was motivated by concerns for the potential social impacts of the New Labour 'sustainable transport' agenda (see §5.1.2). For example, Huby and Burkitt (2000) reviewed the "social policy implications of the UK 1998 White Paper on Transport", concluding that it was "likely to have differential effects on different types of people", with disproportionate impacts on low-income households (p. 379). The report "Changing Infrastructure, measuring socio-spatial inclusion/exclusion by Cass et al. (2003) was originally motivated by the "concern that (..) measures (such as road user charging or place parking levies) might have a disproportionate effect on those already disadvantaged in socio-spatial terms" (p. 5). Similarly, Rajé (2003) focused on how the introduction of road user charging (widely debated in the UK at the time) might have impacted on transport-related social exclusion. Early work by Lucas et al. (2001) also focused on the intersection between transport, the environment and social exclusion, concluding that "in some instances the policies that are currently being promoted may even serve to perpetuate inequality and undermine social inclusion" (p. vii). This has also been argued with reference to specific groups: for example Dobbs (2005), based on a study of the mobility behaviour of women in England, has warned that "the development of sustainable transport systems may have serious gender implications" (p. 266). Overall, Lucas (2006) has argued that, while there is potential sinergy between environmental and social goals in the field of transport, "currently there is a serious policy conflict between these agendas within the UK policy framework" (p. 801). Accordingly, she argues, this represents "*a fundamental dilemma for future transport policy* in the UK, namely, how to control traffic growth, without denying people on low incomes the right to own and drive cars" (2004b, p. 150).

Also outside of the UK, recognition of the tension between social and environmental goals in transport policy is common. However, this is generally condined to brief remarks in either theoretical introductions or the concluding sections of books and research papers (see for example Lucas 2004d; Currie, 2011c). Only rarely has this trade-off been the main focus of attention. However, there are a few exceptions: the pioneering work of Lucas et al. (2001) has discussed in a systematic way the relationship between social and environmental goals, pointing at the existence of both win-win and win-lose measures. More recently, Cucca and Tacchi (2012) have analyzed "the trade-offs between the environmental and social dimensions in sustainable mobility policies" in Italy (p. 70), concluding that accessibility and social justice are often absent from policy initiatives aiming at containing the environmental impacts of transport. Lucas and Pangbourne (2012) have focused on the "social dimensions of the relationship between transport and climate change", assessing "the potential for unintended negative consequences to (..) arise from policies to reduce the climate change impact" (p. 287). Also at the policy level, the issue is attracting increasing attention: the British Sustainable Development Commission (2010) has recently published a report titled "Fairness in a Car.dependent Society", aimed at integrating the two agendas by proposing a "sustainable transport hierarchy" (see below).

In this section, I discuss this tension by putting forward a deliberately simple framework to conceptualize the social and environmental consequences of the transport policy measures reviewed in §1.6 and §2.4. This framework is illustrated in Fig. 2.8 – Transport policies with social and environmental impacts. Source: adapted from Mattioli Fig. 2.8 and is adapted from a previous publication (Mattioli, 2013). The diagram uses a bi-dimensional space to illustrate the tensions underlying transport policies with both environmental and social equity consequences. Axis x shows the expected environmental impacts of the depicted policies, ranging from very negative (i.e., greater environmental damage) to very positive (less damage). Axis y does the same for social impacts, ranging from very negative (more transport disadvantage and related social exclusion) to very positive (less). Accordingly, the first quadrant (upper right) contains 'win-win' measures that are assumed to be beneficial for both goals. The second quadrant (upper left) contains measures assumed to have a positive social impact (reducing transport disadvantage), but a negative one on the environment. The third quadrant (lower left) contains measures that are detrimental to both goals, while the fourth shows 'environmentally sustainable transport' policies that are assumed to have a negative social impact.

Public transport improvements have been discussed both as policy measures for environmental sustainability (§1.6.2) and as a way of tackling transport disadvantage (§2.4.3). This discussion has shown that ‘public transport improvements’ is a generic term covering very different policies. Indeed, as Walker argues, “public transport providers and funding agencies may try to present themselves as serving all the diverse purposes of public transport, but in fact they must make hard choices between competing goals” (Walker, 2008, p. 436). As discussed in §2.4.3, there is a contrast between ‘mass transit’ improvements, aimed at achieving modal shift away from the car, and ‘social transit’ programs aimed at increasing the number of trips and distances travelled by low-mobility, ‘transport disadvantaged’ people. The first are assumed to have a positive impact on the environment, but tend to divert resources away from ‘social transit’ programs. The latter, by contrast, may reduce transport disadvantage and social inequalities, but are likely to increase the number of trips and the distances covered by transport disadvantaged individuals. Overall, this is likely to result in more motorised transport use, thus contributing to unsustainable trends in travel demand (§1.1). For this reason, in Fig. 2.8 ‘public transport improvements’ are located in the first quadrant (between brackets), but are connected by dashed lines to ‘social transit’ in the second quadrant and ‘mass transit’ in the fourth.

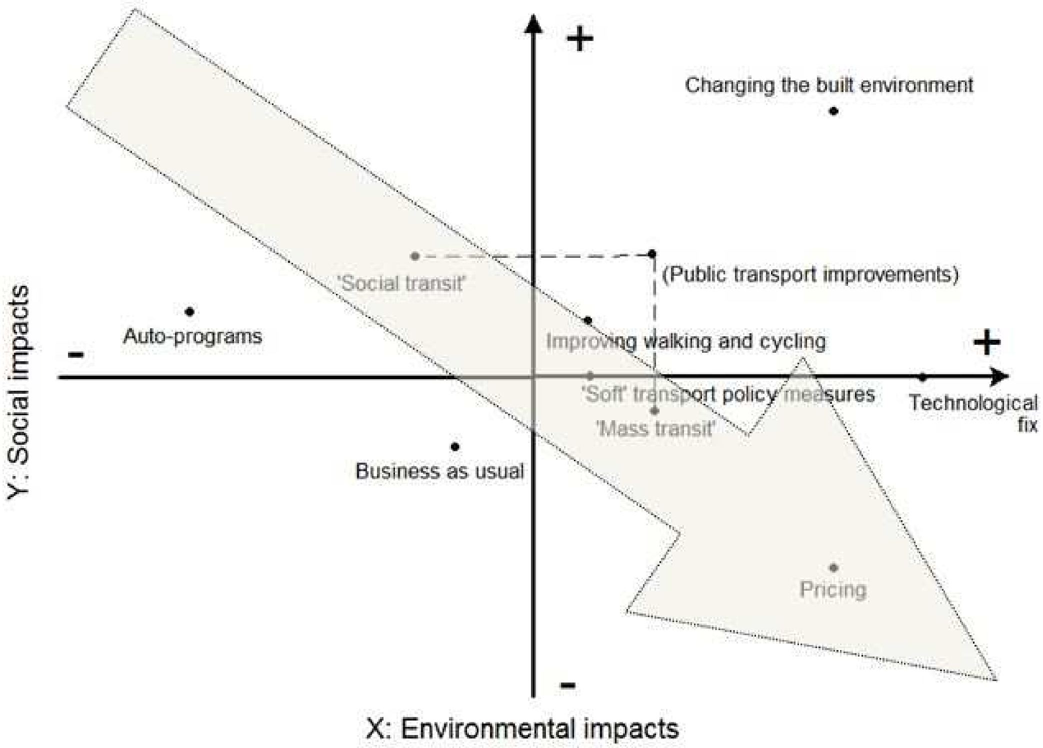

Fig. 2.8 – Transport policies with social and environmental impacts. Source: adapted from Mattioli (2013)

Improving other modal alternatives, such as walking and cycling, is arguably beneficial to both goals (§1.6.2, §2.4.3). However, given the spatial structure of many areas, it is unlikely to be an effective solution. For this reason, in Fig. 2.8 it appears in the lower left corner of the first quadrant.

Changing land-use and the built environment has also been discussed both as a a way to tackle the environmental consequences of transport (§1.6.3) and transport disadvantage (§2.4.3). In that sense, it can be considered as the best ‘win-win’ solution. However, as discussed in §1.6.3, urban planning policies aimed at ‘densification’ and ‘transit oriented development’ have been criticised because they can have negative social impacts, as increased land values and housing prices tend to result in gentrification, displacement of poor households and segregation. This is not taken into account in Fig. 2.8, that considers only the social impacts related to accessibility and transport disadvantage.

Pricing strategies, (such as road pricing, congestion pricing, emission charging and fuel or other motor-related taxes) are assumed to have a positive impact on the environment, but a negative social impact, as discussed in §1.6.4. Notably, increases in the cost of motoring are likely to aggravate the problem of car-related economic stress (§2.2.2). Therefore, pricing measures have raised concerns about equity among both scholars and the general public, and these concerns may effectively hamper their implementation, as was the case in the UK with the Fuel Tax Escalator on petrol (see §5.1.2). In that sense, economic instruments might seem to trade off environmental goals against social goals. For this reason, pricing is represented in the fourth quadrant in Fig. 2.8.

'Soft transport policy measures' (§1.6.5), are assumed to have a (small) positive impact on the environment, as they aim to change individual attitudes and behaviour in order to achieve a modal shift away from the car. With regard to transport disadvantage and social equity, there is no reason to assume that they might have any impact. For this reason, they are located on the right half of axis x in Fig. 2.8.

Promoting car ownership and use through auto-programs such as those illustrated in §2.4.4 is likely to have a positive (albeit limited) impact on the reduction of transport disadvantage and social inequality. However, it goes against the goal of 'environmentally sustainable transport', and this explains why such programs have failed to proliferate (Fol et al., 2007). For this reason, 'auto programs' are depicted in the second quadrant of the coordinate plane.

Two other strategies, not reviewed in the preceding sections, are worth discussing here[40]: firstly, the "technological fix" strategy aims to achieve sustainable transport through improvements in road vehicle technology, rather than through reductions in the overall level of road traffic. Fig. 2.8 suggests that one of the reasons why this strategy is particularly appealing for governments is because it promises a large, positive impact on the environment, with no apparent consequence on transport disadvantage and social equity. However, it must be noted that this might be wishful thinking, since fuel taxes would probably be necessary in order to successfully introduce new vehicle technologies and alternative fuels with a substantial impact on CO_2 emissions. (Schäfer et al., 2009, p.236). Secondly, the impacts of a "business as usual" transport policy, which allows the continuation of current trends, is likely to result in an aggravation of both the environmental and the social impacts of transport. Indeed, as it will be argued in the next chapter (§3.1.2), allowing car dependence to tighten its grip on society will arguably increase the intensity of all forms of car-related transport disadvantage. On the other hand, this strategy would certainly bring about a negative impact on the environment. However, the largely invisible and taken for granted social impacts may nonetheless make it attractive for policy-makers.

In a nutshell, Fig. 2.8 graphically illustrates the latent tension between environmental and social goals in the field of transport, as shown by the clustering of measures along the diagonal arrow. This is equivalent to say that some (though by no means all) of the illustrated transport policy strategies tend to trade off environmental and social goals against each other. The main exception here are strategies aimed at changing the built environment, that stand out as a prominent example of win-win strategy. However, as argued above, this strategy is effective only in the long term, and is likely to have other negative social impacts, unrelated to transport (§1.6.3; §2.4.3). As I have argued elsewhere (Mattioli, 2013), this situation might bring about a 'transport policy stalemate' for policy makers interested in both the environmental and social consequences of transport. Indeed, as (almost) any move seems to go against their declared political goals, immobility is likely to be the answer. In practice then, no serious attempt will be made to reduce car use and all hopes will be concentrated on a 'technological fix' (occasionally complemented by 'soft' transport policy measures) to eventually solve environmental problems. In this scenario, environmental sustainability is likely to be sacrificed in favour of other, more pressing goals. The UK experience provides a good case in point (see §5.1.2, Docherty & Shaw, 2003; 2008): having abandoned their radical sustainability agenda for transport put forward in 1998, Labour governments have subsequently adopted a "pragmatic multimodalism"

[40] Three policy measures aimed tackling transport disadvantage are not depicted in Fig. 2.8: in fact, changing transport decision-making (§2.4.1) does not identify a policy strategy, but rather a meta-policy that is likely to result in concrete policy measures that reduce transport disadvantage, such as 'social transit' programs. By contrast, 'virtual mobility' and 'education and training' measures are currently still quite rare, and their impact in reducing transport disadvantage is likely to be limited. For this reason, in order to improve the readability of the diagram, they are omitted from Fig. 2.8.

approach, “where high(er) levels of road building are pursued alongside enhanced public transport investment to produce a policy compromise based on what it is politically realistic to deliver” (Docherty, 2003, p. 19). It is probably not by chance that the only sustainable transport policy left in this new approach is improvement to public transport: that is, one of the few “win-win” transport strategies represented in Fig. 2.8 (at least on superficial consideration).

If one accepts that there is at least some tension between environmental and social goals in the field of transport, the next step is to ask how, and to what extent, it is possible to reconcile these concerns. This question has been recently discussed by the British Sustainable Development Commission (2011), in a report titled ‘Fairness in a Car-dependent society’ (2011). The commission moves from the premise that

> “our right to freedom of movement must be exercised without unduly compromising the rights of others to live free from the negative consequences that travel imposes. The challenge for Government is to create a framework and introduce policies, which achieve a better balance between potentially conflicting rights and freedoms in a way that is equitable for both this and future generations, and which respects environmental limits” (Sustainable Development Commission, 2011, p. 7)

As shown by this quotation, the Commission frames the problem in a normative manner: this allows to integrate the issue of inter-generational equity associated with global environmental change (Vanderheiden, 2008a), into a discussion of the social impacts of transport. Accordingly, the report lists “future generations and poorer nations” among the groups most affected by the negative social impacts of transport, alongside recurring characters of transport and social exclusion research such as those reviewed in §2.1.5. In that sense, the report argues that the right of future generations to live a decent life needs to be balanced with the right of current generations not to suffer transport disadvantage.

The framework proposed by the Commission consists of a “new sustainable transport hierarchy”, illustrated in Fig. 2.9. The hierarchy consists of four steps, corresponding to four policy strategies; it is “intented as a simple tool which can be used at all levels of transport policy making to structure thinking in generating and prioritising solutions” (Sustainable Development Commission, 2011, p. 40). The idea is that policy-makers should proceed to Step 2 only “once all actions in Step 1 have been taken”, and so on[41] (p. 41).

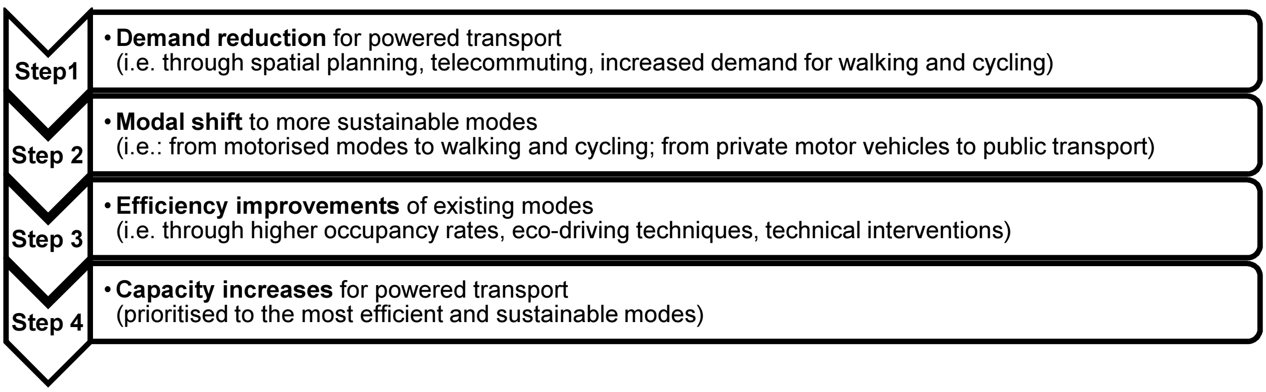

Fig. 2.9 – The ‘sustainable transport hierarchy’ put forward by the British Sustainable Development Commission. Source: adapted from Sustainable Development Commission (2011, p. 41).

Step 1 invites policy makers to consider first if people’s needs can be met without having to travel, or at least with less travel. In this context, a prominent strategy is changing land-use and the built environment, so as to minimise distances between residences, services and opportunities. This reduces overall travel distances, while at the same time encouraging an increase in ‘active travel’ (walking and cycling). Another strategy

[41] A very similar framework has been proposed by Stanley and Stanley, under the title of “an integrated policy approach to moving people and goods” (2011, pp. 282-286).

mentioned by the report is the promotion of 'virtual mobility' solutions to accessibility problems, using ICTs. As the Commission argues "reducing the need for powered transport can reduce its associated negative environmental and social impacs which (..) fall disproportionately on the poorest and most vulnerable sectors of society" (p. 42). Accordingly, Step 1 is expected to help achieve both environmental and social goals in the domain of transport.

Step 2 encourages policy makers to ensure that "remaining journeys" (those that cannot be eliminated altogether) "are as sustainable as possible" (p. 42). This entails two complementary strategies: encouraging a modal shift from powered transport (such as cars and public transport) to walking and cycling for short journeys; and shifting longer journeys from private motor vehicles to public transport. Step 3 is "ensuring the most efficient use of any given mode" (p. 43), and is to be achieved through measures such as: lift-sharing schemes and car clubs; encouraging higher occupancy rates of vehicles; promotion of eco-driving techniques; and technical interventions to improve the vehicle efficiency and more efficient use of transport infrastructure and networks (*ibidem*).

Only once steps 1, 2 and 3 have been completed, should policy makers proceed to Step 4 and implement capacity increases for powered transport, such as road building programs or increased public transport supply. The reason for this is that, as the report argues, "until the impacts of the first three steps of the hierarchy have been fully explored and appraised it is not possible to determine what residual demand for increased capacity remains" (p. 43). Moreover, the Commission suggests that, in implementing this step, policy-makers should give priority to "the most efficient and sustainable modes" (p. 41), thus prioritizing for example increases in public transport supply over car-based strategies.

The policy framework proposed by the British Sustainable Transport Commission is indeed valuable. By recognising the latent tension between the two agendas, it is a welcome antidote to the tendency of transport and social exclusion scholars and policy makers to neglect the environmental consequences of the policies they advocate. Conversely, it encourages planners who aim at reducing the environmental consequences of transport to take into account the possible side-effects on transport-related social exclusion. However, there are a two difficulties worth pointing out.

Firstly, the hierarchy turns upside down the current emphasis in transport and social exclusion research and policy making on 'social transit' programs that increase the supply of public transport with the aim of increasing trip-making and travel distances for transport disadvantaged groups (§2.4.3). In fact, according to the framework illustrated in Fig. 2.9, such measures should only be considered as a solution of last resort. However, as observed by Fol (2009), over time the policies aimed at tackling transport disadvantage among the poor have increasingly aimed at increasing individual mobility by motorised modes (notably the car), to the detriment of measures aimed at ensuring the availability of services and opportunities in the local area. In that sense, an inadvertent outcome of the report is to highlight the gap between the current transport and social exclusion policy agenda and the integrated 'sustainable transport hierarchy' that it puts forward.

Secondly, the hierarchy confirms that strategies aimed at changing the built environment in order to reduce the need for travel are the best win-win strategy in the context of the 'environment vs. society' dilemma. For this reason, they are the first step in Fig. 2.9. However, as noted above, such strategies are inherently long-term. As a result, they are likely to be neglected in favour of measures that are lower in the hierarchy, but are more likely to be effective in the short-term. So for example, policy-makers trying to address transport disadvantage are more likely to implement capacity increases strategies, rather than waiting for new land-use regulations to bring about a more equitable urban form decades from now. Indeed, as argued by Blumenberg and Manville, "transportation remedies may be inherently incomplete, but they are also speedy, and in an era of time-limited welfare, this is no small advantage" (2004, p. 199).

Overall, this second observation suggests that the tension between environmental and social goals in the domain of transport is less serious in the long term, where land-use strategies aimed at reducing the need to travel are likely to be beneficial for both goals. By contrast, the tension is much more serious in the short term: insofar as much policy-making is focused on the short-term, this dilemma is very relevant. The Sustainable Development Commission report, however, gives only scant attention to this complicating factor.

Another way of reconciling environmental and social goals in the field of transport has been suggested by Lucas, when she argues that:

> “ultimately, transport policies need to adopt a balanced approach to allow for a certain amount of increased car ownership and use among low-income sectors of the population where this is appropriate for securing their social inclusion, while curtailing the environmentally damaging and excessive levels of car use among middle- and high-income households” (Lucas, 2004d, p. 295)

In that sense, the ‘social welfare approach to transport’ advocated by Lucas (2004d) entails a redistributive approach, as it suggests that “policy should seek to redistribute transport wealth in the interests of ‘fairness’ or ‘justice’ (2012, p. 106). Overall, this is similar to the ‘contraction and convergence’ approach advocated by some in international negotiations on climate change (Walker, 2012). However, ‘redistributive’ arguments such as those put forward by Lucas are rarely found in transport and social exclusion literature, and even less so in the policy literature: for example, the report ‘Fairness in a Car-dependent Society” (Sustainable Development Commission, 2011) does not address this question. This is probably due to the fact that redistributive arguments are highly politically charged, controversial and are likely to be marginalised in contemporary societies where the right to freedom to travel is paramount (Urry, 2000; Dennis & Urry, 2009).

3. Research questions and hypotheses

3.1 Relevance of the research work

3.1.1. Reconciling two contrasting concerns

The first two chapters of this thesis have focused on two different strands of research literature: Chapter 1 has dealt with increasing car ownership and use, showing how these trends raise concerns about their environmental consequences, Chapter 2 has instead tackled the social consequences of this evolution, showing that it results in an increasing incidence and intensity of car-related transport disadvantage in its different forms.

It is surprising to observe that until very recently these two strands of research have run parallel courses. Indeed, most existing theoretical and research work focuses on either one of these concerns. This is puzzling given that there are arguably important theoretical and practical relationships between them. Notably:

- from a theoretical viewpoint, the first two chapters have shown that increasing concerns for the environmental and for the social consequences of transport are both motivated by the same process: the historical trend towards increasing car ownership and use
- from a policy perspective, the reviews of policy approaches for environmentally sustainable transport (§1.6) and of policy approaches to tackle transport disadvantage (§2.4) have shown that there is a latent tension between the two agendas (§2.4.7)

In a nutshell, then, the process of motorisation gives rise to both environmental and social concerns, that are deeply intertwined. At the same time, it creates a tension between the two. However, the corresponding research fields have remained mostly separate until now, and this is arguably a limitation of existing research. Indeed, even though studies in the transport and social exclusion research literature devote considerable attention to car deprivation and other forms of car-related transport disadvantage, they often fail to situate the issue within the broader process of increasing motorisation. Even when they do, pointing out that it results in diminishing accessibility for non-motorised households (see for example Clifton & Lucas, 2004, p. 15-16), they generally pay less attention to the resulting increased pressure to own a car that is put on them – and thus to the self-reinforcing dynamic of the process as a whole. Conversely, works focused on excessive car ownership and use generally neglect the significance of transport disadvantage in explaining the self-reinforcing nature of motorisation.

This thesis aims at reconciling these two strands of research literature. In doing so, it argues in favour of an integration of environmental and social concerns in the field of transport, while at the same time pointing at the potential tensions and trade-offs between them. This is accomplished in two ways:

- at the theoretical level, I argue that the notion of 'car dependence' is the best suited to take into account both the environmental and the social consequences of increasing motorisation. For this reason, in the next section (§3.1.2) I put forward an original working definition of car dependence, that is based on the literature review illustrated in the first chapter (§1.4), but also aims to integrate into this framework the issue of transport disadvantage
- at the empirical level, the research object of this thesis – the carless – is at the intersection of the two approaches. This will be illustrated in more detail below, in §3.2

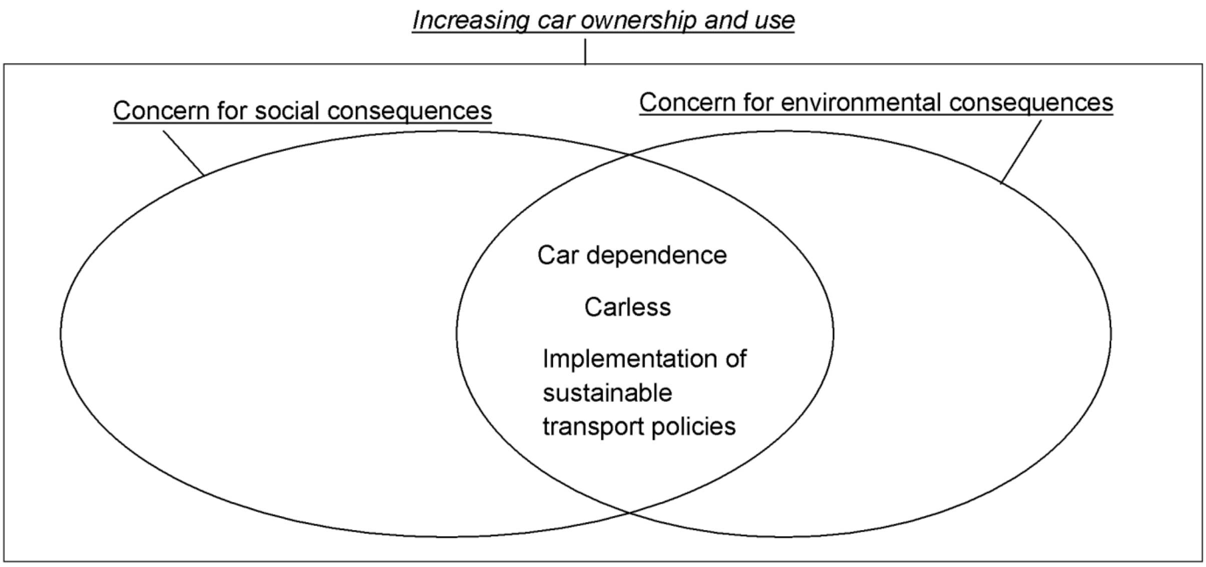

Fig. 3.1 – Research interests and concerns for the impacts of transport. Source: own elaboration.

Fig. 3.1 illustrates graphically how this thesis is situated with respect to existing fields of research. It shows that both the leading theoretical concept (car dependence) and the research object of this thesis (the carless) are best conceived as situated at the intersection of environmental and social concerns for the consequences of increasing car ownership and use. As argued above, there is a latent tension between these two concerns, as certain policy measures aimed at alleviating the environmental consequences of transport may worsen social inequalities in terms of access to services and opportunities, and vice-versa. This is problematic, since the notion of 'sustainable transport' includes both goals: an environmentally sustainable and socially just transport system. In that sense, the results of this study might be of interest for research on the implementation of sustainable transport policies, an area of study that is also located at the intersection of the two concerns, as depicted in Fig. 3.1.

3.1.2. Car dependence: the missing link

The leading concept in this thesis is that of 'car dependence'. Notably, I argue that a macro-social understanding of car dependence, as that illustrated in §1.4, is suitable to link two fields of research, allowing to make a connection between environmental and social concerns in the domain of transport.

If we take the notion of car dependence to be a state (rather than a process), we are compelled to acknowledge that it is relevant to both fields of research. Indeed, in contexts where the car is virtually a necessity, reductions in car ownership and use are hardest to achieve. On the other hand, all forms of car-related transport disadvantage are also at their peak. Finally, in car dependent contexts, environmentally sustainable transport policies are more likely to be met with opposition on the grounds of inequity, because the tension between social and environmental concerns is at its maximum. Accordingly, I argue that high levels of car dependence worsen both the social and environmental consequences of transport, and at the same time reduce the chances of reconciling the two.

Also if we take the notion of car dependence to be a process (rather than a state), we are led to recognize that there is a strong interconnection between the process bringing about increasing car ownership and use and that resulting in an intensification of car-related transport disadvantage. This has been illustrated, with reference to the spatial dimension of transport disadvantage, in §2.3.1, but it is worth reiterating here (Fig. 3.2).

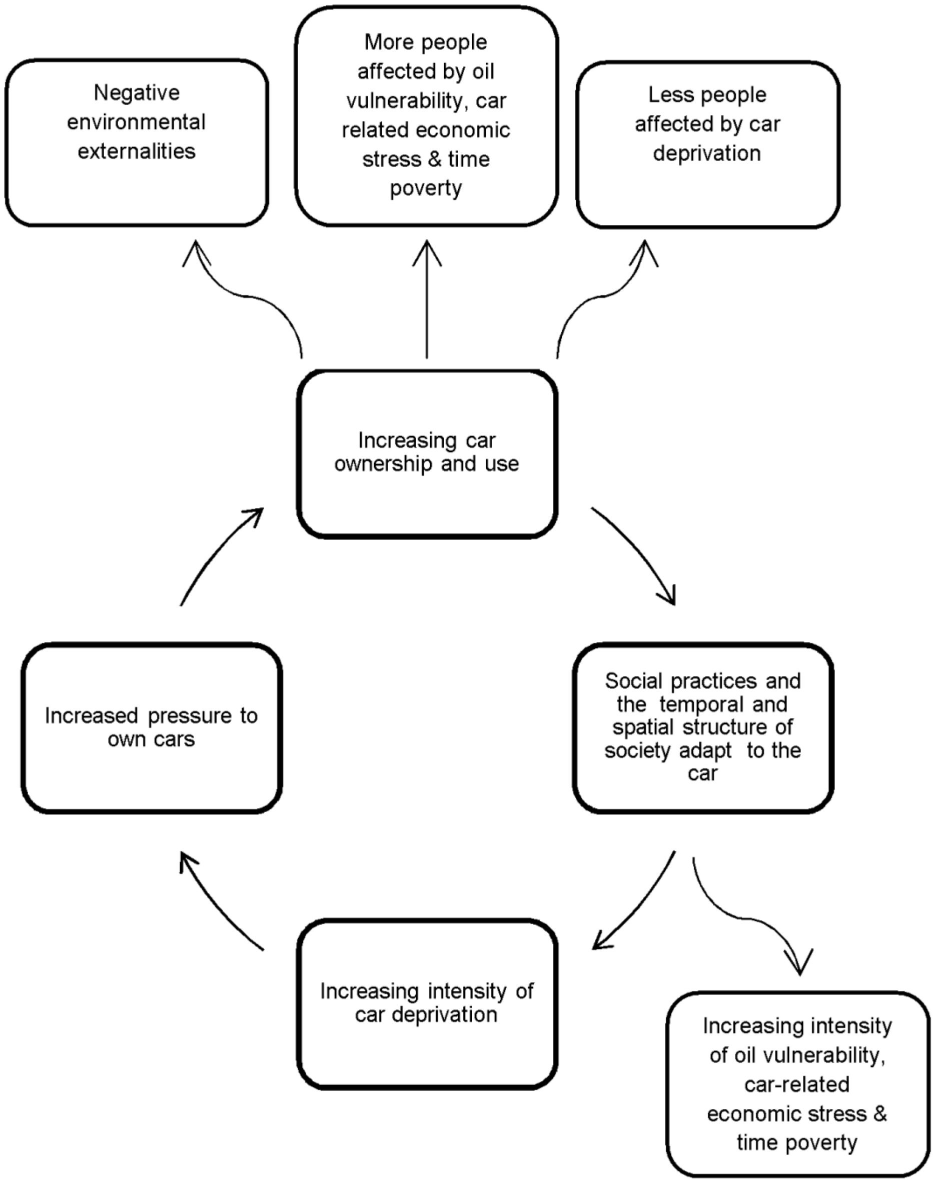

Fig. 3.2 – The cycle of car dependence and forms of car-related transport disadvantage. Source: own elaboration.

Fig. 3.2 illustrates the cycle of car dependence, stressing the consequences on the different forms of car-related transport disadvantage and the role they play in the self-reinforcing process. It shows how increasing car ownership and use results in an increasing need for automobility. This process has an important spatial dimension, as illustrated in §2.3.1: indeed, increasing motorisation encourages automobile oriented and dispersed land-use patterns and suburbanization, all of which make it difficult for modal alternatives to compete.

In the works of authors reviewed in §1.4, the spatial dimension of car dependence is regularly brought to the fore. This is especially apparent in Newman and Kenworthy's understanding of the process, as they stress how the diffusion of the automobile and the development of a whole new kind of settlement (what they call the "Auto City") are deeply intertwined (1999). Dennis and Urry's discussion of automobility (2009) is less focused on the spatial dimension of the car system, even if the authors explicitly recognize the relevance of the fragmentation effect of the car on space, that creates distances between places and activities that in turn require the car to be overcome. Dupuy's account of car dependence (1999a) may appear oblivious of this territorial dimension, focused as it is on showing the relevance of a 'club effect' that is fundamentally a-spatial in nature[42]. However, the inherently spatial concept of accessibility plays a crucial role in his model, as increases in motorisation are assumed to result in proportional improvements of accessibility for car users.However, it would be wrong to conclude that car dependence is exclusively a spatial phenomenon. As several authors have argued, there is an important temporal dimension to this process (Dennis & Urry, 2009; Shove, 2002; Farber & Páez, 2011a). In a nutshell, increasing car ownership and use result in a temporal organization of daily life that is increasingly flexible and desynchronized (Heine et al., 2001; Shove, 2002). This, in turn, tends to make the car an essential prerequisite to participation in daily activities. In that sense, increasing motorisation results in the restructuring of society, in the direction of temporal structures that tend to require car use for the access to services and opportunities. Finally, as argued in §1.4.1, one of the consequences of increasing motorisation is that a wide array of social practices (Shove et al., 2012) have come to depend on car availability, quite apart from the distribution in space and time of trip origins and destinations: in that sense, increasing motorisation is arguably associated with increasing levels of car dependence for the social practices of daily life.

All of these processes result in an increasing need for car ownership and use. As a direct consequence, the intensity of car deprivation (§2.2.1) is assumed to increase. In Dupuy's approach (1999a) the existence of a fundamental gap between the benefits of the automobile system for car users and the situation of non-car users is a crucial driver of the process of car dependence, as it creates an objective interest for outsiders to join the system; at the same time, this gap increases as new members join the "club", thus bringing about a positive feedback on the system itself. In that sense, the increasing intensity of car deprivation (a form of transport disadvantage) results in an increased pressure to own and drive cars, thus feedbacking into the first element of the cycle of Fig. 3.2. This in turn has all kinds of negative environmental consequences, thus illustrating the tight relationship between social and environmental concerns.

This conclusion needs two qualifications. First, it must be noted that car deprivation is the only form of car-related transport disadvantage that is part of the self-reinforcing process of car dependence. Indeed, as illustrated in Fig. 3.2 and argued extensively in §2.3.1, the restructuring of society around the car results in increasing intensity of car-related economic stress, oil vulnerability and car-related time poverty. At the same time, an increasing number of people is affected by these forms of transport disadvantage as car ownership and use increase. In that sense, this dynamic results in an aggravation of all forms of transport disadvantage. However, the worsening of car-related economic stress, oil vulnerability and car-related time poverty does not feedback into the system. This is a fundamental difference between car deprivation and other forms of car-related transport disadvantage. The second caveat is that increasing motorisation aggravates the transport disadvantage of the carless, but at the same time tends to reduce their number. In that sense, the dynamic of car dependence has an ambiguous effect on car deprivation, whereby it increases its intensity while at the same time reducing the number of people affected.

The mechanism illustrated in Fig. 3.2 can be summed up in a working definition of car dependence, that is spelled out in Box 1. This definition is meant to stress how the car dependence process entails a crucial social equity dimension. This definition provides the background for the specific research questions of this thesis.

[42] In fact, the notions of club and network effects have usually been applied to telecommunications (Dupuy, 1999a).

Box 1

Working definition of car dependence

Car dependence is a dynamic, path-dependent and self-reinforcing macro-social process, resulting in continually increasing levels of car ownership and use (in terms of distance covered), that strongly resists any deliberate attempt to induce change, despite increasing awareness of its negative externalities. It acts mainly through the restructuring of society, in the direction of spatial and temporal structures that tend to require car use for the access to services and opportunities. In this context car availability also becomes an essential prerequisite for an increasing number of social practices in daily life.

Accordingly, car dependence entails a fundamental equity dimension, because it tends to progressively worsen the transport disadvantage experienced by non-car users (car deprivation). This in turn is a crucial driver of its spiralling dynamic, as car deprivation results in an increased pressure to own and drive cars.

Therefore, car dependence as a macro-social process tends to create a situation where the car deprivation problems brought about by increasing car ownership and use tend to be solved with further increases in motorisation levels. In that sense, concerns for the social impacts of transport may potentially play a role in the self-reinforcing dynamic of car dependence.

To sum up then, the notion of car dependence allows the integration of concerns about the environmental and social consequences of transport in a single framework. This is an asset in that it counters the tendency of current research to separate these concerns. Moreover, it also provides a consistent framework to conceptualize why social and environmental concerns in the field of transport are sometimes at contrast with each other, while at other times they seem to be in accordance.

3.2 Research object

3.2.1 The carless

In this thesis, I focus on the carless, i.e. people who do not have access to cars. As argued in the previous section, this research object is situated at the intersection between social and environmental concerns in the field of transport. This is true in at least three respects.

Firstly, from an *analytical perspective*, car deprivation is the only form of car-related transport disadvantage that plays a crucial role in the self-reinforcing cycle of car dependence (Fig. 3.2). Accordingly, focusing on the carless allows to shed light on this process. As argued by Lucas & Le Vine:

> "one of the most effective and immediate ways in which to identify the benefits of transport in general and car ownership in particular, is to look (at) what happens when people in predominantly car-based societies do not have regular access to a private motor vehicle" (Lucas & Le Vine, 2009, p. 8-9)

Secondly, from a *policy perspective*, focusing on the carless highlights the latent tension between environmental and social goals in the field of transport. In that sense, the carless are not only at the intersection of several research interests – they also reveal a tension between two policy agendas: on one hand, there is a need to have more carless households, if the environmental externalities of transport are to be reduced; on the other hand however it appears that, in developed countries, carless living is often the consequence of economic deprivation and/or the cause of difficulties in accessing services and opportunities. Accordingly, promoting car ownership and use is sometimes put forward as a solution to car deprivation (§2.4.4). In a nutshell, while environmental concerns lead us to recognize that we need to have *more* carless, transport and social exclusion research suggests that we should have *less* carless. This contradiction is a feature of car deprivation, but it is arguably less relevant for other forms of car-related transport disadvantage. Since this tension may lead to a 'transport policy stalemate' (Mattioli, 2013), it is of great policy relevance.

Finally, in terms of *existing research*, the carless have been studied from both perspectives, even though to a different extent. Indeed, scholars concerned by the environmental consequences of transport have mostly focused on car users, often with the goal of understanding how to encourage behaviour change and modal shift. People without access to cars have received comparatively less research attention, probably reflecting the assumption that their behaviour is unproblematic and thus does not deserve to be studied in depth. An exception in this context is the research literature on car-free neighbourhoods (Glotz-Richter, 1995; Ornetzeder et al., 2008; Morris et al., 2009; Melia 2010; Melia et al., 2010; Ghent, 2012). Car free developments can be 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 et al., 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 et al., 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; Ghent, 2012).

As illustrated in Chapter 2, the way in which households without cars are discussed in research literature on transport and social exclusion could not be more diverse. In this context, it is noted that in industrialized 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 (§2.2.1). 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 sum, then, studies on environmentally 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. This stands in stark contrast with the vast and complex body of knowledge about the determinants of car ownership and use. In this context, it is sometimes pointed out that the ownership of a car might correspond to very different situations, in terms of socio-demographic conditions, economic resources and travel behaviour (Froud et al., 2005). The variety of attitudes and preferences that underpin car ownership and use has also been extensively studied (see for example Anable, 2005). By contrast, relatively little research has focused on those who live without a car, and even less has tried to explain the variety of living conditions of the carless (for an exception see Preisendörfer & Rinn, 2003, §4.2.2). In that sense, while scholars have recognised that "different worlds of motoring" exist (Froud, et al., 2005), much less is known about the different worlds of non-motoring.

By contrast, I argue in this thesis that there is a need to focus on the composition of the carless group as a whole, assuming that the lack of a household car may correspond to very different situations, depending on factors including (but not limited to) household's structure, economic status and type of residential area. The main goal of this thesis is precisely to shed light on the composition of the carless group by building typologies capable of accounting for this variety of situations. In doing that, I will pay special attention to the differences between different types of area, i.e. to the spatial dimension of car dependence.

3.2.2 Autolessness and the spatial dimension of car dependence

According to the working definition put forward in this chapter (§3.1.2), car dependence acts in three main ways: by restructuring the temporal organization of society; by 'recruiting participants' for car dependent social practices; and by restructuring the spatial structure of society. In the context of this thesis, the spatial dimension of car dependence will be the main focus.

	High density historic city centre	Low-density suburban area
Car dependence	Min.	Max.
Intensity of car deprivation	Min.	Max.
Size of carless group	Max.	Min.
Composition of carless group	?	?

Tab. 3.1 – Car dependence, intensity of car deprivation, size and composition of the carless group across different types of area in the European urban structure. Source: own elaboration.

In both chapter 1 and 2, this spatial dimension has been discussed in detail. Notably I have shown that, in the context of the literature on travel and built environment (§1.5) – even though scholars disagree on the details of the 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, especially if compared to compact, walkable inner cities (Ewing & Cervero, 2010). Scholars of transport and social exclusion, for their part, often argue that in low-density areas car access is perceived as a necessity, and this argument is supported by empirical studies relying on a diversity of methods, ranging from econometrics (Dargay, 2002) to focus groups (Smith et al., 2012). In a nutshell, then, adopting the terminology proposed in this thesis, there is a consensus in the literature that low-density peripheral urban and rural areas are characterised by the highest levels of car dependence; accordingly, the intensity of car deprivation is there at its peak, even though the size of the carless group is at its minimum (§2.3.4). At the opposite end of the continuum, compact and walkable inner city areas are characterised by the minimum level of car dependence and the lowest intensity of car deprivation. However, the number of people without access to cars is here at its maximum. All other types of areas are assumed to be located somewhere between these two poles, depending on factors such as (among others) population density, diversity of land-uses and location with respect to the urban hierarchy. Tab. 3.1 illustrates this (deliberately simplified) opposition, with reference to the European city-type (cfr. §2.3.4).

The last row in Tab. 3.1 points at a blind spot in the literature: while there is considerable evidence to demonstrate that less people are carless in low-density peripheral areas (as compared to compact inner cities), less is known about who these people are, i.e. about the composition of the carless group. An exception in this context is the suggestion by Clifton and Lucas that, with increasing pressure to own a car, car ownership becomes a social norm and this results in a concentration of lack of car access in disadvantaged groups (2004, p. 15-16). This is illustrated in Fig. 3.3, which adapts the 'cycle of car dependence' framework of Fig. 3.2 to include the consequences on the composition of the carless group.

Even though Clifton and Lucas do not develop the hypothesis further, it appears to be plausible. Indeed, as car access increasingly becomes a necessity, an increasing proportion of those who are able to own and use an automobile will get one. Accordingly, lack of car access will increasingly be concentrated among those who, for whatever reason (e.g. low income, disability, lack of driving licence, old age, etc.), face important barriers to car ownership and use. In other words, as car dependence increases, motorisation is expected to increase slower for marginal social groups.

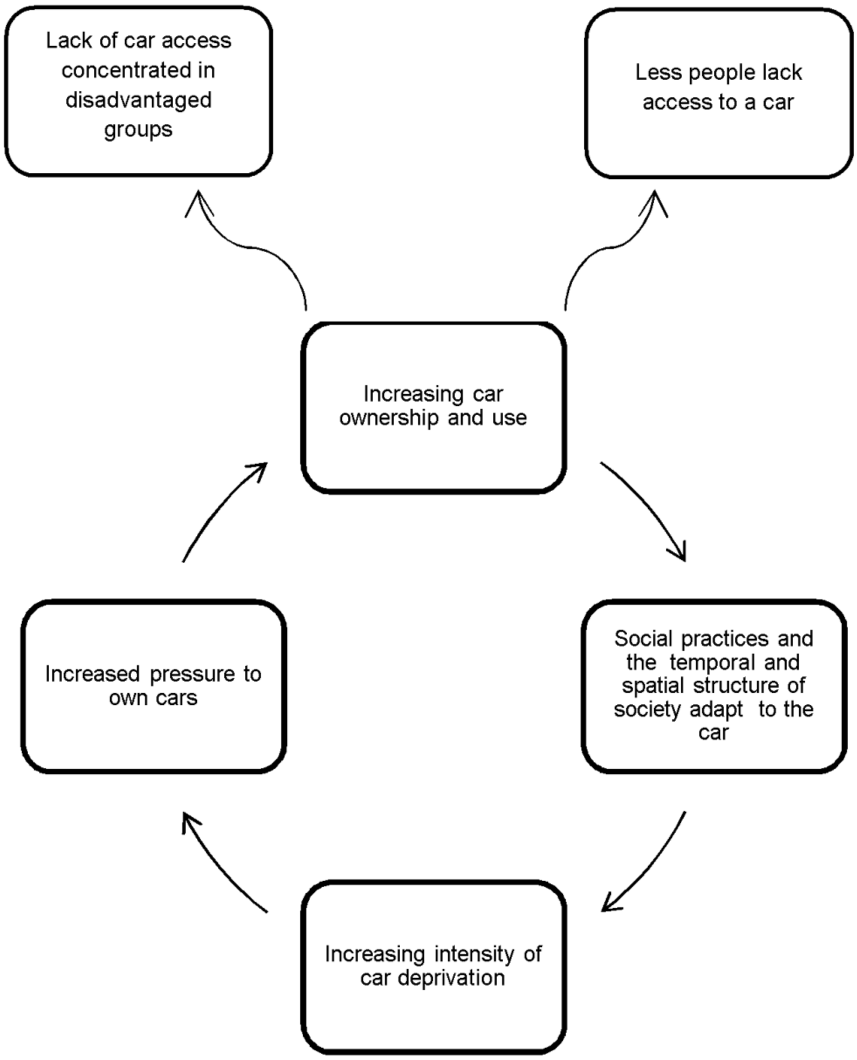

Fig. 3.3 - The cycle of car dependence and its effects on the size and composition of the carless group. Source: own elaboration, adapted and integrated from Clifton & Lucas (2004, p. 15-16).

Despite the simplicity of this hypothesis, there is a striking lack of research evidence on how the composition of the carless group changes across different types of areas. The goal of this thesis is to fill this gap, by demonstrating that the composition of the carless group varies systematically between different types of area, according to their degree of car dependence. In that sense, I put forward the hypothesis that the composition of the carless group is a good indicator for the level of car dependence in a local area. This is equivalent to say that, by looking at *who* lacks access to cars in a given area, we can infer to what extent car ownership and use are a necessity in that context. This hypothesis is developed further below (§3.3).

3.2.3 Households without cars

As argued above, the cycle of car dependence shows how environmental and social concerns about the consequences of transport are intimately connected in a single, self-reinforcing process. However, the focus in the two strands of research is slightly different. From an environmental perspective, the problem is excessive car *use*, in terms of distance covered. From a social equity perspective, the problem is rather lack of *access to cars*. The empirical work of this thesis is, however, focused on *households who do not own cars*, and this requires some explanation.

First of all, as noted in §2.2.1, from a transport and social exclusion perspective lack of access to a car is not the same as non-car ownership, even though of course there is a great degree of overlap: indeed, there are individuals in car-owning households who are excluded from car access, just like there are individuals in non-car owning households who are able to make use of a vehicle. In that sense, for example, a woman living in a car-owning household who often lacks access to the car (when she needs to) arguably experiences greater transport disadvantage than a young girl who does not own a car, but can borrow the vehicle of her parents (who live nearby) every time she needs to. Second, from an environmentally sustainable transport perspective, car ownership does not necessarily imply car use and vice-versa. So for example, the travel behaviour of a car-owning old man who drives only rarely is arguably less environmentally problematic than that of a young man who does not own a car, but uses car sharing for out-of-town leisure trips during the weekend.

Despite these limitations, I argue that focusing on households car ownership is the best research strategy for this thesis, for three reasons:

- from a transport and social exclusion perspective, I argue that lack of household car ownership is a good proxy for lack of car access. Indeed, descriptive statistics for both the German and the British case study (illustrated in §6.1.1 and §7.1.1 respectively) show that there is a big difference between the low levels of car availability for people living in non-car owning households and those reported by individuals living in households with at least one car (considerably higher). In that sense, even though *in theory* lack of household car ownership is not equivalent to lack of individual car availability, *in practice* there is a considerable degree of overlap
- from an environmental perspective, I argue that car ownership is a good proxy for car use. Indeed, as argued in §1.1.2, the research literature on car use has repeatedly shown that car ownership is a crucial determinant of modal choice and travel behaviour at the individual level (Simma & Axhausen, 2001; Scheiner, 2009a; Van Acker & Witlox, 2010). Indeed, to put it bluntly, existing research unequivocally shows that "once people own a car, they tend to use it more often" (Van Acker & Witlox, 2010, p. 73). More formally, as illustrated above (§1.5.4) car ownership can be defined as a "strong mediating element between socio-demographic conditions and the use of transport means" or even as "preliminary choice on the use of transport modes for longer trips" (Scheiner, 2009a, p. 178, own translation). Also this assumption is confirmed by descriptive statistics for both the German and the British case study (illustrated in in §6.1.1 and §7.1.1 respectively) showing that there is a big difference between the (low) levels of car use of people living in non-car owning households and the (relatively high) levels of car use reported by individuals living in households with at least one car. In that sense, even though *in theory* household car ownership is not equivalent to individual car use, *in practice* there is a considerable degree of overlap[43]
- finally, from a practical point of view – in the context of a comparative thesis focused on the secondary analysis of national travel survey data for different European countries (cfr.§3.4.1) – focusing on household car ownership allows me to simplify the data analysis and to exploit the full potential of the datasets. Focusing on alternative variables would limit the scope of the data analysis: for example, questions about car availability are not included in all national travel surveys and, when they are included, they are often formulated in different ways, thus making inter-survey comparison difficult. Moreover, defining the carless group on the basis of a question about car availability would mean establishing an arbitrary threshold under which the individual is considered as lacking car access. By contrast, household car ownership is always one of the key variables in national travel surveys, and it is generally defined in a rather similar way, and this makes inter-survey comparison easier. It also provides an unambiguous way to define the carless, as individuals living in households

[43] Another reason for the environmental relevance of car ownership is the environmental impact of the manufacturing of the vehicles: according to a study Castro et al. (2003), production accounts for up to 10% of the environmental impact of a car.

who do not own cars. Finally, such a definition allows me to use other variables that are related to household car ownership: for example, the latest wave of the German national travel survey (MiD 2008) includes a battery of items about the 'reasons for not owning a car'. Alternative definitions of the carless, such as that based on car availability, would not allow me to analyse these additional variables

In a nutshell then, in this thesis the operational definition of 'the carless' is 'individuals in households who do not own cars'. The underlying assumption here is that they tend to experience lack of access to cars more often, and to move by car less often, than individuals in households who own at least one vehicle. Of course, such a definition limits the scope of my analysis. Notably, since car ownership is a household attribute, this methodological choice obscures possible differences in access to vehicles *within* car owning households. In that sense, this thesis will inevitably overlook the extent of lack of car access for people living in motorised households, as well as the question of the allocation of vehicles in low car ownership households (Vandersmissen et al., 2004; Anggraini et al., 2008; Scheiner & Holz-Rau, 2012a; 2012b; Delbosc & Currie, 2012). This should be considered as a major blind spot of the approach adopted here. Notably, the likelihood to overlook gender gaps in car access is very high.

However, it must be acknowledge that, while this approach obscures possible differences in access to vehicles *within* households, 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. Accordingly, it allows me to identify individuals living in carless households who tend to use the car more often, whether as passengers or as drivers of borrowed or rental cars (e.g. through car sharing), thus partially addressing the question of the difference between car availability and ownership.

3.3 Specific research questions

3.3.1 Analytical approach

The empirical work for this thesis has been organized around two specific research questions, focused on carless households. Question 1 adopts a synchronic approach, focusing on how, in a given moment in time, the size and the composition of the carless group varies between different types of area (Question 1). By contrast, Question 2 adopts a diachronic approach, focusing on how the composition of the group of households without cars has changed over time.

In accordance with the tradition of the doctoral programme in Urban and Local European Studies (URBEUR) at the University of Milan-Bicocca, the empirical work focuses on two European case studies: Germany and Great Britain (see §3.4.2). For each research question, the analysis will be repeated for the two case studies: this is aimed at corroborating the empirical findings, rather than at comparison between the German and the British case[44]. Indeed, it is important to state that this research is not comparative in the strict sense of the word. This implies, for example, that while there are differences in the size and composition of the carless households group, these are not investigated in this thesis.

Finally, it must be noted that the numbering of the research questions indicates the ordering in terms of importance. Accordingly, Question 1 is undoubtedly the main research question of this thesis, as it is based on hypotheses derived from a substantial body of existing research, it will be tested using a variety of data analysis techniques and it is expected to produce findings that are relevant to the debates on sustainable transport, transport and social exclusion and car dependence. Therefore, most of Part III of this thesis is dedicated to the description of the empirical results related to question 1. By contrast, Question 2 is more explorative in nature: accordingly, I test two alternative hypotheses about the changing composition of the

[44] This replication is not trivial, nor an end in itself: as argued by Cohen et al. (2003, p.13) "no conclusions from a given set of data can be considered definitive: replication is essential to scientific progress".

carless group over time. Moreover, limitations in the data available only allow me to have a superficial look at trends over time, and data analysis techniques are limited to descriptive analysis.

In Part III of this thesis, research findings are presented in the following way: Chapter 6 presents the results for carless households in Germany, with reference to Question 1 and 2. Chapter 7 does the same for Great Britain. The two specific research questions are presented in more detail in the following sections (§3.3.2 – §3.3.3).

3.3.2 Question 1: composition of the carless group across different types of area

In §3.2.2 I have put forward the hypothesis that the composition of the carless group is a good indicator for the level of car dependence of a local area: accordingly, I expect households without cars to be more concentrated among disadvantaged groups in areas that are more car dependent. This idea underpins research Question 1.

This question moves from the assumption that there is a wide range of situations that cause people to live without cars. One of the aims of this thesis is precisely to shed light on the composition of the group of carless households, by building typologies capable of accounting for this variety of situations. Accordingly, the first and main specific research question of this thesis is:

> ***(Q1)*** *How does the composition of the carless households group vary in terms of*
>
> 1) *socio-demographics (including economic status)*
> 2) *reasons for not owning a car*
> 3) *travel behaviour*
> 4) *accessibility to services and opportunities*
>
> *across different types of area (in terms of position on the urban-rural continuum, population density, etc.)?*

Existing knowledge allows to formulate the following hypotheses:

> ***(H1.1)*** *first, I expect the group of households without cars in inner cities to be not only larger – but also more diverse in terms of socio-economic composition. By contrast, non-car ownership in peripheral and rural areas is likely to be rarer and more concentrated among marginal social groups*
>
> ***(H1.2)*** *second, I expect the same pattern with regard to the reasons for not owning a car: people who deliberately choose to live without cars are more likely to be found in compact cities, while in sparse areas I expect the carless to mention mainly constraints (e.g. age, disability, low income) when asked about the reasons for not owning a car*
>
> ***(H1.3)*** *third, the same applies to travel behaviour: while I expect non-car ownership in low-density, car dependent areas to correspond mostly to low levels of mobility, this relationship should be somewhat attenuated in dense urban areas*
>
> ***(H1.4)*** *finally, I expect many carless individuals in low-density, car dependent areas to suffer from a significant lack of accessibility to services and opportunities, as compared to members of car-owning households. By contrast, I expect the carless group in inner cities to be more diverse, including a substantial proportion of individuals who enjoy good access to essential services and opportunities*

It is important to clarify that with this question I *do not* aim to identify those carless households who are transport disadvantaged, distinguishing them from those who are not. Indeed, the data used are unsuitable to achieve this goal. Rather, in this thesis I build on the results of previous research suggesting that the car is much more essential for access to essential services and opportunities in sparsely populated areas than in compact inner cities. In this thesis, I am not trying to prove this proposition: rather, I take it as a starting point to formulate my research questions and hypothesis. Indeed, if this proposition is true, I would expect the composition of the group of households without cars to be different across different types of area, consistently with the patterns illustrated in the hypotheses above.

Therefore, corroborating these hypotheses would be consistent with – and would provide new evidence in support of – the thesis that the car is an essential tool for access and social inclusion in peripheral, low density areas, while it is less so in more densely populated and centrally located areas. The goal here is to contribute to the scholarly debate on car dependence, by showing that the composition of the carless group is a good indicator of the level of car dependence of a local area. This would cover a gap in the existing literature.

In addition, answering this research question would also contribute to the debate on environmentally sustainable transport: given the need to increase the number of households without cars there is a need to know who are the people who currently live without cars, as well as current trends in the composition of the group (§3.3.3). Finally, with regard to the debate on transport and social exclusion, focusing on the composition of the carless group provides a welcome antidote to the tendency to assume that lack of car ownership is *per se* conducive to transport-related social exclusion, insofar as it shows the variety of conditions associated with non-car ownership. In this context, even though I will not be able to unequivocally identify the 'disadvantaged' among the carless, the typology obtained might suggest hypotheses that might be tested in future studies based on ad-hoc surveys or adopting a qualitative approach.

Finally, it is important to reiterate that this research question does not adopt a comparative approach. However, the empirical work is going to be repeated for the two case studies: this is aimed at corroborating the empirical findings rather than at comparison between the German and the British case. Moreover, this repetition also fulfills another function: it allows all research hypotheses to be tested. Indeed, it will not be possible to explore all hypotheses in depth for both case study, because of limitations in the datasets (see §3.4.3). In that sense, analysing data from two case studies allows me to expand the range of research questions that I explore.

3.3.3 Question 2: changing composition of the carless group over time

The second research question is directly related to the first, but adopts a diachronic approach. The focus here is on how the composition of the carless group changes over time. In that sense, the question adresses the inherently dynamic nature of the process of car dependence.

> ***(Q2)*** *How does the composition of the carless households group change over time? Notably, how do the trends vary across different types of area?*

In this context, two hypotheses are put forward. The first is derived from the discussion of the notion of car dependence presented above, and states:

> ***(H2.1)*** *Over time, as car dependence increases, and the proportion of carless households in the population shrinks, the lack of a household car is expected to be increasingly concentrated among marginal social groups, especially in peripheral, low density areas.*

An alternative hypothesis is derived from the literature on long term trends in travel behaviour reviewed in §1.1: recent studies have observed that the historical trend towards increasing car ownership and use has slowed down in a number of developed countries (§1.1.4). This has led scholars to debate whether these countries have reached saturation (§1.3.3), or even a state of 'peak car' (Goodwin, 2012). A consequence of this development is that future trends in car ownership will be driven to a great extent by demographic trends (§1.1.5). Notably, two trends have been observed: increasing car ownership among older people, and decreasing car ownership among young adults, notably males (Kuhnimhof, Armoogum et al., 2012;

Kuhnimhof, Buehler et al., 2012). On the basis of this evidence, another hypothesis, alternative to H1.1, is put forward.

> ***(H2.2)*** *Over the last decade, as the decline in the proportion of carless households has virtually stopped, the composition of the carless group is expected to have changed, with an increasing proportion of younger adults offsetting a decrease in the proportion of older households.*

This research question, like the first, does not adopt a comparative approach. However, the empirical work will be carried out for both the German and the British case: the goal is to corroborate the empirical findings through replication, rather than a direct comparison between the two case studies.

3.4 Research strategy and methodological design

3.4.1 Secondary analysis of national travel survey data

To provide an answer to the research questions outlined in the previous section (§3.3), I argue that the best research strategy is quantitative secondary analysis of national travel survey data. This is justified in light of the fact that both questions focus on the composition of the carless group, and how this varies across space and over time. For this reason, it is necessary to use representative data collected across a variety of types of area and over a period of time that is sufficiently long to study the dynamical evolution of the group.

An alternative research strategy would be to conduct qualitative interviews with carless households in carefully selected areas. This may lead to discover motivations, experiences and strategies related to lack of car access, as well as the perceived accessibility to services and opportunities. However, it would not provide information about the composition of the carless group, given the small size and the lack of representativeness of samples in qualitative studies. Ad-hoc quantitative surveys may be better on the criterion of sample representativeness. However, they are expensive and difficult to organize in the context of a PhD thesis. Moreover, they are are generally limited in scope, and thus unlikely to cover a sufficient variety of types of area. Finally, this research strategy does not allow to provide an answer to questions about the changing size and composition of the carless group over time.

Therefore I argue that the only way to test the research questions is to use quantitative secondary analysis. Also, it is necessary to use suitable data sources that, ideally, should be consist of surveys:

- providing individual- and household-level data
- focused specifically on short distance, daily mobility, in order to provide data on all aspects of interest, notably:
    - car ownership
    - stated reasons for not owning a car
    - socio-demographic characteristics, notably economic status (e.g. income, etc.)
    - accessibility to services and opportunities
    - travel behaviour (best obtained with a travel diary)
- at least region-wide, in order to provide a sufficient variety of types of area to compare
- including a wide array of territorial variables (such as, for example an urban/rural typology, population density, etc.) in order to allow comparison between different types of area
- repeated in different waves, in order to allow the observation of the changing size and composition of the carless group over time
- conducted on a large sample size, in order to allow the analysis to focus on the carless household group: indeed, households without a car amount only to a minority of the population, and this reduces sample size considerably

There are only two kinds of survey that fulfill most of these criteria: national and local travel surveys. Indeed, according to Eurostat, national travel surveys focused on short distance passenger travel in Europe:

> "collect information from a sample of population contacted by phone or mail and asked to answer a certain number of questions focusing on their travelling behaviour during a fixed period prior to the moment when each respondent answers the mobility questions" (De La Fuente Layos, 2005, p. 1)

The main and original purpose of national travel surveys is to provide key indicators for transport planning and policy formulation and to feed transport models[45]. Broadly speaking, these surveys aim at capturing the travel behavior of the population in a given moment in time. For this reason, one of their primary goals is representativeness at the national level.

In order to obtain regionally representative data to feed local transport models local travel surveys, focused exclusively on selected urban areas, are conducted in a number of European countries (for example EMD, EDVM, EDGT and EGT in France, SrV in Germany and LTDS in the UK, see below). Besides, regional representativeness is sometimes achieved through regional add-ons to the national sample (as for example for MiD in Germany and ENTD in France).

As stated above, the assessment of relevant indicators (such as modal share, etc.) for planning purposes is generally the main goal of travel surveys. However, they often serve additional purposes (that may vary between surveys), and in recent years the range of issues tackled has broadened in order to satisfy new modeling requirements and to allow innovative research on the data (Endemann, 2010). This has happened in the context of a broader shift from an era when transport was considered as a separate domain of knowledge, dominated by engineering approaches to a new period (since the end of the 20th century) in which transport research is increasingly viewed as a interdisciplinary research field (Black & Nijkamp, 2002, p. xii), including social science approaches (van Geenhuizen et al., 2002, p. 4; Schöller, 2007). This thesis has to be put in the wider context of this shift to multidisciplinarity, as it uses travel survey data in an original way and addresses research questions derived from a theoretical discussion informed by social science concepts.

3.4.2 Case study selection

In accordance with the tradition of the URBEUR doctoral programme, this thesis focuses on two European case studies. In this context, an important case study selection criterion has been the availability of suitable data sources. In this section, travel surveys in three major European countries are judged against the criteria stated above (§3.4.1).

With regards to the availability of travel surveys, unfortunately in Italy there is a lack of available data on daily mobility, and the information that exists is often fragmented across different data sources (Tornaghi, 2008). In particular, there is no such thing as a public national travel survey: ISFORT, a private research centre on transport, conducts a three-monthly survey on daily mobility at the national level, but the data are not available to academic researchers and have several limitations. As a result, in Italy there is a considerable information deficit on daily mobility, notably at the metropolitan level (*ibidem*).

It is not necessarily so in other European countries: Germany, for example has developed a concept of national mobility surveys, composed of three complementary elements (Zumkeller, 2009; Schultz, 2008): a repeated cross sectional national travel survey with a large sample (Mobilität in Deutschland – MiD); an annual panel survey (German Mobility Panel – MOP) with smaller sample but the same core questionnaire as MiD, started in 1994; a panel survey with focus on long-distance travel (INVERMO). These three main surveys are then complemented by regional panels and by a survey focused on single cities and metropolitan areas (SrV – Mobilität in Städten). In the UK, the Department for Transport regularly conducts a National Travel Survey (NTS), described as:

[45] For example the German MiD feeds the Federal Transport Infrastructure Plan (BVWP) based on a transport model (Endemann, 2010, p. 10).

"a continuous survey designed to monitor long-term trends in personal travel in Great Britain (that) collects information on where, how, why and when people travel as well as factors which affect personal travel such as car availability, driving licence holding and access to key services" (DfT, N.d.).

A travel survey has also been conducted in the London area since 2006 (see below). Similarly in France a national travel survey is carried out approximately every decade and, in addition, an increasing number of local travel surveys (consistent with the national level both on definitions and collection methods) have been implemented in many urban areas since the mid-seventies (Gascon, 2006).

Given the lack of available data in Italy, this thesis does not compare an Italian and a foreign case study, as it is often the case for doctoral thesis in the URBEUR doctoral programme. Instead, the work will focus on two foreign case studies in Europe. In order to select the most suitable case studies, I have conducted a review of national and local travel surveys in Germany, France and the UK, evaluating them against the criteria set out in the previous section (§3.4.1). The goal here is to select two surveys in two different countries that satisfy the criteria and, at the same time, have a sufficient number of common features, in order to allow comparison. The results of this review are illustrated in Tab. 3.2. The surveys that have been considered are:

- *Mobilität in Deutschland* (MiD), the German national travel survey, conducted twice since 2002 (from 1976 to 1989 under a different research design, called KONTIV, and carried out in West Germany only)
- MOP, the German national mobility panel, based on a rotating sample and carried out on a yearly basis since 1994
- *Mobilität in Städten* (SrV), a cross-sectional survey on urban mobility, carried out every five years in a number of German urban areas, especially in Eastern Germany where it originated in 1976
- the *Enquête Nationale Transports et Déplacements* (ENTD), the French national travel survey, carried out for the first time in 2007/2008 but preceded by similar surveys from the 1960s to 1994
- EMD (*Enquête Ménages Déplacements*), the French survey on urban mobility, conducted in approximately 60 medium-sized cities and metropolitan areas since 1976
- EGT (*Enquête Globale de Transport*), similar to the EMD but carried out only in the Île-de-France region since 1976
- NTS, the British *National Travel Survey*, conducted since the 1970s in Great Britain (since 1988 on a continuous basis)
- The *London Travel Demand Survey* (LTDS), carried out in the British capital on a yearly basis since 2006

Tab. 3.2 shows clearly that in all countries national travel surveys cover a wider range of topics than local ones, and thus satisfy more criteria. Moreover, only national travel surveys cover rural areas, that offer an interesting context to explore the specific research questions of this thesis (cfr. §2.3.3). National travel surveys in all three countries include some territorial variables, allowing to characterize the areas were households live with regard to spatial and social structure; notably, the MiD 2008 database is especially exhaustive. Finally, the sample size of national travel surveys is generally larger. In a nutshell, then, the review illustrated in Tab. 3.2 indicates that national travel surveys are more suitable to answer the research questions of this thesis than local travel surveys.

This limits the choice to three national travel surveys: MiD, ENTD and NTS. The German national travel survey is an ideal choice, because of easy data availability, large sample size and the availability of all key variables listed in Tab. 3.2. The second case study selected is the British NTS, and this for the following reasons:

- easy data availability: academic researchers can download NTS data freely from the website of UK Data Archive. By contrast, in September 2011 the ENTD 2008 dataset had not yet been released to the public

- since 1988, NTS is carried out on a continuous basis (see §C.1). This is a major difference with other national travel surveys, such as MiD and ENTD, that are conducted irregularly. In the context of this thesis, using continuous survey data has two major advantages. Firstly, it allows me to better explore the changing size and composition of the carless group over time (Question 2). Secondly, it enables me to work with a larger sample size by pooling the data for several years. This, in turn, allows for more disaggregate analysis and more robust estimates than would be possible for individual years
- finally, the British NTS is the only national survey in Tab. 3.2 including a one-week travel diary instead of a one or two day travel diary (see §C.1). This is an asset since weekly travel behaviour is more likely to be representative of the average travel behaviour of the individual in question. This allows me to classify non-car owning individuals on the basis of travel behaviour, something that is not possible with one-day travel diary data

		Germany			France			UK	
Survey name		**MiD**	**SrV**	**MOP**	**ENTD**	**EMD**	**EGT**	**NTS**	**LTDS**
Available waves		2002, 2008	2008	1994-2009	2008		2002	1995-2010 (continuous survey)	2006-2009
Level		National	City	National	National	Urban area	Île-de-France	National (GB)	London
Survey design		Cross-sectional	Cross-sectional	Panel	Cross-sectional	Cross-sectional	Cross-sectional	Cross-sectional	Cross-sectional
Availability of key Variables[46]	*Income*	X	X	X	X		X	X	X
	Territorial variables	X		X	X			X	X
	Accessibility	X		X	X			X	?
	Reasons for not owning a car	X			X		?		?
	Travel diary	X	X	X	X	X	X	X[47]	X
Sample size (thousand households)		25	50,7[48]	1	11	>1[49]	10,5	9[50]	5-8

Tab. 3.2 – National and local travel surveys in Germany, France and UK: main features and availability of key variables. Source: own elaboration.

However, NTS data have one major shortcoming: a question about the reasons for not owning a car is

[46] For most surveys, the available variables change with every new wave. In Tab. 3.2, the availability of key variables refers to the last available wave.

[47] Unlike other surveys listed in Tab. 3.2, the British NTS includes a one-week travel diary, instead of a one or two-day travel diary, see §C.1.

[48] 50,748 households for the pooled sample of all cities participating to SrV 2008. The sample size for single urban areas varies from 1,000 to approximately 38,000 individuals (in Berlin).

[49] The sample size for EMD surveys is at least 1,000 households for each city/ metropolitan area.

[50] Since 2002, the annual sample size of the NTS is around 9,000 households. Previously, it was approximately 3,500 households, see §C.1.

missing from the survey for all waves over the period 1995-2010. This does not allow me to test hypothesis H1.2 for this case study. However, it is my argument here that the assets of the NTS (continuous survey, one-week travel diary) more than make up for this problem.

As illustrated in the previous section (§3.3) both research questions will be addressed for both countries. In this context, it is important to point out that, even if MiD and NTS have a sufficient number of features in common to allow me to explore the same research questions, this is not equivalent to say that they are comparable in the strict sense. Indeed, even if travel surveys have been conducted in many countries around the world for at least forty years, during that period no successful attempt has been made to standardize the process in terms of research design, sampling methods, etc.; in the European context, while Eurostat has successfully harmonised national time use surveys, a similar process for travel surveys is still ongoing (De La Fuente Layos, 2005). As a result, “there are presently no agreed standards for conducting comparable and reliable surveys at an EU level” and thus “the methodological differences between countries' surveys do not allow a full comparison of the results obtained” (p. 1-2). However, De La Fuente Layos argues that “despite the heterogeneity of the available data, it is nevertheless possible to make some analyses for those countries where data exist”, even if methodological differences between countries' surveys have to be borne in mind (*ibidem*).

In practice, this means that there are considerable differences between MiD and NTS in important features such as sampling design, variable definitions and the like. Given these differences, an analysis as similar as possible will be conducted on the two datasets, making the best out of the available variables. No comparative analysis in the strict sense of the word will be conducted.

Finally, the choice to focus the analysis on national (rather local) travel surveys has one major limitation: it does not allow me to provide spatially and contextual specific analysis. So for example, while I will illustrate differences in the composition of the carless group between different types of areas (such as between large cities and peripheral low density areas), I will not be able to illustrate differences between specific areas (such as, for example, York and Bristol). However, I will be able to discuss data at the city level for London, since the British capital is considered as a region in the administrative structure of the UK, and is thus identified as such in the travel survey.

In the next sections (§3.4.3 – §3.4.4) I Illustrate in more detail the research strategies, methods and data analysis techniques employed for every specific research question. The data analysis techniques are also illustrated in more detail in Appendix A.

3.4.3 Question 1

With reference to the first research question (varying composition of the carless group across different types of area), I have put forward four complementary hypotheses (§3.3.2). As argued above, given the differences between the datasets (§3.4.2) it will not be possible to explore all of them for all case studies. The resulting research strategy is illustrated in Tab. 3.3.

Since both surveys provide a wide range of socio-demographic variables (including household economic status indicators), I will be able to test H1.1 for both case studies. However, there is no variable to indicate the reasons for not owning a car in the British survey: therefore, this hypothesis (H1.2) will be tested only for the German case. Since both surveys include a travel diary, it will be possible to observe how the travel behaviour of carless individuals varies across different types of area (H1.3) in both case studies. However, the NTS questionnaire includes a one-week travel diary for all household members, while the German survey only a one-day diary. Therefore, I will explore this hypothesis more in depth for the British case – as illustrated in Tab. 3.3 with the double X. The opposite is true for the fourth hypothesis, focused on the composition of the carless group in terms of accessibility: indeed, the MiD questionnaire includes a battery of items about the accessibility to essential services with different means of transport. These variables allow to explore in more depth the differentials in accessibility between different groups and areas, as compared to those available in the British survey.

		Germany (MiD)	Great Britain (NTS)
H1.1	*socio-economic composition*	X	X
H1.2	*reasons for not owning cars*	X	
H1.3	*travel behaviour*	X	XX
H1.4	*accessibility to services and opportunities*	XX	X

Tab. 3.3 – Hypotheses related to Question 1 and case studies. Source: own elaboration.

In terms of methods, to answer Question 1 it is necessary to use various data analysis techniques. In this context, it is useful to distinguish four steps in the analysis of data, as illustrated in Tab. 3.4.

	Data analysis steps	**Data analysis techniques**
1	*Differences between car-owning and carless households (§6.1.1, §7.1.1)*	- descriptive analysis and significance tests - logistic regression (see §A.1)
2	*Socio-demographic composition of the carless households group across different types of area (§6.1.2, §7.1.2)*	- descriptive analysis and significance tests - odds ratios - logistic regression (see §A.1)
3	*Classification of carless households/individuals (§6.1.3, §7.1.3)*	- latent class analysis (MiD) (see §A.4) - cluster analysis (NTS) (see §A.3)
4	*Description of the typology of carless households/individuals (§6.1.3, §6.1.4, §7.1.3, §7.1.4)*	- descriptive analysis and significance tests - multinomial logistic regression (see §A.2)

Tab. 3.4 – Data analysis steps and data analysis techniques for research question 1. Source: own elaboration.

In a first analytical step (§6.1.1, §7.1.1), I will focus on the systematic differences between car-owning and non-car owning households. This preliminary step has two goals: first, it allows to interpret correctly the differences between different groups of carless households, that constitute the focus of subsequent steps. Second, it allows me to explore whether and how the determinants of non-car ownership vary across different types of area, thus adressing Question 1 from a different angle. In this context, I will present logistic regression models (outcome: non-car ownership) (see §A.1), as well as the results of descriptive analysis and significance tests.

In a second analytical step (§6.1.2, §7.1.2), I will focus on how the socio-demographic composition of the carless households group changes across different types of area, thus addressing H1.1. This is accomplished by discussing descriptive statistics, odds ratios and goodness-of-fit statistics for logistic regression models (see §A.1).

The third analytical step is the classification of the carless in different groups (§6.1.3, §7.1.3). The goal here is to propose a typology accounting for the variety of situations associated with non-car ownership. Because of differences in survey design, the classification will be based on different variables and units of analysis for the two case studies: notably, while German *households* without cars will be classified according to the stated reasons for not owning a car (set of categorical variables), British carless *individuals* will be clustered on the basis of their travel behaviour during the survey week (assessed with continuous variables). This difference explains why I use two different clustering techniques: latent class analysis (best-suited for categorical variables, see §A.4) for the German case, and cluster analysis (§A.3) for NTS.

The fourth and final step for this research question is to describe the typology obtained with respect to variables including socio-demographics, travel behaviour, accessibility to services and opportunities and the different types of area. In this context, I will mainly use descriptive analysis and significance tests. I will also use multinomial logistic regression (§A.2) to illustrate what is the simple way to describe the composition of the carless group and how it changes across different types of area.

3.4.4 Question 2

The second research question of this thesis is focused on how the composition of the carless group changes over time. The period under consideration will be slightly different for the two case studies. In the German case, cross-sectional data are available for the whole country only for the years 2002 and 2008: therefore, the analysis will focus on differences between these two waves of MiD. By contrast, the British NTS is a continuous survey, and data are available for every year since 1988 (see §C.1). However, several important features such as questionnaire design, sample size and weighting have been changed starting from 2002. For this reason, I will limit most of the analysis to the period 2002-2010 (the latest wave available as of spring 2012). However, as some geographical variables are not available for the years 2009 and 2010 (see §C.1.5), some analysis will be limited to the period 2002-2008. Finally, in order to identify longer term trends for key variables, I will occasionally analyse data from the 1995-2001 dataset (see §C.1.8).

In terms of methods, I will use descriptive analysis and significance tests and logistic regression models, in order to test the hypotheses with time-series data. However, it is important to point out that there are several limitations to this analytical approach, notably:

- with reference to the German case, the availability of only two waves makes the identification of trends difficult. Therefore, every conclusion drawn for the German case will be provisional, and should be considered as useful for the formulation of hypotheses for future research. In this context, however, trends observed for both case studies can be assessed with more certainty, given that the NTS dataset is more suitable for this analysis
- however, even in the case of a continuous survey such as the NTS, the data provider points out that the survey “is primarily designed to measure long-term trends in travel in Great Britain and is not suitable for monitoring short-term trends” (UK Data Archive, 2012, para. 1). Therefore, trends in the size and composition of the carless group identified for the period 2002-2010 will have to be interpreted with great care
- national travel surveys are continually adapted: accordingly, a myriad of details (such as question wording, answer categories, etc.) change in different waves (see §B.1, §C.1.7). This should be taken into account, and findings should be interpreted with care when such changes have been made

Given the limitations listed above, the findings related to Question 2 will have to be interpreted with caution, and should be considered as suggestive rather than conclusive evidence. However, the approach of this thesis (involving two national case studies) is arguably an advantage, as it allows the identification of trends common to both countries, that can be considered with more certainty.

PART II – COUNTRIES

4. Germany

In this chapter, I provide information about the first case study country: Germany. The chapter is structured as follows. In the first section (§4.1) I focus on land use and transport trends and policies. This provides the context for the empirical study focused on households without cars (§6) and for the conclusions that can be drawn from it. In the second section (§4.2), I focus on existing studies that have focused on car ownership (or lack thereof) in Germany. Finally (§4.3), I provide information about the data source used for the analysis, the German national travel survey. Further technical details about the survey are provided in Appendix B.

4.1. Spatial development and transport in Germany: trends and policies (overview)

In this section, I focus on spatial development and transport trends and policies in Germany. It is important to state that this is not meant to be an exhaustive review. It should be rather considered as a short overview, meant to provide the basic information necessary to contextualise the empirical results presented in chapter 6. The section is structured as follows: in the first sub-section (§4.1.1) I focus on spatial development, as this is strongly related to transport (as discussed in §1.5 and §2.3). In a subsequent section (§4.1.2), I focus on German transport policy more specifically. In these first two sections, the focus is on the consequences of spatial development and transport policies on environmental problems. Policies aimed at tackling transport-related social exclusion are the object of the last sub-section (§4.1.3).

4.1.1 Spatial development

From the outset, it must be noted that Germany as a whole is one of the most densely populated countries in Europe (230 in./km^2), preceded only by the Netherlands, Belgium and Great Britain. (BBR, 2005 , p. 15). Notably in the regions located along the so-called “European Blue-Banana” (Brunet, 1989), the country is characterised by a dense network of medium-sized towns.

With regard to trends, from the second half of the 20th century Germany, like other industrialised countries, has undergone a process of suburbanisation. As noted above (§1.5), this process is intertwined with changes in travel behaviour and increasing motorisation. Scholl and colleagues (2007) describe German post-war trends in spatial development as follows:

> “the demand pattern for housing has shifted to the single-family house on green fields, encouraged by the public incentives to building one’s own house. This growth in the form of urban sprawl and suburbanisation on green-fields on the outskirts of cities has led to more mobility and hence to more pressure on the road network. To keep pace with these developments, immense investments were devoted to transport networks. This trend extended to the East after the reunification in 1990 in a more intensive way. Although the population growth is stagnating or negative in many regions, the demand for more residential areas in some regions has not yet decreased because of the increasing living standards and the increase of small and single households that led to a continuous increase in average residential area per person” (Scholl et al., 2007, p. 49)

Similarly, Holz-Rau (2011) observes that “the regional development of the last decades can be described with the keywords de-densification, segregation and dispersion” (p. 125, own translation). These trends were similar in all states of the former West-German Republic (Schöller-Schwedes & Ruhrort, 2008, p. 241). As a result of this process, in most German urban regions in 2002 the majority of the population (approximately 60%) was living in the suburbs (BBR, 2005 , p. 193) rather than in the city-core. Therefore, population density in urbanised areas has declined (p. 61). Relocation in the suburbs has been more frequent among higher-income households, leading to an increase in socio-demographic differences between the suburbs and the city-cores (p. 195). These trends are also associated with worrying developments in terms of land consumption: in the last decades, land consumption for settlements and transport infrastructure has increased much more rapidly than the population (p. 54).

While this rapid process of suburbanisation has many determinants, rising income and changes in transport technology (motorisation) have allowed people to relocate further away from the city cores. Moreover, socio-demographic trends such as population ageing and household size reduction (both particularly pronounced in Germany) have certainly contributed to increasing land use consumption. For example, Wende et al. (2010) observe that:

> "particularly in the years since 1995, many detached houses have been built, although the housing stock in many regions, considered purely arithmetically, would have sufficed to provide even families with children with sufficiently large flats. However, that would have required motivating older people to move into smaller flats after the end of their family-raising years. In the course of the demographic change in Germany, there is the danger that additional single-family houses will be built in regions which are already stagnating today, while flats and detached houses which are today inhabited by older people might become vacant in large numbers within a few years" (Wende et al., 2010, p. 865)

Finally, the historical role of the public policies in encouraging suburbanization should not be overlooked. Nuissl and Rink (2005), for example, argue that:

> "there are many policy fields, and not only in Germany, where urban sprawl has traditionally been supported. (West) German national housing policy had always granted financial support for new owner-occupied property. Local and regional business development policy usually harbours powerful incentives for urban sprawl, too" (Nuissl & Rink, 2005, p. 126)

Similarly Hascher (2011) observes that:

> "policy encouraged the building of one's own house and long-distance commuting with various fiscal incentives, and this resulted in settlements where living without cars is hard to imagine. In this way the structure of a car-society was cemented, even beyond the intentions of housing policy-makers" (Hascher, 2011, p. 157, own translation)

In a nutshell, then, the development of car-oriented settlement patterns in Germany should be considered both as a voluntary and an inadvertent outcome of public policies in the fields of spatial development and housing.

Finally, this process can also be considered as a by-product of lack of coordination between different levels of government. As Scholl et al. (2007) observe:

> "almost each municipality has attempted to designate land for development purposes on green-fields, aiming at attracting new investors and, in turn, taxpayers. This situation has led, through the weakness of the legal regulations for inter-municipal coordination and planning, to an uncoordinated suburbanisation process" (Scholl et al., 2007, p. 50)

Compared to the suburbanization of residences, the decentralization of workplaces has been less pronounced (BBR, 2005 , p. 42-48). However, the trend towards an increasing dispersion of workplaces was apparent until at least the mid-1990s, and has been encouraged by the generous provision of transport infrastructure, notably motorways (*ibidem*). This has not led, as the 'decentralisation' hypothesis in the travel and the built environment literature would suggest (see Siedentop et al., 2005, p. 51-56) to a decrease of commuting distances (as a result of reduced distances between residences and workplaces): quite to the contrary, empirical studies show that this has led to an increase in long distance and tangential commuting trips, contributing in turn to the increase in travel distances (BBR, 2005, p.78-84; Guth et al., 2010; Holz-Rau, 2011, p. 131).

Spatial development in the East German states (former GDR) has followed a (partially) different path. Here, a rapid suburbanization trend has taken place only after reunification in 1990 (Herfert, 2002; 2007; Ott, 2001; Nuissl & Rink, 2005). There are two main determinants to this process (Nuissl & Rink, 2005): on one hand, change in social and economic conditions, whereby increasing income allowed urban residents to improve their housing condition, moving out of low-quality dwellings in inner cities (p. 126). On the other hand, however, Nuissl and Rinkl argue that "urban sprawl in eastern Germany is above all a reflection of (national) governmental policy" (p. 133) and of "specific legislative and political conditions" (p. 123) in the context of post-socialist transformation. Notably, they highlight how

> "in eastern Germany, the most effective incentives to sprawl (...) came from the programmes and fiscal instruments implemented by the federal government in order to stimulate the influx of capital. By awarding high subsidies without distinguishing between different locations, these programmes and instruments attracted several enterprises and companies to suburbia where building development was easiest" (Nuissl & Rink, 2005, p. 126)

According to Herfert (2002; 2007), in the context of the more general demographic shrinkage of eastern Germany since reunification, two phases should be distinguished. The first (during the 1990s) is characterised by "processes of relatively small-scale suburbanisation" (2002, p. 334). In a second phase (approximately from the turn of the century) "tendencies of regional polarisation, ranging from signs of reurbanisation to wider-scale deconcentration" (2007, p. 435) are observed. Notably, reurbanisation processes have been observed for larger cities like Leipzig (Kabisch et al., 2010), while strong suburbanisation is observed for Berlin (Herfert, 2007, p. 436). On average, population density in urbanised areas has declined more rapidly in East German states (as compared to their western counterparts) since reunification, partly as a result of demographic shrinkage (BBR, 2005 , p. 61).

Historical trends in spatial development have recently changed (at least in part) also in the rest of the country. Indeed, recent figures show that suburbanization trends are slowing down virtually everywhere, for both residences and workplaces (BBR, 2005 , p. 197-199; Guth et al., 2010). Also the pace of land consumption seems to be slowing down since the mid-1990s (BBR, 2005 , p. 53).

Recognition of the negative environmental impacts of these trends in spatial development, and notably of the strong relationship between suburbanization and increasing car ownership and use, have led scholars and policy makers to consider how to steer spatial development in a more sustainable direction. Notably, since the approval of a new federal law on spatial planning in 1998, "the supreme declared goal of spatial planning in Germany is creating the preconditions for sustainable development in the whole territory of the Federal Republic by bringing ecological considerations into line with the social and economic demands on land" (Scholl et al., 2007, p. 20). The Strategy of the Federal Government for Sustainable Development (Bundesregierung, 2002), for example sets an ambitious target for the reduction of land consumption to 30 hectares per day. If applied, this would mean a drastic limitation of further suburbanisation (BBR, 2005 , p. 199).

In this context two main 'leading paradigms' (*Leitbilder*) have been discussed (Siedentop, et al., 2005; Stein & Wolf, 2006). Firstly, the 'compact city' paradigm has dominated discussions on spatial development internationally, at least since the 1990s (Siedentop et al., 2005). In Germany this is frequently referred to as the 'short-trips city' paradigm (*Stadt der kurzen Wege*) (Gertz, 1998; Zeitler, 2007), whereby:

> "inhabitants should be encouraged to reduce travel distances by implementing higher building densities, mixed land use and high quality dwellings at the neighbourhood level. The goal is to achieve higher levels of active travel and public transport use" (Stein & Wolf, 2006, p. 173, own translation)

In a nutshell, the leading paradigm of the 'compact city' envisages nothing less than "the reversal of trends towards more disperse settlement patterns" (Siedentop, et al., 2005, p. 34, own translation). This is to be achieved gradually, by prioritising inner-city redevelopment on brown-field sites to green-field developments on the outskirts of urban areas (p. 35). However, as noted by Siedentop et al. (*ibidem*), the paradigm has little to say about what happens to existing suburban areas.

By contrast, the second leading paradigm, named “decentralised concentration” (*dezentrale Konzentration*) (Priebs, 2010; Siedentop, et al., 2005, p. 42-50), aims to “develop suburban centres at the regional level as a complement to the city-core. The goal is to reduce distances in the region, and to concentrate travel flows, in order to preserve the chances of an attractive public transport service” (Stein & Wolf, 2006, p. 173, own translation). In a nutshell, this leading paradigm aims to achieve a higher concentration of development outside the city-core in a few compact, ‘suburban nodes’ that are well-served by public transport, thus providing an alternative to car ownership and use. Moreover, these centres should be mixed-use and have a significant supply of jobs, in order to minimise the need to travel (Siedentop, et al., 2005, p. 45). In that sense as Siedentop et al. argue, ‘decentralised concentration’ should be considered as a “realistic compromise between a city-oriented densification policy and a merely market-driven decentralisation trend” (Siedentop, et al., 2005, p. 43, own translation), that moves from the premise that a general trend towards suburbanisation is inevitable (p. 42).

As Siedentop et al. argue (2005, p. 43), while the leading paradigm of ‘decentralised concentration’ is less popular in transport research than the ‘compact city’ paradigm, Germany is, with Austria and the Netherlands, one of the countries where this paradigm has been the most influential on policy. Indeed, in their report on spatial planning in Germany, Scholl and colleagues argue that “decentralized concentration is *the* spatial strategy that guides spatial planning in Germany” (2007, p. 14, emphasis added).

Quite apart from the discussion on the leading paradigms of German spatial planning, a number of ‘car-free’ developments (see §3.2.1) have been promoted in Germany since the 1990s. According to the overview of car-free housing in Europe conducted by Morris et al. (2009), “as of 2004, Germany had ten significant purpose-built car-free residential areas and another nine approved” (p. 22). These included the pioneering development of Bremen (Glotz-Richter, 1995) and neighbourhoods in Halle (Reutter, 2002), Freiburg (Nobis, 2004), Hamburg (Wagner, 2004), Cologne (Herbertz, 2004) and Berlin (Morris et al., 2009, p.21). Despite many local initiatives, to the knowledge of this author there is no policy guidance at the federal level concerning car-free developments. In fact, as accounted by Morris et al. (2009) in Germany “each car-free scheme must be justified as a novel proposal and authorised as a deviation from conventional parking standards or zoning ordnances” (p. 20).

More generally speaking, in the context of this thesis, it is important to stress that both leading paradigms of German spatial planning (‘compact city’ and ‘dencentralised concentration’) are more or less explicitly aimed at reducing motorisation in new or re-developed areas. As Holz-Rau and Scheiner (2005) argue:

> “according to existing knowledge, the positive effects of integrated spatial planning on transport are quite visible. *In this context, households without cars play a fundamental role*. The key is to develop locations that allow for most households a comfortable life with less or even without a car; indeed, once a car is purchased, it is only rarely disposed of (..), and the high fixed costs of motoring reduce the use of alternatives” (Holz-Rau & Scheiner, 2005, p. 72, own translation, emphasis added)

Moreover, both paradigms move from the premise that it is necessary to increase the coordination between spatial and transport policy and planning: as argued by Schöller-Schwedes (2010), this is one the three dimensions of the ‘integrated transport policy’ strategy in Germany (see §4.1.2 below). Notably this was the motivation behind the unification of the Ministry of Transport with the Ministry of Spatial Planning in 1998 (Schwedes, 2011b, p. 29). However, as Schwedes argues, the integration has been merely formal, as the two previous ministries have separate structures in the new integrated ministry (*ibidem*). The same problems of separated organisation of spatial and transport policies have been observed at the municipal level (Bracher, 2011).

More broadly speaking, several authors have stressed the limitations of strategies pursuing the integration of spatial planning and transport policy, such as the two leading paradigms cited above. According to Siedentop et al. (2005), criticism has focused on the growing gap between the leading paradigms of sustainable spatial planning and the real developments (further suburbanisation, etc.) (2005, p. vii). As Scheiner (2009a) argues, there is:

> “a certain disillusion in transport research and practice about the outcomes of integrated, sustainable transport planning. (..) Attempts to steer transport development have shown only limited success: car use continued to grow unperturbed and has stagnated since around 2000 mostly for economic and demographic reasons, and not as a result of integrated transport planning. Also the tireless warnings of researchers and planners about the negative consequences of dispersed low-density development seemed to fall on deaf ears. Quite to the contrary, during the 1990s suburbanisation experienced a new advance. Even where complex ‘new urbanism’ pilot-projects were implemented, the positive effects on transport failed to appear. The incoming population groups do not work in the area, in spite of the good job provision, and do not give up the car. In fact, they consist for the most part of households who were living without a car before moving to the area. Therefore, the results in terms of modal shift and traffic reduction are very limited” (Scheiner, 2009a, p. 17, own translation)

In a nutshell, as Stein and Wolf argue, “despite the high relevance of integrated land-use and transportation planning, its success in reducing traffic growth remains limited” (2006, p. 172, own translation).

Interestingly however, while studies focused on Germany often reach pessimistic conclusions about the effectiveness of national integrated spatial planning strategies, *comparative* studies often present Germany as a role model in the international context. So for example Kesteloot (2005), in a review of socio-spatial configurations in European cities, observes that, compared to other European countries:

> “in the Netherlands and Germany suburbanization has been contained, and urban environments adapted to the needs of a growing middle class were created, even if many of these inhabitants would have preferred a suburban way of life. In Germany this happened through the post-war reconstruction programs” (Kesteloot, 2005, p. 128)

Similarly Buehler et al. (2009), in a report titled “Making transportation sustainable: insights from Germany” argue that:

> “the packaging of self-reinforcing land use and transportation policies is perhaps the most important lesson that Germany can offer the United States. *Transportation policies in Germany have been effective in promoting a sustainable transportation system precisely because they are integrated with land use policies aimed at discouraging car-dependent sprawl*. In Germany, federal, state, and local governments participate in a top-down and bottom-up interactive planning process. At all levels of government, land-use planning is formally connected to transportation and other areas of planning” (Buehler et al., 2009, p.28, emphasis added)

This apparent contradiction might be explained as follows: when comparing trends in transport and spatial development with the *goals* of an environmentally sustainable transport system, the German situation is clearly negative. However, when comparing (in a synchronic perspective) the German situation with that of other comparable countries, it can be argued that German policies have had a moderate success in limiting the development of car-dependent suburban areas.

4.1.2 Transport policy and planning

For decades after the Second World War, transport policy and planning in Germany have encouraged increasing levels of car ownership and use. As Becker puts it: “if the goal of transport policy would have been increasing people’s travel distances, then such policy should be described as a success” (2011, p. 78, own translation). This development is consistent with that of other industrialised countries in the second half of the 20th century (see §5.1.2). It is important to stress that, despite ideological differences, East and West Germany followed very similar paths in this respect (Kuhm, 1997; Schmucki, 2003; Hascher, 2011). Post-war German transport policy and planning aimed at accommodating increasing car ownership and use (assumed as inevitable); notably, the provision of new road and parking facilities was identified as the solution to the side-effects of increasing motorisation (traffic accidents, congestion) (Kuhm, 1997). As Kuhm argues (1997, p. 106), in this period transport policy was 'depoliticized' and seen as a merely technical task. At least in West Germany, this led to larger road building programmes, as compared to other West European countries, partly as result of a particularly powerful road lobby (Banister, 2002, pp. 169-170).

With reference to urban transport planning in Germany, Schmucki (2003) identifies four distinct phases (p. 153-164): firstly, in the 'car friendly city' (1945-1955), in the context of post-war reconstruction, it was put forward that the solution to urban traffic problems was the separation of different types of traffic; in a second phase ('the automobile friendly city', 1955-1971), this leading paradigm was put into practice, and this resulted in a strongly car-oriented transport planning, with the goal to "move as many automobiles as possible through cities" (p. 159). This also resulted in a push to suburbanization "because it improved connections to suburbia and made life in the city centre unattractive" (p. 169). In the 1970s (third phase: 'city friendly traffic'), the leading paradigm of 'cities as traffic machines' was increasingly put into question as "no longer was the city supposed to be amenable to traffic, but rather traffic was now to be made amenable to the cities" (p. 160). While this did not change the practice of transport planning immediately, it laid the premises for the subsequent phase ('the human-friendly city', 1980-present), when for the first time transport planning set the goal to "reduce the dominance of cars in traffic" (p. 160): this led to the improvement of conditions for alternative modes of transport.

The 1970s stand out as a first turning point for transport policy and planning in Germany. As Holz-Rau puts it, in this decade "the consensus about infrastructure development was broken beyond retrieval", although the planning of transport infrastructure at the federal and state level essentially kept following the principles of 'predict and provide'" (2011, p. 115, own translation). The reasons for this change were essentially the energy crises and the rise of environmental movements, as well as the growing side-effects of car-oriented planning. While transport policy and planning did not change radically during the 1970s, Banister (2002, pp. 169-175) identifies two developments that were initiated in that decade: the implementation of pioneering 'traffic-calming' plans within cities, including pedestrianization of city centres; and an increase in public transport expenditure (notably rapid rail systems, subways and tramways) financed at least partially by an increased petrol tax. In Munich, for example, the first measures aimed at restraining car use and expanding public transport service were implemented in the years preceding the 1972 Olympics (Preisendörfer & Rinn, 2003, p. 86). Pucher and Buehler (2008) also trace the origins of the first efforts to improve cycling conditions in Germany to the 1970s (see below).

The 1970s are also the decade when the idea of an *integrated transport policy* was first put forward (Schwedes, 2011a). As Schwedes illustrates:

> "in 1973, the social-liberal coalition government initiated a change of paradigm with its *Kursbuch für Verkehrspolitik* (Instructions for a Transport Policy). It questioned the simplistic application of the principles of market economy for all sectors of transport. Instead, it saw the necessity "to solve the growing conflict between fulfilling social needs on the one hand and satisfying private interests on the other" (Schwedes, 2011a, p. 9)

In a nutshell, this paradigm change was aimed at limiting the expansion of car use, that had happened at the expense of rail-based public transport (Schwedes, 2011b, p. 26). The idea was essentially to limit the 'competition' between different transport means (Schöller-Schwedes, 2010), and this was also the goal behind a reform in the organizational structure of the Ministry of Transport (Schöller, 2006, p. 33-34).

It is only in the 1990s, however, that the paradigm of 'integrated transport policy' became the leading paradigm of transport policy in Germany (Schöller-Schwedes, 2010). This time, the rise of the concept was influenced by the new focus on 'sustainable development' brought about by environmental discussions conducted internationally in the 1980s (Schwedes, 2011a, p. 14). While integrated transport policy strategies were put forward in Germany as early as 1992 (Schwedes, 2011a, p. 14), the turning point is 1998, when a red-green coalition was elected in Berlin (Schöller, 2006, p. 34). The policy change at the Federal level was also reflected at the State level, with the Länder increasing public transport expenditure since the early 1990s (Schöller-Schwedes & Ruhrort, 2008). As observed by Schwedes (2011a, p. 14), this mirrors what happened in other European countries (such as the UK with the “White Paper for Transport”, see §5.1.2) and at the EU level, where ‘integrated transport policy’ became a new keyword.

As argued by Schöller-Schwedes (2010), there are three dimensions of integrated transport policy in Germany (p. 85): first, a technical integration between different sectors of transport; second, a political integration between transport policy and other policy fields that are influenced and/or influence transport, such as spatial development (see §4.1.1 above) and environmental policy. Finally, a social integration between different social interests, that should be invited to participate to the process of policy-making (Schöller-Schwedes, 2010, p. 85). In policy documents such as the ‘Transport Report 2000’ (BMVBW, 2000), the concept of integrated transport policy is also linked with the notion of ‘sustainable development’, including an economic, a social and environmental dimension.

According to Schöller-Schwedes, the ‘integrated transport policy’ framework should be considered as an ‘hegemonic discourse’ (2010, p. 85): while different actors agree on the general idea of an integrated transport policy, this is sufficiently vague to allow the co-existence of profound disagreements and ‘hidden agendas’ (Schwedes, 2011a; 2011b). Based on an empirical study on the configuration of actors in the field of transport policy in Germany, Schwedes (2011a) observes that three different understandings of integration can be distinguished “which basically relate to the three pillars of the sustainability concept: an economic, social and ecological integration“ (p. 18). Moreover, the analysis of the field reveals “a power imbalance in favor of the economic integration strategy, corresponding with a missing public resonance of the social and ecologic dimension” (p. 28). This in turn explains why policy documents such as the ‘Transport Report 2000’ (BMVBW, 2000) and the ‘Federal Transport Plan 2003’ (BMVBW, 2003) strongly emphasise the link between transport and economic growth, much to the detriment of the social and environmental dimensions (Schöller, 2006). Accordingly, these policy strategies do not envisage a significant transfer of public expenditure from the car to rail-based public transport (*ibidem*). For these reasons, Schöller-Schwedes (2010) argues that, in Germany:

> “the current transport policy develops along quite conservative lines, orientated towards the individual transport sector’s efforts of optimisation that are inherent in the existing system. At present, one can hardly speak of a sustainable transport policy in the sense of an equal consideration of economic, ecological and social aspects. Reflections in transport policy continue to be dominated by criteria of economic efficiency, and environmental and sociopolitical measures are only a by-product” (Schöller-Schwedes, 2010, p. 85)

This leads to a situation characterized by “an extraordinary discrepancy between programmatic goals and real transport development” (Schwedes, 2011a, p. 7). This is apparent also for public transport. As argued by Dziekan (2011):

> “if one looks at European and German lip services to sustainable transport policy, it should ideally be as following: there is a large and attractive public transport provision in metropolitan as well as in rural areas. Service is cheap, easily accessibile for all and can satisfy most mobility needs. Virtually everybody uses some form of public transport. The reality, however, is that the modal share of public transport is on average 9% (…) and for most of the population public transport is not the first mobility option of choice (Dziekan, 2011, p. 330-331, own translation)

Levels of public transport service are obviously different across different types of area in Germany. According to the synthetic scheme put forward by Dziekan (2011, p. 328), cities over 1 million inhabitant typically have a subway network, several ‘suburban train’ lines (*S-Bahn*) and a regional railway system, as well as tramways and buses. Cities from 500.000 to 1 million inhabitants typically have mixed tramway – subway system (with tramway lines going underground in the city centre), as well as extensive bus and regional train networks. The public transport network of middle-sized towns (50.000-500.000 inhabitants) typically consists of tramways and buses, as well as regional trains. The inhabitants of smaller towns typically rely on buses and/or on forms of flexible public transport (Dziekan, 2011, p. 328). As this short summary indicates, the provision of rail-based public transport is quite extensive in German towns: indeed, as Rye (2008, p. 216) shows, Germany is the western European country that realised most new rail-based infrastructure between 2000 and 2006.

Public subsidies to local public transport are the rule in Germany (Dziekan, 2011, p. 320-324), although they amount to just 26% of operating costs (Buehler et al., 2009, p. 18). As illustrated by Dziekan (2011), local public transport functions according to the orderer-provider principle (*Besteller-Ersteller-Prinzip*): this means that orderers (local authorities) make political decisions about the quantity and quality of public transport service; the task to implement these “local transport plans” is then assigned to public and/or private firms, acting as providers (Dziekan, 2011, p. 320-323). Therefore, local public transport in Germany is under public sector control, unlike what happens for example in the UK[51] (see §5.1.2).

In metropolitan areas, ‘Transport Associations’ (*Verkehrsverbund*) have been developed since the 1960s (Pucher & Kurth, 1996). According to Pucher and Kurt, “the *Verkehrsberbund* system of public transport organization appears to be an ideal solution to the problem of providing an integrated regional public transport service for the increasingly suburbanized metropolitan areas” (1996, p. 279-280). Indeed, the extension of metropolitan areas across institutional borders can make public transport use difficult, when different public transport operactors co-exist (Bracher, 2011, p. 283). As illustrated by Pucher and Kurt (1996), German transport associations provided a solution to these problems by: coordinating the different actors involved; integrating fare structure, ticketing system and route network across the metropolitan area; integrating timetables between lines and different public transport modes (in order to facilitate transfers); expanding service and improving service quality; introducing flexible public transport services in low-density areas; offering discounted monthly and yearly tickets. The authors conclude that ‘transport associations’:

> “have succeeded in providing truly regional public transport services. The more extensive, higher-quality and better integrated services they offer have significantly increased ridership above pre-Verbund levels, and the modal-split share of public transport has either grown or stabilized in most of the Verbund regions, in sharp contrast to the plummeting modal splits of public transport in some other countries” (Pucher & Buehler, 2008, p. 290)

German *Verkehrsverbunde* often integrate very large areas in a unified public transport system, such as in the case of the Rhein-Ruhr and the Berlin-Brandenburg region (Bracher, 2011, p. 283).

International comparative studies often present Germany, with other northern European countries, as a role model for cycling. Pucher and Buehler (2008), for example, refer to Germany, the Netherlands and Denmark as countries that have made cycling “irresistible” as a “safe, convenient and practical way to get around their cities” (p. 495). According to the authors, this is the result of a “massive reversal in transport and urban planning policies in the mid-1970s” that has stopped (and even partly reversed) the decline in cycling levels (p. 496). In detail, Pucher and Buehler attribute this result to the coordinated implementation of the following measures (p. 510-520): the provision of safe and convenient separate facilities (bike paths and lanes); traffic calming measures such as speed limits in residential streets (30 km/hr), restrictions to car traffic in city centres and ‘bycicle streets’; intersection modifications aimed at facilitating safe cyclist crossings; extensive provision of bike parking facilities, especially at train stations; integration with public transport; the training of children in safe and effective cycling techniques; traffic laws that give special consideration to cyclists; programmes to “stimulate interest and enthusiasm for cycling by all groups” (p. 520). Importantly, many of these measures also had the effect to encourage walking (Pucher & Dijkstra, 2003).

However, it is important to observe that, despite these policy efforts, national travel survey data do not show a trend reversal in active travel. In fact, as illustrated by Deffner (2011, p. 364), cycling accounts for approximately 10% of trips since 1976, and the modal share of walking has stabilised at 20-25% only in the mid-1990s, after decades of steady decline. A small increase for active travel modes is observed only in the first decade of the 21th century.

[51] Indeed, while the British model of ‘quantity deregulation’ or ‘market initiated competition’ (see §5.1.2), was adopted by other countries such as New Zealand, many developed countries have opted the model of ‘authority initiated competition’ through ‘competitive tendering’ (van de Velde & Wallis, 2013). This is the case for Germany, where competitive tendering of local public transport bus services was introduced gradually since the mid-1990s, with the number of tenders increasing only in recent years (Beck, 2011).

In conclusion, this short overview of transport policy and planning in Germany confirms the conclusion put forward for spatial development (§4.1.1). When comparing current transport policies with the *goals* of an environmentally sustainable transport system, the German situation is clearly negative (Schwedes, 2011a). However, when comparing (in a synchronic perspective) the German situation with that of other comparable countries, it can be argued that developments in transport policy that have taken place since the 1970s (such as the diffusion of 'transport associations' and pro-cycling measures) have had a moderate success in limiting the decline of modal alternatives to the car, particularly in urban areas. Banister sums up the particular features of German transport policy and planning as follows:

> "the Germans seem to have been more active than the British in building new roads around and between cities, in substantial investment and subsidy in public transport, and by calming traffic in city centres and residential areas. Rigurous change has been implemented simultaneously on these three fronts, whilst in Britain and France a more cautious approach has been adopted" (Banister, 2002, p. 174)

4.1.3 Transport and social exclusion

As discussed in §2.1.2, the issue of transport and social exclusion has not attracted the same attention in Germany, as compared to other countries such as the UK. This is true for research, but also for policy. Indeed, Kemming and Borbach (2003), in an early review of transport and social exclusion in Germany acknowledged that "social exclusion connected with the field of transport is not a topic at all" in the national debate (p. 26). In the last ten years, not much has changed: Scheiner (2009a), for example, after empirically demonstrating that economic and social status are key determinants of travel behaviour in Germany, complains that "at the policy level, such a debate is still lacking" (p. 186, own translation). Similar considerations are made by Daubitz (2011).

A look at federal policy documents on transport and on poverty confirms this impression. As Kemming and Borbach (2003, p. 9) point out, the first National Report on Poverty and Wealth (BMAS, 2001) did not consider transport problems. The same applies to the most recent report (BMAS, 2013). Conversely, transport policy documents give only scant attention to social issues in transport. As Kemming and Borbach (2003, p. 9) point out, the 'Transport Report 2000' (BMVBW, 2000) pays lip services to the social side of transport (as part of the triple bottom line of sustainable development) but does not include a clear strategy to tackle the issue of transport disadvantage. Similar considerations apply to the 'Federal Transport Plan 2003' (BMVBW, 2003). In a nutshell, both documents accord higher priority to the economic and environmental consequences of transport.

Lack of a consistent policy framework at the national level does not mean, however, that there are no initiatives at lower administrative levels. For example, Kemming and Borbach (2003, p. 20) illustrate how flexible public transport services (see §1.6.2) and community transport initiatives (see §2.4.3), including hitch-hiking schemes, collective taxis, dial-a-ride buses and the like, have been implemented since the 1970s in Germany. The goal, however, has been to "bridge the existing gap between regularly scheduled public transport services and private transport by car" (*ibidem*), thus encouraging modal shift.

An example in this context is the *Bürgerbus* services (Schiefelbusch, 2013). These can be defined as "a type of small-scale public transport service that closes gaps in the network of traditional public transport at much lower cost, thanks to volunteers driving the vehicles"; the goal is to provide "a basic level of public transport provision (...) for the mobility needs of those without access to a car or who are unable to drive" (p. 35). Since the implementation of the first *Bürgerbus* in 1985, the number of services has increased rapidly, reaching 170 in 2012 (Schiefelbusch, 2013). Most *Bürgerbus* services are found in rural areas, where providing a public transport alternative to the car is more difficult (Ahrend & Herget, 2012). However, the initiatives are strongly concentrated in states, such as North-Rhine Westphalia, Lower Saxony and Rhineland-Palatinate, that have supported them with "dedicated funding and support" (Schiefelbusch, 2013, p. 37). Most initiatives also target exclusively older people (*ibidem*).

Finally, as illustrated in a recent report by Ahrend and Herget (2012), in some German rural areas "mobile services" (such as a mobile bank and a mobile library) have been developed. These initiatives aim not only at reducing car use in rural areas, but also to protect rural residents from the impacts of increasing fuel prices (*ibidem*), thus tackling the issue of oil vulnerability (see §2.2.4).

4.2. Car ownership in Germany: existing research

4.2.1. Car ownership trends

In the last decades, general trends in travel behaviour for the German population were similar to those observed in other developed countries (see §1.1.1): travel distances and speed have considerably increased as a result of a modal shift towards the car, while per capita trip rates and the average time spent on daily travel have remained approximately constant (Scheiner, 2010). Based on a descriptive longitudinal analysis of national travel survey data for West Germany in the period 1976-2002, Scheiner (2010) shows that, while the modal share of the car has considerably increased even within the same distance categories, this effect almost disappears when car availability is controlled for. In short, this means that increasing motorisation is the main cause for the observed changes in travel behaviour.

Indeed, motorisation has increased rapidly in Germany, from 10 vehicles per 1.000 inhabitants in 1950 to 444 in 1990 (the year of the German reunification) and 517 in 2010 (Kuhm, 1997, p. 240; ADAC, 2012, p. 13). While motorisation was lower in East Germany (237 vehicles per 1.000 inhabitants in 1989, as compared to 475 in West Germany), it has caught up very rapidly in the years following reunification (403 vs. 496 in 1993) (Kuhm, 1997, p. 240).

The analysis carried out by Scheiner for West Germany (2010) shows that the increase in motorisation has been considerably stronger in small towns than in large cities (where it was already lower). As a result, a "widening spatial gap in motorisation" is observed (p. 83). More recent data confirm that, while motorisation has increased between 2002 and 2008 in Germany as a whole, it has slightly decreased in large cities, thus further widening the gap (BBSR, 2011, p. 10). Tab. 4.1, showing the share of individuals living in households without cars in West Germany, illustrates this trend[52].

	1976	1982	1989	2002	2008	percent variation 1976-2008
500 or more	39.8	23.7	31.5	28.8	22.8	-43%
100 to 500	33.7	17.9	28.0	18.7	16.3	-52%
20 to 100	28.8	12.1	19.9	12.0	7.8	-73%
5 to 20	26.6	9.6	18.4	8.7	5.2	-80%
2 to 5	23.8	7.6	16.0	5.4	4.9	-79%
Less than 2	20.6	7.1	10.7	5.4		-76%

Tab. 4.1 – Share of individuals in households without cars in West Germany 1976-2008, by municipality size (thousands of inhabitants), percentage values. Unit of analysis: individuals. Source: Scheiner (2010, p. 82); for the years 1976-2002; own elaboration on MiD data for 2008.

52 In the table, data for the year 1989 show an unexpected surge in the share of households without cars. As argued by Scheiner (2010), this is probably due to the sample selection method used in 1989 (random route method), that probably led to oversampling of households without cars. Also, it must be noted that data for 2008 do not include West Berlin, and do not distinguish between municipality sizes under 5,000 inhabitants. For this reason, the percent variation (1976-2008) for the two smallest municipality size categories has been computed assuming that the share of households without cars is 4.9% for both categories.

As Scheiner (2010) argues, this trend should be interpreted as the result of changes in spatial development, whereby:

> "as car travelling increasingly becomes a societal norm and also a necessity (because of the spatial and invidividual separation of urban functions such as housing, working, shopping and so on), the big cities become (with some slight exaggeration) the last areas where one can still live without a car and where car-less households are gathering, regardless of whether their car-less life is voluntarily chosen or caused by a lack of resources" (Scheiner, 2010, p. 83)

In another study, based on a multivariate longitudinal analysis of national travel survey data for West Germany for the period 1976-2002, Scheiner (2006a; 2009a) is able to demonstrate that, over time, regression models including 'structural' predictors (socio-demographics, place of residence, car availability) are less and less able to 'explain' travel behaviour[53]. This is mostly due to the declining predictive power of car ownership: indeed, while car availability is considerably higher in 2002, the average travel behaviour of car-owning individuals is less dominated by the car (more 'multimodal') than it was in 1976 (Scheiner, 2010). Scheiner (2009a) interprets this result as proof of an increasing 'individualisation' of travel behaviour, whereby the importance of individual preferences and lifestyle increases, while that of 'structural' determinants diminishes. Interestingly, however, he also argues that the increasing importance of individual agency in travel behaviour is a by-product of high levels of motorisation, that allow people to choose where to live, work and the location of other activity destinations (2009a, p. 18, 33, 49). In that sense, paradoxically, the individualisation of travel behaviour is conditioned on car availability: in other words, Germans have become more 'free' to choose their travel behaviour, but less free to decide whether to own a car or not.

In this context, Scheiner puts forward the hypothesis that, over time, the predictive power of structural predictors of car ownership and use decreases, while the opposite (increasing predictive power) happens to models predicting public transport use, as the group of public transport users is increasingly composed by people who cannot afford car ownership (2009a, p. 68). In that sense, Scheiner applies the thesis of a decoupling of socio-demographics and travel behaviour to car ownership and travel mode choice (*ibidem*). Empirical results, however, provide only partial support for these hypotheses: while car use is considerably less 'predictable' in 2002 than in 1976, the goodness of fit for the model predicting public transport use is only slightly higher at the end of the period. Moreover, the hypothesis of a decreasing predictability of car ownership is not tested. The findings illustrated in this thesis with reference to research question 2 (§6.2) might contribute to this discussion, although the short period of interest (2002-2008) does not allow to assess long-term trends.

Interestingly, the analyses conducted by Scheiner (2009a) also show that the predictive power of territorial variables in models predicting mode choice increases over time: as noted above, he interprets this result as proof that living whithout a car is becoming virtually impossible everywhere in Germany, except for the cores of metropolitan areas (2009a, p. 96). This is clearly related to the suburbanisation trends of the last few decades[54] (see §4.1.1). Recent qualitative research on households with children living in German rural areas (Ahrend & Herget, 2012) confirms this impression: when asked about how they would cope without a car, most parents said that they would rely on car-pooling and/or car lifts by friends and relatives; this highlights the lack of 'practicable' modal alternatives in these areas, but also the high levels of car reliance of households with children.

Indeed, German transport research has highlighted that households with children are the least likely to make do without cars. Heine et al. (2001), for example have interviewed 60 households with children in different

[53] In detail, the travel behaviour variables considered by Scheiner (2009a) are: "at least one trip", "at least one trip for work reasons", "at least one shopping trip", "car use", "public transport use", "non-motorised modes use" (all refered to travel diary day in the KONTIV / MiD databases over the period 1976-2002) (p. 75-96).

[54] A further study by Scheiner, carried out with a "mobility biography approach" in the Cologne area (2005), however, shows that residential self-selection mechanisms are also partially responsible for this result: households who move from inner city to the suburbs are more likely to be car owners even before moving; Yet, the same study shows demonstrates that the built environment influences car ownership, even after controlling for residential self-selection (motorisation increases after moving to the suburbs).

types of area in the Hannover region, in order to understand why they keep owning and using cars in their daily life, despite widespread awareness of its negative environmental impact. Their thesis is that "for most people, giving up the car would mean a backslide from the standards of a good life" (p. 23, own translation). In that sense, their findings shed light on the *social* determinants of car ownership in Germany. In a nutshell, Heine and colleagues conclude that car ownership leads to to a rationalisation of travel behaviour, increased flexibility and expansion of the household's activity space (p. 146). The kind of daily life that the car makes possible then becomes a "moral standard" that households feel compelled to achieve. In this context, the authors highlight how car ownership interweaves with other key moral imperatives for parents. To cite but a few examples, car use allows parents to fulfil the moral imperative to 'protect' the child (from the dangers of traffic, bad weather, crime, etc.), but also to bring him/her to the leisure activities of choice, no matter how distant they are, thus preventing the social exclusion of the children. Even the decision to move to the suburbs (a 'standard' for young German households at the time of household formation) is justified as a way to allow the kids to grow up in healthy and safe environment. At the same time, the car allows mothers to reconcile the imperative to take care of the child with the (historically more recent) imperative to participate in the labour market, thus allowing female "double presence". Finally, car use, by providing a quicker way to reach destinations, creates a standard of 'time rationalisation' that becomes a moral standard: 'wasting time' by using other travel modes is thus perceived to be a moral failure, that is sanctioned by society. Overall, Heine et al. conclude that the kids' growing up results in a "spiralling process of increasing car dependence" (p. 78) for German households.

The Findings report (*Ergebnisbericht*) of the latest wave of the German travel survey *Mobilität in Deutschland* (infas, 2010c) provides the most recent and detailed information about car ownership in Germany. Overall, the report suggests that the historical trend towards increasing car use has stopped in Germany between 2002 and 2008 (if measured in terms of modal split) – although the car remains by far the most important transport mode[55]. These results are consistent with what observed in other industrialised countries (see §1.1.1, §5.2.1). In terms of car ownership, however, the share of carless households decreases slightly between 2002 and 2008, while the number of households with two or more cars increases (see §6.2.1).

The report also shows that carless households are overrepresented among single-person households, Eastern Germans, young adults, older people and low-income households[56]. Conversely, non-car ownership is particularly low among households with minor children (see also Follmer, 2009). The report also presents the results for the variable 'reasons for not owning a car (priority)': given that the way in which this variable was built is questionable (see §6.1.3), I do not discuss these results here. With regards to effects on travel behaviour, the Findings report shows clearly that carless households have shorter travel distances, and use alternative modes more often. Notably, the share of public transport trips decreases "dramatically" as soon as an households owns a car (infas, 2010c, p. 2). As a result, the daily travel-related CO_2 emissions of carless households are considerably lower; similarly, lower emission levels among low-income households are mainly explained by lower motorisation (pp. 154-155). In terms of accessibility, however, MiD 2008 findings indicate that respondents judge the automobile as the travel mode providing the best accessibility to essential services and opportunities (workplace, place of education, shops for daily shopping).

Findings from MiD 2008 also suggest that powerful demographic trends are shaping the evolution of travel demand (cfr. §1.1.5). Notably, while driving-licence ownership, car ownership and use and travel demand have increased rapidly for older people[57], the opposite trend is observed for young people, and notably for young men in cities (infas, 2010c, pp. 154-155).

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[55] Also, the trend towards more powerful (and thus more polluting) engines continues between 2002 and 2008 (infas, 2010c, pp. 5, 163).

[56] However, the results of the study by Dargay et al. about "the dynamics of car ownership in EU countries" (2008) suggest that, in the mid-1990s, the distribution of households with access to a car by income quintile was more equal than in all other European countries considered except Italy, Luxembourg and France.

[57] The results of the study conducted by Ottman (2006) on the German Mobility Panel (MOP) for the period 1994-2004 also suggest that, among older people, the share of 'low mobility' individuals is decreasing rapidly, while the size of more mobile and car-oriented clusters is increasing.

A recent study by Kuhnimhof, Buehler and colleagues (2012, see also Kuhnimhof et al., 2011) is of particular interest in this context: based on a range of data sources, the authors show that, while motorisation increased, there has been a trend divergence for young adults (18-29) since the 1980s, resulting in a decline in car ownership rates (p. 446). Since the turn of the millennium, also the share of licensed drivers has stagnated for this age group (*ibidem*). In depth analyses show strong gender differences among young adults: while driving licence and car ownership have increased for women, they have declined for men. As a result the gender gap in motorisation has disappeared among the youngest cohorts (p. 443-444, 447). As the authors argue, this is surprising since “for decades these young adults represented one of the most car oriented age groups” (p. 443). These trends in driving licence and car ownership have an impact on the travel behaviour of young adults: car use has decreased since 2000, and multimodal travel behaviour is increasingly observed also for young adults with car access (*ibidem*). Overall, these trends are consistent with what observed in other developed countries (Kuhnimhof et al., 2011; Kuhnimhof, Armoogum et al., 2012).

The reasons for this development, however, are still unclear. Kuhnimhof, Buehler and colleagues (2012) suggest that factors such as the increasing share of young people attending universities (often located in large cities), decreasing workforce participation, late start of professional career, real income losses for young professionals and increasing age for starting a family might play a role, insofar as “all of these trends contribute to a larger share of young people being in a life situation in which they are less likely to use or own an automobile” (p. 448). Moreover, in the last twenty years in Germany the cost of driving increased faster than the cost of public transport; notably, the introduction of Semester Tickets (Müller, 2012) has reduced the cost of public transport for university students (Kuhnimhof, Buehler et al., 2012, p. 448-449). Besides these structural factors, Kuhnimhof, Buehler and colleagues suggest that psychological factors such as increased environmental awareness and pragmatism might play a role (*ibidem*). None of these factors, however, is able to explain the observed differences between young men and women (p. 449).

With regard to older people and car ownership in Germany, Scheiner (2006b), based on data for the year 2003, has investigated whether car availability (that is high among the elderly but declines sharply after the age of 80, notably among women) has an independent effect on leisure mobility. He concludes that, when key intervening variables such as health are controlled for:

> “car availability does not seem to have any influence on leisure mobility and the fulfilment of leisure needs. Where it plays a role at all (with respect to realised mobility), the availability of a season ticket for public transport indicates an influence into the same direction. Thus, it is not the car, which makes elderly persons mobile and satisfied, as frequently assumed in gerontological mobility research. Rather it is the healthier, more mobile and more satisfied seniors who frequently own a car and/or a season ticket for public transport. The availability of transport means rather represents a certain type of individual with a certain mobility behaviour than being a determinant for mobility. (Scheiner, 2006b, p. 168)

4.2.2. Households without cars: existing research

As illustrated in the previous section, increasing motorisation has resulted in a rapid decrease in the share of households without cars, as illustrated in Fig. 4.1. The graph shows that the share of households without cars has declined both in East and West Germany since the 1960s, even though the rate of decline is slowing down since the early 1990s[58].

Preisendörfer and Rinn (2003) reviewed existing empirical studies on German households without cars in social science, concluding that “only a few studies exist” and that they have “certain flaws, weaknesses and shortcomings” (p. 10). Of the four studies reviewed by Preisendörfer and Rinn (p. 18-19), two have a qualitative approach, while the other two are based on very small samples. For this reason, in this section I

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[58] The increase in the percentage of households without cars in East Germany between 2002 and 2008 is probably due to the fact that MiD 2002 considers former West-Berlin as part of West Germany, whereas the 2008 wave includes it in East Germany for the first time. As in Berlin households without cars are strongly overrepresented (approximately 40% of all households both in 2002 and 2008), this results in an abnormal increase in the percentage of carless.

focus exclusively on the research monograph by Preisendörfer and Rinn (2003); to the knowledge of this author, this is the last work that has focused on German carless households and conducted a secondary analysis of survey data. In doing this, I illustrate the findings and I highlight the limitations of the study: the goal is to illustrate how the present thesis adds to existing knowledge on carless households in Germany.

From the outset, it must be acknowledged that the monograph on households without cars by Preisendörfer and Rinn (2003) is clearly driven by an *environmental* perspective. Admittedly, the authors aim to situate carless households along a 'choice or constraint' continuum, and notably to identify whether there is an avant-garde of households who give up the car voluntarily for environmental reasons, and whether there are advantages to a carless life (p. 10-12). In doing this, they aim to disprove the idea that non-car ownership necessarily corresponds to social marginalisation.

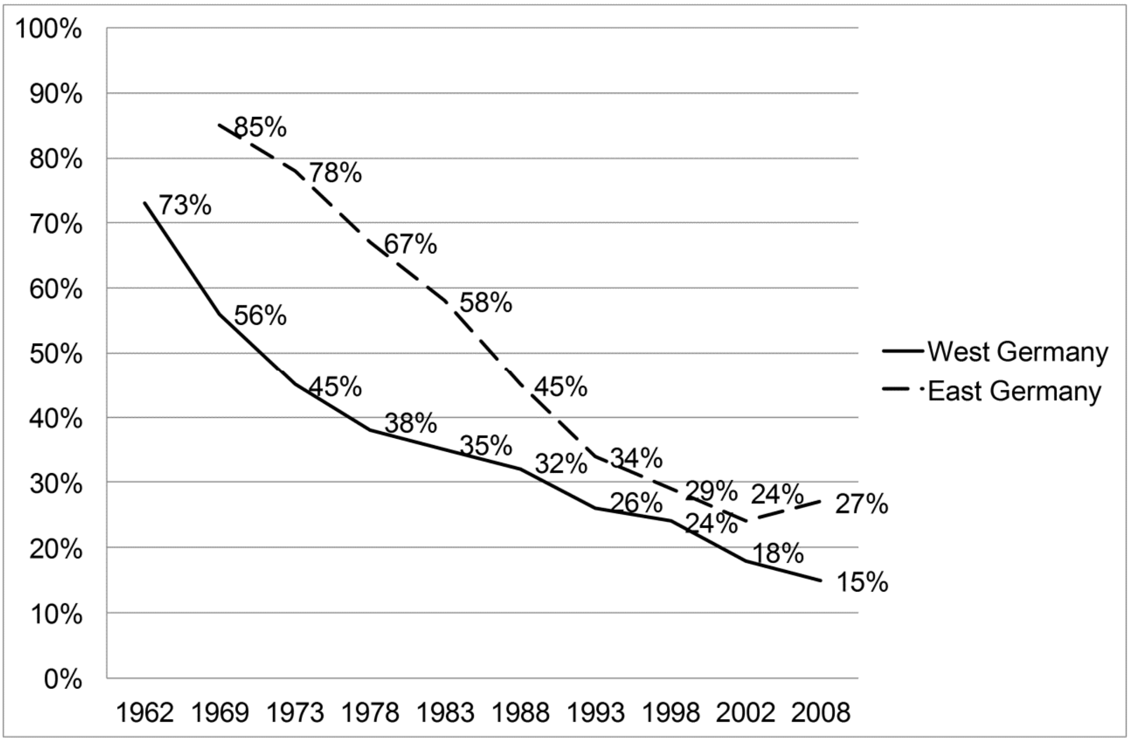

Fig. 4.1 – Households without cars in East and West Germany, 1962-2008. Unit of analysis: households. Sources: Preisendörfer & Rinn (2003, p.20) for the years 1962-1998; own elaboration on MiD 2002 & 2008 data for subsequent years.

The empirical analysis is composed of two main parts. Firstly, the authors use data from the German sample survey on income and expenditure (*Einkommens und Verbrauchsstichprobe*, EVS) and the socio-economic panel (*Sozioökonomischen Panels*, SOEP) in order to single out the main determinants of non-car ownership. Secondly, they present the results of a primary survey conducted in the city of Munich, including several specific questions about non-car ownership.

The results of the logistic regression analysis performed on EVS and SOEP data show the importance of socio-demographic characteristics (household size, income, gender, age, working status, etc.) and attributes of the residential area (municipality size) in predicting non-car ownership (2003, p. 78-79). By contrast, environmental awareness does not have any significant effect. Therefore, the authors conclude that "in spite of the alleged individualisation and pluralisation of lifestyles, non-car ownership is strongly related to socio-structural determinants" (p. 172, own translation). Moreover, by comparing several logistic regression models, Preisendörfer and Rinn single out several 'interaction effects' between predictors of non-car ownership (p. 71): for example, they show that the effect of gender is stronger in East Germany, for older people and in small municipalities.

The SOEP dataset also allows the authors to explore the impact of non-car ownership on leisure activity participation, while controlling for other socio-demographic factors. The results are unambiguous: for 14 activities out of 16, non-car ownership has a statistically significant negative effect. Interestingly, this is true for both outdoor and indoor activites. However, the authors emphasise that there is no difference in self-assessed satisfaction with leisure activities: individuals in carless households are as likely as their motorised counterparts to be satisfied (p. 72-80).

The primary survey conducted involved a sample of 600 households without cars (as well as 600 car owning households, in order to allow comparison) in the municipality of Munich. The results of logistic models predicting non-car ownership broadly confirm the conclusions of the secondary analysis, although carless households in Munich are on average younger and more frequently employed (p. 98); they also suggest that population density at the neighbourhood level and distance from the city centre are powerful predictors of non-car ownership (p. 96).

The primary survey allows Preisendörfer and Rinn to explore the reasons behind non-car ownership (p. 102-110). The results show that the most frequently selected reasons are ‘economic reasons’, lack of need (good public transport provision), followed by lack of a driving licence. Health, age and environmental reasons account only for a small share of the sample (p. 105). In contradiction with this picture, the results for a separate question show that most respondents (59%) consider lack of car ownership as choice (*freiwillig*), rather than a matter of constraint (*unfreiwillig*, 13%). Furthermore, the authors apply cluster analysis to 10 Likert items, corresponding to possible reasons for not owning cars: the results however are not satisfying; for this reason, they put forward a five-classes typology (*old/ill, environmentalists, poor, cold calculators, pragmatists*) but this is based on a priori assumptions, rather than on the use of a clustering technique (p. 107-109). As a conclusion, Preisendörfer and Rinn argue that “an important finding of our research is that non-car ownership is motivated by respondents predominantly in a pragmatic way” (p. 173, own translation), rather than with environmental and ‘anti-car’ arguments

The results of the primary survey also allow the authors to focus on the consequences of non-car ownership. In terms of travel behaviour, there are dramatic, albeit predictable, differences in travel behaviour between car-owning and carless households (p. 114-115). In terms of leisure activity participation, Preisendörfer and Rinn do not find support for the thesis that carless individuals spend more time in the neighbourhood. However, the lack of a household car has a negative effect on the frequency of out of town trips, on active participation in groups and associations, and on the likelihood to attend leisure activities outside the home, even after controlling for other intervening factors (p. 124-129). In contradiction with these results, a large majority of the carless does not feel that the lack of a car ‘limits’ their leisure activities (p. 130). With regard to the households’ social networks, the lack of car does not seem to have any significant effect (p. 132).

Finally, based on the results for several ‘subjective’ questions about the advantages and disadvantages of living without cars, Preisendörfer and Rinn conclude that “for the vast majority of those live without a car, disadvantages, limitations and inconveniences are relatively unimportant or are not even perceived” (p. 148, own translation). On this basis, the authors conclude that “the whole argument that the car is essential for social participation stands on shaky ground” (p. 174, own translation).

While the monograph by Preisendörfer and Rinn provides precious information about German households without cars, in the remainder of this section, I focus on its limitations. Firstly, as argued by Schöller (2007), “the conception of the study and the interpretation of the findings are strongly influenced by the basic political and normative orientation of the authors” (p. 255, own translation), namely the conviction that car ownership is not essential in contemporary society. This leads them to systematically overlook the ‘objective’ findings that would disprove this thesis (such as the negative impact of non-car ownership on leisure activity participation), and to overestimate the ‘subjective’ findings that point in the opposite direction (such as the fact that individuals in carless households are as likely as their motorised counterparts to report satisfaction with their leisure time). As Schöller argues, however, this discrepancy between objective and subjective results can be easily explained by psycho-social phenomena such as ‘cognitive dissonance reduction’ (p. 256).

Secondly, the data sources used in the study have several limitations. On one hand, as acknowledged by the authors (Preisendörfer & Rinn, 2003, p. 15-46), the EVS and SOEP surveys provide only limited information on car ownership and virtually no information on travel behaviour. In order to compensate for these limitations, the authors conducted a primary survey. However, the fact that the survey was restricted to Munich is arguably a limitation, as the kind of carless households found in a compact city with an excellent public transport network is very unlikely to be representative of German carless households as a whole (p. 176). In the present study, by contrast, I use a National Travel Survey that is representative at the national level and includes a one-day travel diary for all household members (§4.3) : this enables me to overcome these limitations and put forward a typology of carless households that is generalizable at a national level. Also, it allows me to show the links between reasons for not owning cars, travel behaviour and accessibility to services and opportunities.

Thirdly (and relatedly), the study by Preisendörfer and Rinn does not take into account the crucial influence of land use and the built environment on non-car ownership. For instance, while the results of the secondary analysis show the existence of interaction effects between municipality size and socio-demographic predictors of non-car ownership, the authors do not put forward any overarching hypothesis to explain this. Similarly, on the basis of the results of the primary survey, the authors argue that:

> "While the results of the secondary analysis for the whole Germany strongly suggest that households without cars are either poor, old or in education ('AAA-Group': *arm, alt oder in Ausbildung*), for Munich this picture should be corrected, as no strong concentration in the AAA group is observed" (p. 172, own translation)

However, the authors do not put forward any specific hypothesis about the relationship between the socio-demographic profile of the carless households group and the type of area. In this thesis, by contrast, I aim to demonstrate that the composition of the carless households group varies systematically with the degree of car dependence of a local area (see §3.3.2).

This brings us to the last limitation of the study, namely the lack of theoretical grounding of the empirical work: the authors explicitly acknowledge this, justifying it in light of the shortage of previous studies on households without cars (p. 177). By contrast, the hypotheses put forward in this thesis are derived from the theoretical concept of car dependence (§3), as well as from extensive literature reviews on car ownership and motorisation (§1) and car-related transport disadvantage (§2).

4.3. "Mobilität in Deutschland": the survey

As observed in §3.4.2, Germany has developed a concept of national mobility surveys, composed of three complementary elements (Zumkeller, 2009; Schultz, 2008): a repeated cross sectional national travel survey with a large sample (Mobilität in Deutschland – MiD); an annual panel survey (German Mobility Panel – MOP) with smaller sample but the same core questionnaire as MiD, started in 1994; a panel survey with focus on long-distance travel (INVERMO). These three main surveys are then complemented by regional panels and by a survey focused on single cities and metropolitan areas (SrV – Mobilität in Städten).

Mobilität in Deutschland (MiD), the German national travel survey, has been carried out irregularly since 2002 (Kunert & Follmer, 2005): following a first wave on that year, a second wave has been realised in 2008. Data for previous years are only partially comparable (Holz-Rau & Scheiner, 2006): from 1976 to 1989 a national travel survey with a different research design (KONTIV) was conducted, but only in West Germany. Therefore, in this thesis I will limit my analysis to the MiD 2002 and 2008, that are representative for the whole country. Key variables included in the databases and sample size are summarized in Tab. 4.2.

	Wave	2002	2008
Available variables	Income	in part	X
	Basic territorial variables (size of the municipality, etc.)	X	X
	Additional territorial variables (population density, etc.)		X
	Accessibility to services and opportunities with different modes of transport	in part	X
	Reasons for not owning a car		X
	One day travel diary	X	X
	Travel related CO_2 emissions		X
Sample size	Households	25,848	25,922
	Persons	61,729	60,713
	Trips	167,851	193,290

Tab. 4.2 – *Mobilität in Deutschland* surveys: availability of key variables and sample size.

As shown clearly in Tab. 4.2, the most recent wave of MiD includes a wider array of variables that can be useful in describing the group of carless households. For this reason, as well as for it being more up-to-date, in chapter 6 I use the MiD 2008 data to provide an answer to Question 1. I use MiD 2002 data only to provide an answer to Question 2 (concerning the changing composition of the carless households group over time). Both waves include a one-day travel diary.

The MiD 2002 survey was conducted by the independent social research institute *infas* (*Institut für angewandte Sozialwissenschaft GmbH*) and the German Institute for Economic Research (*Deutsches Institut für Wirtschaftsforschung*, DIW) on behalf of the German Federal Ministry of Transport, Building and Housing (*Bundesministerium für Verkehr, Bau- und Wohnungswesen*). MiD 2008 was conducted by infas and the German Aerospace Center (*Deutsches Zentrum fuer Luft- und Raumfahrt e.V.*, DLR) on behalf of the German Federal Ministry of Transport, Building and Urban Development (*Bundesministerium für Verkehr, Bau- und Stadtentwicklung,* BMVBS). The MiD 2008 and the MiD 2002 data sets of the German Federal Ministry of Transport, Building and Urban Development were kindly provided by the Clearing House of Transport Data at the DLR Institute of Transport Research in Berlin. Additional geographical variables were kindly provided by the German Federal Ministry of Transport, Building and Urban Development.

Further details about the MiD datasets are provided in Appendix B.

5. UK

In this chapter, I provide information about the second case study country: the United Kingdom. However, given the institutional complexity of the British state, it is necessary to distinguish between:

- the United Kingdom of Great Britain and Northern Ireland (UK), a sovereign state, is composed by four 'countries': England (accounting for approximately 50 of its 60 million inhabitants), Scotland, Wales and Northern Ireland
- 'Great Britain' refers to the largest of the British islands, thus excluding Northern Ireland. The data source used for secondary analysis in this thesis (NTS), refers only to Great Britain (see §5.3)

To add further complexity, since the devolution reform of 1998 (Tomaney, 2000), substantial powers have been attributed to the devolved administrations of Scotland, Wales and Northern Ireland, as well as Greater London. With regard to transport policy, this means that the devolved administrations "are responsible for developing their own transport policies and local authority guidances, while England continues to be governed and legislated for by the UK Government and UK Parliament" (Lucas & Currie, 2012, p. 152).

For the sake of simplicity, in the first part of this chapter (§5.1) I focus essentially on UK policy documents. It must be noted however that "in practice, however, similar policy approaches have been adopted by all the other devolved administrations" (Lucas & Currie, 2012, p. 152, see also Smyth, 2003; MacKinnon & Vigar, 2008). When illustrating trends, I generally have to rely on data limited to Great Britain or England. With regard to policy documents, I focus mainly on the period up to 2010. This is consistent with the empirical study, that uses data for the period 2002-2010 for Great Britain only. The policies of the Liberal-conservative coalition government (2010-present) are sketched out only when they mark a radical change from previous Labour policies.

The chapter is structured as follows. In the first section (§5.1) I focus on land use and transport trends and policies. This provides the context for the empirical study focused on households without cars (§7) and for the conclusions that can be drawn from it. In the second section (§5.2), I focus on existing studies that have focused on car ownership (or lack thereof) in the UK. Finally (§5.3), I provide information about the data source used for the analysis, the National Travel Survey (NTS). Further technical details about the survey are provided in Appendix C.

5.1. Spatial development and transport in the UK: trends and policies (overview)

In this section, I focus on spatial development and transport trends and policies in the UK. It is important to state that this is not meant to be an exhaustive review. It should be rather considered as an overview providing information to contextualise the empirical results presented in chapter 7. The section is structured as follows: in the first sub-section (§5.1.1) I focus on spatial development, as this is strongly related to transport (as discussed in §1.5 and §2.3). In a subsequent section (§5.1.2), I focus on British transport policy more specifically. In these first two sections, the focus is on the consequences of spatial development and transport policies on environmental problems. Policies aimed at tackling transport-related social exclusion are the object of the last sub-section (§5.1.3).

5.1.1 Spatial development

In the second half of the 20th century, spatial development in Britain was marked by the same trends towards suburbanisation and decentralization that have been observed in other developed countries (§1.5.1), including Germany (§4.1.1). According to figures published by the Department of the Environment, Transport and the Regions (DETR, 2000a), between 1951 and 1981, Britain's major conurbations lost 10% of their population, while the overall population of Britain grew by 9% (p. 24). Notably, for several decades net migration within the UK has been directed towards more peripheral locations (p. 24-25). Breheny (1995), based on figures for the period 1945-1991, shows how the largest population gains throughout the period are observed for small urban and rural areas (p. 88), that are also those with the highest transport-energy consumption (p. 93). According to several authors, this denotes a process of 'counterurbanisation' (Breheny, 1995; Colomb, 2007; Siedentop, 2008).

During this period, building densities were also low. According to Banister (2005), while the standard in the 19th century was to build at 40-80 dwellings per hectare, "current averages are only 23 dwellings per hectare" (p. 107). Similar figures were provided by government policy documents at the turn of the century (DETR, 2000a, p. 49). Such low densities are problematic, because they make it difficult to provide efficient and economically viable public transport service: as Power (2012) illustrates, the density required to run a bus service that results in a significant modal shift away from the car (at least 50 homes per hectare) is substantially higher than that of the average British city (35 households per hectare) (p. 42).

The decline of British urban areas was particularly apparent during the 1970s and the 1980s, as a result of deindustrialisation. In this period "many larger cities rapidly lost tens of thousands of manufacturing jobs and virtually their whole economic rationale" (ODPM, 2006, p. 11). More recent trends, however, show a slightly different picture. The Government Report "State of English Cities" for the period 1981-2003, suggests that the overall trend can be summarized as "the smaller the settlement size, the stronger is its rate of population growth" (ODPM, 2006, p. 37). The biggest exception however is the largest British city – London – that started growing in the second half of the 1980s and shows the highest growth rate of all areas at the end of the period. Also, the rate of decline for other metropolitan areas and large cities has decreased throughout the last two decades of the 20th century, although this obscures differences between the South and the East (where cities have grown) and the North and the West (where they still decline, albeit to a lesser degree than in the past) (*ibidem*). In detail, the growth of larger cities is mostly due to natural change, while the strong increase observed in small towns and rural areas is essentially due to migration, that more than offsets negative natural change (pp. 44-45). The report concludes that "the quest for the 'rural idyll' appears just as strong nationally as in the past (..) as evidenced by continued high levels of net out-migration from England's larger cities." (p. 34). Indeed, several recent studies confirm that the location preferences of Britons remain strongly oriented towards suburban and rural areas and detached or semi-detached housing (Stead & Hoppenbrouwer, 2004, p. 123; Pacione, 2004; Senior et al., 2004; Evans & Unsworth, 2012).

With regard to employment, during the 1990s the rate of growth was strongest in small towns and rural areas, as compared to large cities, although the strongest growth was observed for metropolitan areas in the North and the West (ODPM, 2006, p. 61). A more recent report (DCLR, 2011) suggests that in the period 2003-2008 most English cities experienced employment growth, albeit at a slower rate than other types of area, and this trend is expected to continue over the period 2008-2028 (p. 69). The positive dynamic of rural areas is confirmed by the most recent Statistical Digest of Rural England (DEFRA, 2012).

Overall, population and employment change trends can be summarized as a continuing trend towards deconcentration, tempered by signs of reurbanisation (DETR, 2000a; Colomb, 2007; Siedentop, 2008).

With regard to services and opportunities, it has been observed that these have been decentralised (away from old town centres) and centralized (in few large centres, as opposed to several local centres). Lucas (2006) provides some interesting figures about this development:

> "many neighbourhoods have lost local shops as the big retailers have taken over their customer base. For example, between 1991 and 1999, the number of households living more than a 27-min walk from a shopping centre doubled from around 40% to 90% of all households. Similarly, in 1991, approximately 72% of households lived within a 27-min walk of a doctor's surgery, whereas this had dropped to 40% by 1999. (..) Hospitals and health services are being rationalised into fewer, larger units serving wide areas and located in places that are difficult to reach without a car" (Lucas, 2006, p. 802)

These developments have led to the phenomenon of ‘food deserts’ (Wrigley, 2002; SEU, 2003, p. 117-121), that has attracted more research attention in Britain, as compared to other European countries (Fol, 2009, p. 16).

As illustrated in §1.5.1, all of these trends in spatial development were made possible by increasing levels of car ownership and use (see §5.2 below). At the same time, they have made car access an essential precondition for access to services and opportunities. This has been criticized by sustainable transport scholars. In the words of Docherty (2003):

> “Britain’s towns and cities have followed the American trend towards low density suburban sprawl and the rapid growth of satellite dormitory settlements around major cities, encouraged by a laissez-faire attitude to widespread car use. (..) These trends in land use and transport then reinforced each other over several decades, resulting in a situation of widespread ‘car dependence’. Many people, particularly those locked into sub- and ex-urban land-use patterns, now require (very) high levels of mobility simply to maintain their lifestyles. (..) At the same time, people without access to a car find their situation deteriorating (..) The result is social exclusion” (Docherty, 2003, p. 6)

Similarly, the Department of Environment, Transport and the Regions has acknowledged in 2000 (2000a) that:

> “past planning policies have (..) allowed: major new shopping developments outside urban areas which have threatened the competitiveness and viability of town and city centres, as well as neighbourhood shopping; the fragmentation of communities and separation of the places where people shop, work and spend their leisure time from the places in which they live; patterns of development which encourage unnecessary travel, damaging the environment and undermining sustainable development (DETR, 2000a, p. 50)

Since the mid-1990s, recognition of the negative transport impacts of these trends has led to a rethink of spatial planning policies in the UK (Owens & Cowell, 2002). This mirrors the shift towards ‘sustainable’ and ‘integrated’ policy in the field of transport (see §5.1.2). In this context, the main assumption is that spatial and transport planning need to be more coordinated, if the goal is to reduce the dominance of the car in daily travel. As accounted by Vigar and Stead (2003), with this goal in mind the newly elected Labour government merged the Department of the Environment and the Department for Transport into the Department of Environment, Transport and the Regions (DETR) in 1997 (p. 55-56). However, the attempt was not a success: despite the merge, the planning and transport sectors remained separate within the new department, so that by 2001, separate departments were created again[59] (*ibidem*). Interestingly, this development mirrors what happened in Germany (see §4.1.1).

Starting from 1994 British planning policy documents show a new emphasis on using spatial planning regulations to reduce travel demand and promote modal shift away from the car. This mirrors the rise of the ‘compact city’ agenda at the international level during the 1990s (Breheny, 1995; Owens & Cowell, 2002; Stead & Hoppenbrouwer, 2004), as illustrated for the case of Germany (§4.1.1). Notably, the British debate was influenced by the Dutch ‘ABC’ policy (Owens & Cowell, 2002; Stead & Hoppenbrouwer, 2004).

The pre-1994 situation in British spatial planning has been described as follows by Owens & Cowell (2002):

> “in the decades of accommodation, if land-use planning had a role at the local scale it was essentially one of modifying the fabric of the built environment to facilitate the free flow of rapidly growing levels of traffic. Indeed, the main players in the field were not planners but traffic engineers, with surprisingly little communication between these professions, an interesting example of the institutional and cultural barriers to ‘integration’ (..). The traditional approach to conflict between

[59] Interestingly, this had happened before: as illustrated by Owens and Cowell (2002, p. 77) in 1970 “the new UK Department of the Environment (DoE) brought together the functions of the Ministry of Transport and the Ministry of Housing and Local Government (with the goal to) to include responsibility for urban planning and transport in one department in the interests of economy and efficiency”. However, in 1976 the departments were separated again.

motorised and non-motorised transport was to subordinate pedestrians and cyclists, and the legacy of this thinking remains imprinted on many urban and rural areas." (Owens & Cowell, 2002, p. 84)

In contrast with this background the Planning Policy Guidance Note 13 on transport issued in 1994 by John Mayor's conservative government (DoE and DoT, 1994), had the aim to:

"ensure that local authorities carry out their land-use policies and transport programmes in ways which help to: reduce growth in the length and number of motorised journeys; encourage alternative means of travel which have less environmental impact; and hence reduce reliance on the private car. In this way, local authorities will help meet the commitments in the Government's Sustainable Development Strategy to reduce the need to travel; influence the rate of traffic growth; and reduce the environmental impacts of transport overall" (DoE and DoT, 1994, unpaginated)

Moving from the assumption that "the location and the nature of development affect the amount and method of travel" (para 1.3), and from the overarching goal to "plan for less travel", PPG13 outlined the guidelines for the location of development in local authorities. With regard to housing, it suggested to "allocate the maximum amount of housing to existing larger urban areas (..) where they are or can be easily accessible to facilities" or at least in "locations capable of being well served by rail or other public transport" (para 3.2). Also, it encouraged local authorities to "set standards to maintain existing densities and where appropriate increase them, and juxtapose employment and residential uses, where feasible, through mixed-use development (..) to make it easier for people to live near their work" (para 3.3). With regard to retail, it urged local authorities to "maintain and revitalise existing central and suburban shopping centres by enabling development to take place there" or to "seek edge-of-centre sites, close enough to be readily accessible by foot from the centre and which can be served by a variety of means of transport" (para 3.10). Similar guidelines were issued for leisure, education and other facilities.

Since 1994, policy documents have reiterated the importance of coordinating spatial and transport planning. In 1998 the Department of Environment, Transport and the Regions published the Guide "Planning for Sustainable Development: Towards Better Practice" (DETR, 1998b) with the aim to illustrate how planning could contribute to the goals of the White Paper "A New Deal for Transport: Better for Everyone" (DETR, 1998a, see §5.1.2 below). In order to reduce the need to travel and to encourage the use of modal alternatives, it suggested to increase densities, promote mixed-use development and maximising the reuse of previously developed land within cities. In case of urban extensions of new settlements, the white paper stressed the importance of locating them in areas that are well-served by public transport. The Planning Policy Guidance Note 12 (PPG12) on development plans (DETR, 1999a), the government stressed the importance of integrating planning and transport strategies at the local level. Notably, the note argued that "in taking decisions about the location of development and related subsequent implications for transport requirements, local authorities should undertake a rigorous examination of alternative options that may be available (with) be a strong presumption against (the building of a new road) unless all other options can clearly be shown to be impractical" (p. 26). In this context, two major developments have been the creation of Regional Transport Strategies (RTS) as "key integrating force for planning and transportation communities" and "the requirement to produce Transport Assessments of major developments" (Vigar & Stead, 2003, p. 54, 56).

In 1999, the British government asked to an 'Urban Task Force' headed by Lord Richard Rogers to produce a report titled "Towards an urban renaissance" (UTF, 1999), with the mission to "identify causes of urban decline in England and recommend practical solutions to bring people back into our cities" (p. 2). The report made the case for creating "attractive" urban neighbourhoods "by improving the quality of design and movement, creating compact developments, with a mix of uses, better public transport and a density which supports local services and fosters a strong sense of community and public safety" (*ibidem*). As argued by Colomb (2007) "the report was very influential and the term 'Urban Renaissance' has permeated policy discourses and official documents since" (p. 4). The government's answer to the report was the Urban White Paper "Our Towns and Cities: The Future - Delivering an Urban Renaissance" (DETR, 2000a): it vowed to accommodate most new housing on brownfield land, to "encourage people to remain and move back into urban areas" (p. 34), to foster mixed-use development (p. 50-51) as well as to increase building densities from the then average of 25 dwellings per hectare (p. 49). According to Colomb (2007) the importance of the Urban White Paper should not be underestimated as it "marked a significant break with a long tradition of 'anti-urbanism' in English urban policy" (p. 4-5).

In the same year, the revised Planning Policy Guidance Note 3 on housing (DETR, 2000b) was issued. It encouraged local planning authorities to "create more sustainable patterns of development by building in ways which exploit and deliver accessibility by public transport to jobs, education and health facilities, shopping, leisure and local services" (p. 6), thus re-using urban land and buildings ("by 2008, 60% of additional housing should be provided on previously-developed land and through conversions of existing buildings", p.11), by concentrating "larger housing developments around major nodes along good quality public transport corridors" (p. 17) and promoting mixed-use development. Importantly, PPG3 stated that the Government expected local planning authorities to "avoid developments which make inefficient use of land (those of less than 30 dwellings per hectare net) (and) encourage housing development which makes more efficient use of land (between 30 and 50 dwellings per hectare net)" (p. 19), thus actually imposing a minimum density standard for housing in England. As Evans and Unsworth (2012) observe, "this was a substantial shift from the attitudes expressed in the previous version of PPG 3, published in 1992, (which) talked of ensuring that new housing fitted in with the characteristics of the surrounding environment and other housing in the area" (p. 1166).

Finally, Morris et al. (2009) have identified "explicit support for car-free housing within UK national planning guidance, which is not present in other European countries"[60] (p. 25). For example, the Department for Transport issued in 2008 guidance on transport within so-called "Eco-towns", defined as "exemplar green developments, designed to meet the highest standards of sustainability" (DfT, 2008a, p. 4), encouraging planners to "create a completely, or partially, car-free site (possibly using car-free demonstration areas)", in order to reduce car dependence (p. 12). Despite the growing number of projects, however, Morris et al. (2009) observe that "most car-free housing in the UK thus far has taken the form of small-scale infill developments that rely on existing public transport infrastructure and local amenities" (p. 19), a "do minimum approach" that compares negatively with large-scale car-free developments in mainland Europe.

What have been the effects of the shift towards integrated land-use and transport strategies in Britain? In the 1990s a scholar of the compact city like Breheny (1995) observed that the share of new housing built within existing urban areas during the 1970s and 1980s was already 50% and argued that increasing this "surprisingly high figure" even further would prove difficult (p. 91). In fact, the goals of the Labour governments for brownfield redevelopment were achieved eight years ahead of schedule in 2000 (Schulze Bäing & Wong, 2012, p. 2990) and by 2005, a national average of 70% of new development was on brownfield land, compared with 56% in 1997 (UTF, 2005 p. 2). In 2009, this figure had risen to 80% (DCLG, 2010a, p. 63). With regard to building densities, the government surpassed its own goals, with figures increasing from 25 dwellings per hectare in 1997 to 40 in 2005 (UTF, 2005, p. 2) and 43 in 2009 (DCLG, 2010a, p. 63). This is partly the result of some local authorities promoting dwelling densities even greater than the national minimum in some areas (for example Lancaster, see Byoko & Cooper, 2012). As a result, the share of flats on new build completions increased dramatically from 20% in 1999/2000 to virtually 50% in 2009/2010, although flats still represented only 18% of the stock of dwellings in 2008 (DCLG, 2010a, p. xiv). Evans and Unsworth (2012) argue that this dramatic rise is mostly the result of government planning policies, mediated by economic pressures – the proof being that no such trend is observed for Scotland, where government planning guidance was different. Overall, Siedentop (2008) has argued that Labour's spatial planning policies explain part of the recent trend towards (limited) reurbanization.

Despite the apparent success of Labour's 'compact city' policies, these have been criticized for falling short of bringing about the desired impacts on travel behaviour. For example, while Lucas (2006) emphasises that "many new major developments continue to be located in out-of-town and dispersed locations through various loopholes in the planning regulations" (p. 802), Weinberger and Lucas (2011) have argued that:

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[60] The same conclusion is reached by Melia, Barton and Parkhurst (2011).

> "while in the United Kingdom policies to reduce the need to travel by car and to encourage development which supports existing town centres and use of transit have incrementally been introduced since 1994, there is no hard evidence from the UK travel statistics that this has had any impact on the number or length of the trips people make[61]" (Weinberger & Lucas, 2011, p. 74)

Similarly, Owens and Cowell have argued that:

> "greater priority for green modes and planning to reduce the need to travel by car have not only become broadly accepted rhetorical objectives but have also been written into policies at different levels of governance. At the level of detail, and of implementation, however, it is less clear either that such policies are sufficient or that they have been (or could be) applied in ways that are likely to bring about lasting change." (Owens & Cowell, 2002, p. 89)

While some authors have criticized UK spatial planning policies for not being advanced enough, and urged the government to adopt even higher building densities standards (see UTF, 2005; Banister, 2005, p. 107; Power, 2012), there are probably structural reasons for this lack of success. Notably, as argued by Vigar and Stead (2003):

> "financial issues (..) create a major stumbling block in the integration of transport and land-use policies. Since development decisions are heavily influenced by economic arguments, planning decisions are often based primarily on jobs and new businesses rather than on strong transport or land-use criteria. Local authorities are often too fearful of losing out on new development (and jobs) to impose too many conditions on development (..). In many authorities, there is political pressure for development at (almost) any cost, particularly in less prosperous areas"[62] (Vigar & Stead, 2003, p. 62-63)

Overall, as Owens and Cowell observe (2002, p. 93), land-use planning has been loaded with unrealistic transport and environmental objectives, that can only be achieved when a comprehensive package of policies (including, albeit not limited to, transport policy measures) are implemented. Otherwise "land-use policies may (..) continue to work against the grain of a system that in other ways remains conducive to high mobility, in which case they will be ineffective or even counterproductive" (p. 99-100).

To conclude, it is important to mention briefly the repercussions of political change on British spatial planning policy. Soon after its election in 2010, the Liberal-Conservative coalition revised the Planning Policy Statement 3 on Housing (PPS3) (DCLG, 2010b). This, together with subsequent policy documents (HM Treasury and BIS, 2011; DCLG, 2012) has brought about a complete reversal of previous Labour's policies. Firstly, the national requirement that housing density should be at least 30 dwellings was abolished because (in the words of the responsible minister), it had "resulted in local authorities not having enough flexibility to set density ranges that suit the local needs in their areas-particularly for family houses" (Barclay, 2012, p. 3). Evans and Unsworth suggest that this is likely to reduce the proportion of new homes built as flats, thus reversing the trend observed since 2001 and reducing building density (2012). Secondly, the Coalition government removed national targets for the use of previously developed land in 2011, arguing that the "the nationally imposed target has helped to drive up land prices in certain areas and would increasingly limit the supply of new housing, which would harm first time buyers in particular" (HM Treasury and BIS, 2011, p.45). According to Metz (2012), "this could make it more difficult to achieve carbon reduction" (p. 24). However, the government remains formally committed to "encourage the effective use of land by reusing land that has been previously developed (..) (and) promote mixed use developments" (DCLG, 2012, p. 6).

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[61] An exception in this context is perhaps London where, according to Metz, "the recent past and projected future experience (..) illustrates the way in which increasing population density in an urban area may be accompanied by a shift from private to public transport use" (Metz, 2012, p. 21-22).

[62] As Owens and Cowell observe, this problem is relevant especially in rural areas "where both public transport and local facilities have been in decline" (2002, p. 92).

5.1.2 Transport policy and planning

Banister (2002) describes the history of post-war transport policy and planning in the UK as consisting of five phases:

- firstly, starting at least from the 1960s, British transport policy was marked by the predict and provide approach. This, in a context of strong population, income and car ownership growth, resulted in large road building programmes and, at the urban level, in a more general adaptation of cities to the car (Banister, 2002, p. 25-26). In this context, for example, most urban light rail systems were closed down, as they were considered as an outdated mode of transport, incompatible with car traffic (Knowles & White, 2003, p. 137). Still, the negative impacts of increasing motorisation in terms of accidents and deterioration of the local environment started to be acknowledged – for example in the seminal 'Buchanan Report' (Ministry of Transport , 1964).
- the early seventies saw a "rejection of the 1960s" as well as the rise of a "movement against transport planning and large-scale road building programmes" (Banister, 2002, p. 30), related with increasing environmental concerns. The general trend was one of shift "away from investment in roads to better management and use of existing resources" (p. 33) and in this period "most cities abandoned their road building programmes, at least temporarily" (p. 36).
- later in the 1970s, in the context of economic crisis and deindustrialization, a car-oriented approach to transport planning re-emerged. However, there was a crucial difference in that "essentially the schemes were now seen as means to promote economic development and traffic growth, not as a means to accommodate growth that was assumed to be inevitable" (p. 37). Moreover, many road programmes were curtailed (notably in urban areas) as a result of public expenditure cuts, and several key topics (the need for traffic management and greater coordination between spatial and transport planning) entered the debate during that decade
- a "radical policy change" happened with the rise of Margaret Thatcher's Conservatives to power in 1979. The leading principle during this phase was the reduction of the role of the government (which had played an interventionist role up to that point) and privatisation and deregulation of the transport sector. Notably, the conservatives actively pursued the reduction of levels of public expenditure in transport (p. 77-78). According to Banister, the 1980s "brought about the most fundamental changes in transport policy seen in Britain this century" (p. 78). Undoubtedly, the most significant reform was the deregulation of local bus service (see Preston & Almutairi, 2013). As accounted by Preston (2003, p. 158-159), with the Transport Act of 1985, the government privatised municipally owned bus companies and abolished the service licensing system: this resulted in "quantity deregulation" whereby "provided that they followed some basic registration and licensing procedures, commercial operators were now free to provide as much, or as little, bus service as they wished"[63] (2003, p. 159). Local authorities however retained the power to "plug the gaps of the commercial network by tendering to companies to operate services that are not commercially viable" (SEU, 2003, p.72). In the period 1985-2003, approximately 15% of the bus network was subsidised in this way (*ibidem*). Indeed, the main goal of the reform was to reduce the level of subsidy to public transport, which had risen considerably during the 1970s as a result of declining modal share for public transport (Banister, 2002, p. 82-88). While the reform succeeded in reducing the level of public subsidies (which are now among the lowest worldwide, see Preston, 2003, p. 169), it resulted in a significant increase in fares and a strong decline in passenger numbers, in a period when the real costs of motoring were sinking (Banister, 2002, p. 90-95; Preston & Almutairi, 2013). Also the bus market is currently dominated by a small number of large companies, thus creating a oligopolistic situation (*ibidem*). British Railways was also privatized in the early 1990s, albeit the government retained the power to specify minimum levels of service (Banister, 2002, p. 85-86; Shaw & Farrington, 2003; Preston, 2008; Preston & Robins, 2013). With regard to infrastructure, the 1980s saw "a switch from public transport investment to investment in roads" (Banister, 2002, p. 80), although little road building took place in urban areas, and investments concentrated on orbitals and intercity roads (p. 92-97). Overall, as Banister observes, the Conservative reforms of the transport sector were not

[63] This reform did not apply to London (see below).

driven by a coherent vision of transport policy, but rather by ideological (the primacy of the market) and financial (reducing public expenditure) goals (p. 83, 94-95)

Overall, the first four phases described above are similar in that there was no serious attempt to contrast the trend towards increasing car ownership and use. Indeed, Docherty (2003) goes as far as to argue that "until the early 1990s, the core concern of roads policy (and by implication transport policy more generally) in Britain remained the straightforward implementation of predict and provide" (p. 7), while Owens and Cowell (2002) observe that

> "(while) transport planning in preceding decades had (not) been uniformly in favour of road-based mobility (..) the main thrust of policy was to accommodate traffic growth, and other measures had little real impact on the decline of public transport. Non-motorised transport received hardly any attention at all. A number of other European countries (including France, Germany and the Netherlands) were more supportive of public (and in some cases, non-motorised) transport (..), but they too failed to curb the massive growth in car ownership and use" (Owens & Cowell, 2002, p. 180-181)

From this perspective, the path followed by British transport policy and planning in the second half of the 20th century mirrors similar developments in other developed countries. This is true also for the fifth phase – referred to by Banister as "contemporary transport policy" (2002, p. 102-125) – which starts in the early 1990s. The remainder of this section focuses on this phase.

As illustrated by various authors (Goodwin, 1999; 2003; Owens & Cowell, 2002) in the early 1990s several factors contributed to bring about a paradigm shift in transport policy. These included international environmental concerns and the rise of the concept of sustainable development (World Commission on Environment and Development, 1989), as well as doubts about the possibility to accommodate further increases in road traffic using a predict and provide approach. As illustrated by Goodwin (2003), in the course of the 1990s, "a string of scientific and research-based reports had the effect of underpinning and increasing confidence in the tentative policy reorientation" (p. 233). For example, the Royal Commission on Environmental Pollution's Report "Transport and the Environment" (RCEP, 1995) highlighted the negative impacts of mobility growth (in terms of air and noise pollution) and made the case for a sustainable transport policy aimed at reducing the dominance of motor traffic, promoting less damaging modes of transport and integrating transport and land-use planning. Similarly, a seminal report by the Standing Advisory Committee on Trunk Road Assessment (SACTRA, 1994) examined the evidence on whether road capacity influences the amount of traffic, concluding that "at the macroscopic level (the) answer is an unequivocal 'yes'" (p. 165). The main implication of this phenomenon, known as 'induced traffic' (Goodwin, 1996) is that the predict and provide approach is inadequate, as it results in a self-reinforcing cycle of increased road capacity and increased traffic (as noted by scholars of car dependence, see §1.4.1). Also, recognition of this phenomenon has led Biritish scholars and policy-makers to consider policy measures (such as bus lanes, cycle lanes and pedestrianisation schemes) that reduce road space for cars in order to cut traffic (Cairns et al., 1998). Finally, a report of the RAC Foundation for Motoring and the Environment (1995) introduced the concept of 'car dependence' to the British policy debate, thus highlighting the complexities involved in reducing car use.

Overall, the simultaneous pressure of various kinds of criticism led to the rise of a new leading paradigm, under the name of 'new realism' (Goodwin et al., 1991). In the words of Shaw and Docherty (p. 2008), the central point of this approach was that "transport conditions would continue to degenerate unless policy makers embraced a suite of policy measures capable of promoting both modal shift and some form of demand *management* – as opposed to *encouragement*" (p. 9). As observed by Owens and Cowell (2002, p. 73), this discourse reached rapidly a remarkable degree of consensus, prompting Tolley (2003) to write that "the 'new realist' policy prescription (..) has become a mainstream one, the logic of which is widely accepted by transport professionals, academics and even politicians, and (..) no other intelllectually coeherent policy package has emerged" (p. 191).

While a re-thinking of transport policy priorities started under John Major's conservative government, the first attempts to implement the new approach to transport policy coincided with the return of the Labour party to power in 1997. In this context, the White Paper "A New Deal for Transport: Better for Everyone" (DETR, 1998a) is generally considered as a turning point. It advocated an "integrated transport policy", meaning:

> "integration within and between different types of transport - so that each contributes its full potential and people can move easily between them; integration with the environment - so that our transport choices support a better environment; integration with land use planning - at national, regional and local level, so that transport and planning work together to support more sustainable travel choices and reduce the need to travel; integration with our policies for education, health and wealth creation - so that transport helps to make a fairer, more inclusive society" (DETR, 1998a, p. 8)

With regard to transport policy at the local level, according to Vigar and Stead (2003, p. 53-61), four themes characterized the Labour approach: first, integration, understood both as physical integration between different modes of transport and as policy integration between different levels of government (vertical integration) and between different policy communities (horizontal integration); second, decentralization of responsibilities to the local level, strengthening the role of regional planning institutions; third, "a greater belief in the power of public spending", as compared to conservative governments; fourth, a commitment to engage other actors in forms of participatory policy-making.

The 1998 White Paper has been the object of criticism from at least two perspectives. Firstly, scholars have questioned the implications of the new sustainable transport agenda on social exclusion, raising equity concerns (Huby & Burkitt, 2000; Lucas et al., 2001; Lucas, 2006). Indeed, as illustrated in §2.4.7, these concerns are arguably one of the reasons behind the emergence of the "transport and social exclusion" research field: this illustrates the latent tension between social and environmental goals in sustainable transport policy. Secondly, advocates of environmentally sustainable transport have criticized the the White Paper for its lack of courage. For example Docherty (2003) complained that it "had more to say about potential 'carrots' designed to entice motorists out of their cars, rather than the more powerful 'sticks' fashioned to force them out" (p. 14).

This second line of criticism has become stronger throughout the years. In fact, the sequence of transport policy documents of the New Labour era (1997-2010) (DETR, 2000c; DfT, 2004a; DfT, 2007a) has been widely interpreted by commentators as a retreat from the sustainability agenda (Docherty, 2001; Shaw & Walton, 2001; Begg & Gray, 2004; Docherty & Shaw, 2003; 2008; 2011). Notably, the 'Ten-Year Transport Plan' of 2000 (DETR, 2000c) was criticized for shifting the focus from reductions in travel demand to reducing congestion; accordingly, Shaw and Docherty lamented (2008) the "absence of any meaningful demand management strategy" in the plan (p. 12), arguing that it marked "something of a return to previous policies designed to accommodate increasing mobility" (Docherty, 2001, p. 321). This has led Shaw and Walton (2001) to identify the emergence of a new paradigm in British transport policy, 'pragmatic multimodalism', "where high(er) levels of road building are pursued alongside enhanced public transport investment to produce a policy compromise based on what is politically realistic to deliver" (Docherty, 2003, p. 19). According to Goodwin (2003), the Plan was "essentially a programme to 'slow down the pace at which things get worse, rather than to make (..) improvements" (p. 229).

Furher setbacks in the following years (such as the abandonment of the targets of the Ten-Year Plan a mere three years later and failed attempts to introduce pricing measures outside London, see below) have recently led Docherty and Shaw (2011) to conclude that "after thirteen years in power (Labour) had neither transformed policy nor tackled longstanding transport trends" (p. 224), "largely failed to meet even its own rather undemanding targets, let alone more optimistic expectations" (p. 225), achieving "little more than displacement activity"[64] (p. 231).

[64] Several authors have observed that this evolution at the UK level was mirrored by similar developments in the devolved administrations (Smyth, 2003; MacKinnon & Vigar, 2008; Shaw et al., 2009). Interestingly, according to Smyth (2003), the obstacles to the implementation of the sustainable transport agenda were even greater in the devolved administrations (with the significant exception of Greater London) because "being generally less prosperous, and with large rural areas with very low population densities, the priorities of policy makers in Scotland, Wales and Northern Ireland therefore tend to focus much more on regional economic development creation and social inclusion rather than the problems associated with rising traffic" (p. 37). This illustrates how the tension between

In the remainder of this section, I illustrate what this retreat from the sustainabe transport agenda has meant for the specific policy measures. In doing this, I refer to the typology of policies for environmentally sustainable transport illustrated in §1.6[65].

As illustrated in §2.4.1, criticism has been directed at transport decision-making for its inability to take into account the environmental (as well as the social) impacts of transport. Accordingly, in the British context, *changing transport decision making* was promoted as part of the integrated transport agenda since the mid-1990s. Notably, two new policy instruments have been promoted. Firstly, moving from the assumption that previous methods for the economic appraisal of transport projects, based on cost-benefit analysis, were biased in favour of ever-increasing road construction (Walton, 2003, p. 84-85), the Labour Government promoted a 'New Approach to Appraisal' (NATA) (DETR, 1998a; 1998c; Price, 1999; Walton, 2003; DfT, 2007b). This aimed at taking into account a wider range of criteria, as stated in the 1998 White Paper:

> "decisions on when and where to invest in network improvements, including measures to manage traffic, will be taken in the light of the new approach to appraisal based on the criteria: integration - ensuring that all decisions are taken in the context of our integrated transport policy; safety - to improve safety for all road users; economy - supporting sustainable economic activity in appropriate locations and getting good value for money; environmental impact - protecting the built and natural environment; accessibility - improving access to everyday facilities for those without a car and reducing community severance" (DETR, 1998a, p. 57-58)

In a nutshell, then, NATA was developed to "ensure that (..) appraisal of investment decisions in the trunk road network takes account of sustainable development principles and that environmental, economic and social factors are properly examined and evaluated in a clear and consistent way" (DETR, 1998c, p. 22).

Secondly, 'Multi-Modal Studies' (MMSs) (DETR, 1998d; Marsden, 2002; 2005; Shaw et al., 2006) were commissioned in 1998 to "take a view on how *all modes* can contribute to the solution for the transport problem identified and to make recommendations on relevant road schemes from the previous administration's programme" (Marsden, 2002, p. 3, emphasis added). Indeed, the MMSs used the NATA. Despite expectations that this would result in a shift of resources from road programmes to alternatives, the balance is mixed. While Marsden (2005) argues that the studies "have undoubtedly brought about a more balanced and integrated approach to transport planning" (p. 86), Shaw and colleagues (2006) argue that "although the process led to substantial achievements in some areas, its main outcome has been the approval of a host of new road schemes and (..) very little else" (p. 575). Notably, Shaw and Docherty (2008) illustrate how the Department for Transport "ignored most of the studies' public transport elements and sanctioned many of their road schemes" (p. 13). According to Vigar and Stead (2003), this "reflects a degree of path-dependence for local and national transport policy" (p. 58).

With regard to *improving modal alternatives* (§1.6.2), the outcome varies depending on the travel mode. As far as *local buses* are concerned, Labour governments did not reverse the deregulation reform. However, they introduced legislation to improve bus service across the country (DETR, 1998a; 1999b; 2000c; Preston, 2003) by putting so-called 'Quality Partnerships' (which already existed) on a statutory basis. Quality Partnerships are voluntary agreements between operators and local authorities meant to improve qualitative aspects of bus service in order to encourage a modal shift away from the car. Also, they introduced 'Quality Contracts', i.e. exclusive contracts for bus routes in a specified area (including service and fares specification and performance targets) let by tender by the local authorities, with the goal to ensure integrated networks. As of 2012, however, only "a couple" of Quality Partnerships had been picked up, and no Quality Contract was implemented (Preston & Almutairi, 2013, p. 209). While the requirement of central government approval for each single Quality Contract certainly played a role, this result can also be interpreted as "victories for the bus operators in the face of government failure to stand up to vested interests" (Knowles & Abrantes, 2008, p. 104). Moreover, research has shown that Quality Partnerships "when introduced as a stand-alone policy

social, economic and environmental goals in the field of transport policy is greater in low-density areas, where car dependence is stronger.

[65] Policy measures aimed at *changing the built environment* were reviewed in the previous section (§5.1.1).

struggle to achieve significant modal shift and traffic decongestion" (Davison & Knowles, 2006, p. 177). Labour governments however had more success in introducing concessionary fares (Preston & Almutairi, 2013, p. 209). Overall, local bus demand (measured as passenger journeys) has increased in Great Britain since the turn of the century, but only as a result of increasing bus demand in London, offsetting the stagnation of passenger journeys in the rest of country since 1997 (Preston & Almutairi, 2013, p. 209). Clearly, Labour transport policies have not brought about a significant modal shift towards local buses in the country as a whole.

With regard to *light rail*, the picture is also bleak. While light rail is historically less developed in British cities than elsewhere in Europe (Knowles & White, 2003; Rye, 2008), early Labour policy documents (DETR, 2000c) strongly encouraged the development of light rail, by setting ambitious targets (doubling light rail use by 2010 and delivering 25 new routes), prompting Knowles and White to state in 2003 that "England could be on the verge of becoming a European leader in light rail" (p. 145). However, the targets were scrapped a couple of years later (Knowles, 2007), leading Knowles and Abrantes to conclude, in 2008, that "after 25 years of dashed hopes for light rail in Britain, it is now clear that its future expansion, at least in England, will be limited" (p. 111). Moreover, the evidence about the effectiveness of existing British light rail schemes in discouraging car ownership and use is mixed (Knowles, 1996; Lee & Senior, 2013).

With regard to *railways*, the evidence is more positive, with passenger kilometres increasing substantially since the privatization of the mid-1990s (not reversed by subsequent Labour governments) (Shaw & Farrington, 2003; Preston, 2008; Preston & Robins, 2013). However, rail fares have also increased in real terms throughout the period, and so have those of bus and coaches, while the cost of motoring has fallen (Shaw & Docherty, 2008, p. 15). Also, Rye (2008) shows that in the UK public transport fares have increased more rapidly than the EU-25 average over the period 1996-2005 (p. 215-216). This is consistent with past trends, but not with the goal of encouraging modal shift.

With regard to *nonmotorised modes* (walking and cycling) policy intentions have not resulted in remarkable changes in aggregate travel behaviour. Since 1996, various governments have promoted an increase in the modal share of walking and transport (DoT, 1996; DETR, 2000d; DfT, 2004d) . Notably, since 2005, the programme "Cycle Demonstration Towns" funded a number of cities to implement "behaviour change programmes – including both infrastructure and Smarter Choices measures - to increase cycling for short urban trips" (DfT, 2010a, p. 6). However, despite increasing action at the local level, and £150m invested in promoting cycling infrastructure, "the levels of utility cycling have scarcely changed and (..) remain well below levels in comparable continental European countries" (Pooley, 2011, p. 2). This stands in stark contrast with the ambitious targets set by the Department of Transport in 1996: doubling bicycle use by the year 2002, and quadrupling it again by 2012 (DoT, 1996). Similarly, the national targets set for walking in 2000 (DETR, 2000d, p. 32) have not been met: the proportion of trips where walking is the main mode has not increased to one third by 2008 – but it has remained stable at around 10-11% over the period 2002-2010 (source: own elaboration on NTS 2002-2010 data). There are several reasons for this failure. According to Tolley (2003; 2008), the shift of Labour transport policy from a sustainable agenda to the reduction of congestion has impacted negatively on the chances to increase active travel. Similarly, Aldred (2012) observes that:

> "infrastructure aimed at encouraging cycling was only permitted if it would not adversely impact 'other modes' (i.e., the car). While modal shift was encouraged as a headline goal, this was not translated into clear commitment to increase cycle trips and reduce car trips, and reducing motor vehicle capacity remained seen in most cases as politically untouchable" (Aldred, 2012, p. 100)

Finally, the research team lead by Pooley (Pooley, 2011; Pooley, et al., 2013), based on quantitative and qualitative empirical results from a number of British cities, has argued that "policies to increase levels of walking and cycling should focus not only on improving infrastructure (..) but also must tackle broader social, economic, cultural and legal factors that currently inhibit walking and cycling" (Pooley, 2011, p. 1).

With regard to *pricing* measures (§1.6.4), the Labour years have seen a considerable amount of discussion about road pricing and congestion charging, as well as more action than in other comparable countries. Indeed, while forms road pricing had been discussed in the UK at least since the 1960s (Banister, 2002, p.

26-27), notably for London (p. 39), the White Paper of 1998 vowed to "make increasing use of economic instruments such as pricing and taxation to send clear signals about the wider social and environmental impacts of travel decisions" (DETR, 1998a, p. 21). Furthermore, it identified "dedicated income streams from road user charging and parking levies to fund local transport packages" as a "new way of funding" transport (p. 83) and it envisaged the introduction of charging schemes for motorways and trunk roads (p. 104). Two years later, it also established the principle of hypothecation, i.e. "ring-fencing revenues from fuel duty increases and local congestion charging or workplace parking schemes solely for investment in transport" (DETR, 2000c, p. 5). The Ten-Year Plan of 2000 also encouraged local authorities to "set up congestion charging schemes and/or workplace parking levies in their areas in order to tackle congestion and other problems" going as far as to assume that "eight of our largest towns and cities will introduce congestion charging schemes and a further twelve will bring in workplace parking schemes over the next decade" (DETR, 2000c, p. 35). However, while 35 authorities showed an interest (Walton, 2003, p. 98), as of 2008, only one authority outside London (Durham) had adopted a (small-size) charging scheme (Shaw & Docherty, 2008, p. 11) and another one (Nottingham) a Workplace Parking Levy scheme (Ison & Burchell, 2012). Two other major British cities tried to introduce congestion charging: Edinburgh (McQuaid & Grieco, 2005; Saunders, 2005; Gaun et al., 2007; Gorman et al., 2008) and Manchester (Ahmed, 2011; Vigar et al., 2011), but both schemes were rejected by voters in referenda. The Government also made a feasibility study into a nationwide road-charging scheme (DfT, 2004c), with the goal of "moving away from the current motoring taxation system, and introducing charges to use roads that vary depending on how congested they are" (p. 2). However, the plan was shelved after 1.7 million people signed an online petition against charging in 2007 (Parkhurst & Dudley, 2008, pp. 68-69). Similarly, the fuel price escalator introduced in 1993 by the Conservatives for environmental reason, and later increased by Labour to 6% per year ahead of inflation, was abolished in 2000 as a result of protests against the rising cost of fuel (Docherty, 2003, p. 11, 20). In the meantime, scholars had highlighted that the impact of the escalator was hardest on car dependent households in rural areas (Gray et al., 2001). To sum up, then, lack of public acceptability goes a long way in explaining why pricing measures were not implemented on a large scale in Britain during the Labour's years.

Finally, with regard to *soft transport policy measures* (§1.6.5), there has been a certain progress. After commissioning a report on their potential to achieve traffic reductions (Cairns et al., 2004), the Department for Transport sponsored these measures (DfT, 2004e), implementing Smarter Choice Programmes in three middle-sized 'Sustainable Travel Demonstration Towns' (Darlington, Peterborough and Worcester). The implemented measures included personal travel planning, travel awareness campaigns, promoting walking and cycling, public transport as well as workplace and school travel plans (Sloman, et al., 2010, p.5). According to the progress report by Sloman and colleagues (2010), the initiative has been a success, resulting in car trips reductions and increasing use of modal alternatives; the authors therefore conclude that "the current evidence base is sufficient to justify a substantial expansion of implementation of Smarter Choice Programmes" (p. 8). To the knowledge of this author, however, this did not happen and the programme concluded in 2008/2009.

Overall, despite expectations, 13 years of 'sustainable transport' policies under Labour have not brought about significant results. Indeed, Goodwin (2008) has argued that:

> "there is not a single voice – in government, in opposition, among stakeholders or in academia – who would say that an extrapolation of the vagaries of the last decade indefinitely into the future can be described as 'sustainable', in any of the disputed senses of the word" (Goodwin, 2008, p. 231)

Similarly, Rye (2008) observed that:

> "outside London, the average English person will not have observed much change in their local or regional transport system (..). Overall, the key variables that affect mode share – the relative journey time and journey cost by car and by public transport, and to a lesser extent the quality and reliability of public transport – have changed little in most places during this period" (Rye, 2008, p. 225)

The exception in this context is London (Knowles & White, 2003; White, 2008), where policies and trends have been different. Notably, contrary to what observed for the rest of the country, public transport use increased strongly, while car use decreased up to 2010 (Metz, 2012, p. 21-22). Cycling also increased, although growth is concentrated among certain social groups and in central areas (Pooley, et al., 2013, p. 67). This has prompted White (2008) to state that London is “the only jurisdiction in the UK to have met the aspirations of A New Deal for Transport” (p. 188). The following factors contributed to this result. Firstly, the bus deregulation reform of 1985 did not apply to the British capital, where the model of ‘authority initiated competition’ through ‘competitive tendering’ (van de Velde & Wallis, 2013) was implemented instead. This allowed London local government to maintain control over the public transport network. Indeed, several commentators have observed that this system is better adapted to delivering sustainable transport. In a recent assessment of the long term impacts of the bus reforms of the 1980s, Preston and Almutairi (2013) conclude that welfare increases per capita have been “five times greater in London” (p. 208), as compared to the rest of the country. Similarly, the Urban Task Force (UTF, 2005, p. 8) has suggested to extend the London system to the rest of the country, in order to facilitate higher-density mixed use development. Secondly, the devolution of powers to the Greater London Authority made it easier to implement a sustainable transport agenda: indeed Marsden and May, in a study of local transport policy and implementation in London, West Yorkshire and Edinburgh (2006), find support for the hypothesis that “a single conurbation authority, with lower tier authorities responsible for detailed implementation, is more effective than separate, potentially competing single tier authorities” (p. 24). Thirdly, congestion charging was introduced in Inner London in 2003 and was generally greeted as a success (Banister, 2004; Santos & Shaffer, 2004), although its net impact is still the object of controversy (Givoni, 2012) and further extensions of the charging area have encountered problems of public and political acceptability.

The rise to power of the Liberal-Conservative coalition in 2010 has arguably marked a further retreat from the sustainable transport agenda, with the new Secretary of State for Transport declaring in his very first interview that he would “end the war on motorists”, because “motoring has got to get greener but the car is not going to go away” (Millward, 2010). For example, the Coalition opposes road pricing and local charging and has vowed to stabilise fuel prices (Butcher & Keep, 2011). Consistently, the 2011 White Paper “Creating Growth, Cutting Carbon. Making Sustainable Local Transport Happen” (DfT, 2011a) shifts the focus of British transport policy towards economic growth and “making car travel greener”, while modal shift is given comparatively less attention. Pro-cycling policies have also been negatively affected (Aldred, 2012, p. 100).

5.1.3 Transport and social exclusion

As illustrated in §2.1.2, transport-related social exclusion as a research and policy issue has attracted considerable attention in the UK. In the words of Lucas and Currie, Britain is “a world leader in this policy agenda” (2012, p. 154). While a social dimension of transport policy was briefly discussed in national policy documents at the end of the 1970s (Banister, 2002, p. 43), it was not until the New Labour governments of the 1990s that the issue was really addressed. In the meantime, the bus deregulation reforms of the 1980s arguably contributed to make the problem of transport disadvantage both more pervasive and more visible (Hine & Mitchell, 2003, p. 27; Docherty & Shaw, 2008, p. 8). This goes some way in explaining the greater attention given to the topic in the UK, as compared to other European countries (cfr. §2.1.2).

As illustrated in §2.1.2, with the election of Labour in 1997, ‘social exclusion’ became a key policy concept in Britain, as shown by the launch of the Social Exclusion Unit (SEU). The social impacts of transport started to be acknowledged, as shown by the report on ‘Social exclusion and the provision of public transport’ published by the Department of Environment, Transport and the Regions in 2000 (DETR, 2000e). In 2003, the SEU published the report ‘Making the Connections: Final Report on Transport and Social Exclusion’ (SEU, 2003).The main outcome of the report was the proposal to implement ‘Accessibility Planning’ at the local level. This idea has been developed and tested in the following years (DHC and University of Westminster, 2004; DfT, 2006; Lucas, 2006), and starting from 2006 local authorities have been required to include accessibility plans in their travel plans.

The general framework of accessibility planning is described shortly in §2.4.1, and it is thus not repeated here. The outcomes of several years of accessibility planning have recently been evaluated by Kilby and Smith (2012), who have reviewed initiatives of relevance to accessibiltiy planning (personalised travel planning/training, 'Wheels to Work' schemes, demand responsive transport, community transport, and mobilised services) in a number of case study authorities, concluding that "most of the initiatives seemed to have a positive direct impact for users" (p. 26). Overall, the authors conclude that while accessibility planning "had an influence in developing understanding about, and the 'identity' of accessibility as a local policy objective" (p. 7), it "is not yet being embraced as a cross Government concern but tends to be viewed by non-transport agencies, locally and nationally, as a responsibility of transport authorities" (p. 34), and "there is need for greater evidence to inform (it)" (p. 35).

In the remainder of this section, I review some examples of policies aimed at tackling transport related social exclusion in the UK. In doing this, I refer to the typology of policies put forward in §2.4. As many of the policy examples illustrated in §2.4 referred to the British context, they are only briefly recalled here.

With regard to *changing transport decision-making* (§2.4.1), as accounted above, the very goal of accessibility planning was to introduce accessibility considerations into local transport plans, and this seems to have been achieved (Kilby & Smith, 2012). Also, reforms of transport decision-making implemented since the 1990s have arguably led to more attention for accessibility: indeed, accessibility is one of the additional appraisal criteria introduced in the 'New Approach to Appraisal' (NATA) (see §5.1.2 above).

With regard to *changing land use and urban planning* (§2.4.2), I illustrated in §5.1.1 how many spatial planning documents since the PPG13 of 1994 (DoE and DoT, 1994), stressed the importance of locating housing, workplaces and services in places that are accessible for non-car users. While the main goal of these directions was to reduce car travel and its negative environmental impacts, they would also contribute to reduce the intensity of car deprivation (to adopt the terminology put forward in §2.2). There is also evidence that the practice of accessibility planning at the local level has sometimes led to the choice of more accessible locations for public services, by revealing the hidden transport costs of relocating services in car-dependent areas (Halden, 2009, p. 4), although Halden observes that "for every situation where accessibility has been maintained or improved through the planning system, there remain many more examples where development has been allowed to proceed in unsustainable locations" (*ibidem*). Overall, as observed in §2.4.7, changing land-use and the built environment can be considered as a 'win-win' solution with respect to the social and environmental impacts of transport: therefore, much of the British policies illustrated in §5.1.1 are also likely to reduce car-related transport disadvantage.

With regard to *improving modal alternatives* (§2.4.3), this is probably where accessibility planning had the most impact. Lucas, Tyler et al. (2008) have investigated the value of providing new public transport in deprived areas in British cities, showing that increased public transport supply resulted in more travel, better access to work, more social capital, expanded travel horizons and cost savings for residents, as well as in wider social benefits for their communities. On the other hand, however, early work on transport and social exclusion in Britain had identified Statutory Quality Partnerships and Quality Contracts as promising ways to deliver 'transport inclusion' (Hine & Mitchell, 2003; SEU, 2003). The fact that these have (virtually) not been picked up is arguably bad news for this policy agenda. By contrast, community transport services are well developed in the UK (Jones, 2004) with 15-million trips provided by the 1,700 community transport organizations in England in 2010 (DfT, 2011b, p. 4). In 2011, the government also published a guidance for local authorities on community transport (DfT, 2011b).

With regard to *promoting car ownership and use* (§2.4.4), despite repeated calls for measures that improve access to cars among transport disadvantaged groups, these have failed to be implemented on a large scale. Indeed, in their international review of auto-programs, Fol and colleagues (2007) conclude that these are less common in the UK than in France and the US. The recent evaluation report of accessibility planning (Kilby & Smith, 2012) lists "Wheels-to-work" initiatives among the most important measures implemented at the local level, but these are generally based on the lending of scooters rather than cars.

With regard to *education and training* (§2.4.6), "widening travel horizons" was identified by the SEU report (2003) as one of the five key "measures that can help tackle accessibility problems" (p. 6). Indeed, personalised travel training initiatives have been implemented in several local areas to address invidual barriers to access, by providing people with tailored travel advice (Westwood, 2004; Kilby & Smith, 2012).

More recently, Lucas (2012) has voiced concern that the "transport and social exclusion agenda appears to be on the wane in the UK" (p. 111), as a result of economic austerity measures and cuts to subisidies to public transport services. Similarly, Kilby & Smith (2012) have reported negative consequences of spending cuts on funding for buses on non-commercial routes, in rural areas and in off-peak times, as well as for community transport, dial-a-ride and school transport schemes (p. 8).

5.2. Car ownership in the UK: existing research

5.2.1. Car ownership trends

In the last decades, general trends in travel behaviour for the British population were similar to those observed in other developed countries (see §1.1.1): travel distances and speed have considerably increased, while per capita trip rates and the average time spent on daily travel have remained approximately constant (Banister, 2011; Metz, 2010). In detail (DfT, 2010b; Banister, 2011, p. 956), in 1972/73, the average distance travelled per year in Great Britain was 4,476 miles, a figure which has increased to 6,775 in 2009. In the meantime, however the time taken to cover this distance has remained quite stable at around one hour per day (353 hours per year in 1973/73, 372 in 2009). Similarly, while average trip length has almost doubled in the last forty years (4,7 miles in 1972/73, 7 in 2009), the average trip time is virtually identical at around 22-23 minutes. This corresponds to an increase in speed of 44% (DfT, 2010b; Banister, 2011, p. 956). Most of these changes can be attributed to increasing car ownership and use. As Banister (2002) argued:

> "the total amount of travel by road (..) has increased in the last 30 years by almost three times with only 8% of that figure attributable to population increase. The remainder is due to increases in mobility, which relates to the amount of travel in terms of the numbers of journeys, and the lengths of those journeys. (..) Across the whole period it has been the growth in car travel, which has explained almost all the increase. (..) *This increase in mobility reflects the increased motorisation and the changes in location facilities, which have become more dispersed and distances between them have increased*. These longer journeys make it less convenient to walk or cycle, or to use the bus" (Banister, 2002, p. 2, emphasis added)

With regard to household car ownership, Fig. 5.1 shows trends for Great Britain for the last decades, as well as forecasts for the next twenty years: these are based on figures reported by Whelan (2007), who developed a forecasting methodology for the Department for Transport[66].

The graph shows clearly that the proportion of households without cars has declined sharply in the second half of the 20th century, from 86% in 1951 to 26% in 2001. Since the turn of the century, however, it seems to have stabilized, and according to the forecasts that it will reduce by only 6 percentage points by 2031. Interestingly, the proportion of households with one car has not increased since the mid-1960s (see also Leibling, 2008, p. 4), and is also expected to be stable at around 44% over the next 20 years (Whelan, 2007, p. 217). However, the motorisation rate is expected to increase as a result of the growing number of households with two or more cars (*ibidem*).

Overall, it seems that motorisation growth is slowing down in Great Britain, as compared to the second half of the twentieth century. In 2009, the motorisation rate of the UK was 470 passenger cars per 1,000 inhabitants, lower than the EU-15 (503) and the EU-27 average (473) (European Commission, 2011, p. 79). However, Leibling (2010a) shows that, given the lower motorway provision, Great Britain's figure for cars related to road length is higher than in many other developed countries (p. 12). This might help explain the importance of the congestion issue in the British transport policy debate (see §5.1.2 above), arguably greater than in other comparable countries (such as Germany, see §4.1.2).

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[66] The forecasts make several assumptions, including a 2.25% per annum growth to GDP, reductions in car purchase costs and stable real car use costs from 2001 onwards (Whelan, 2007, p. 217).

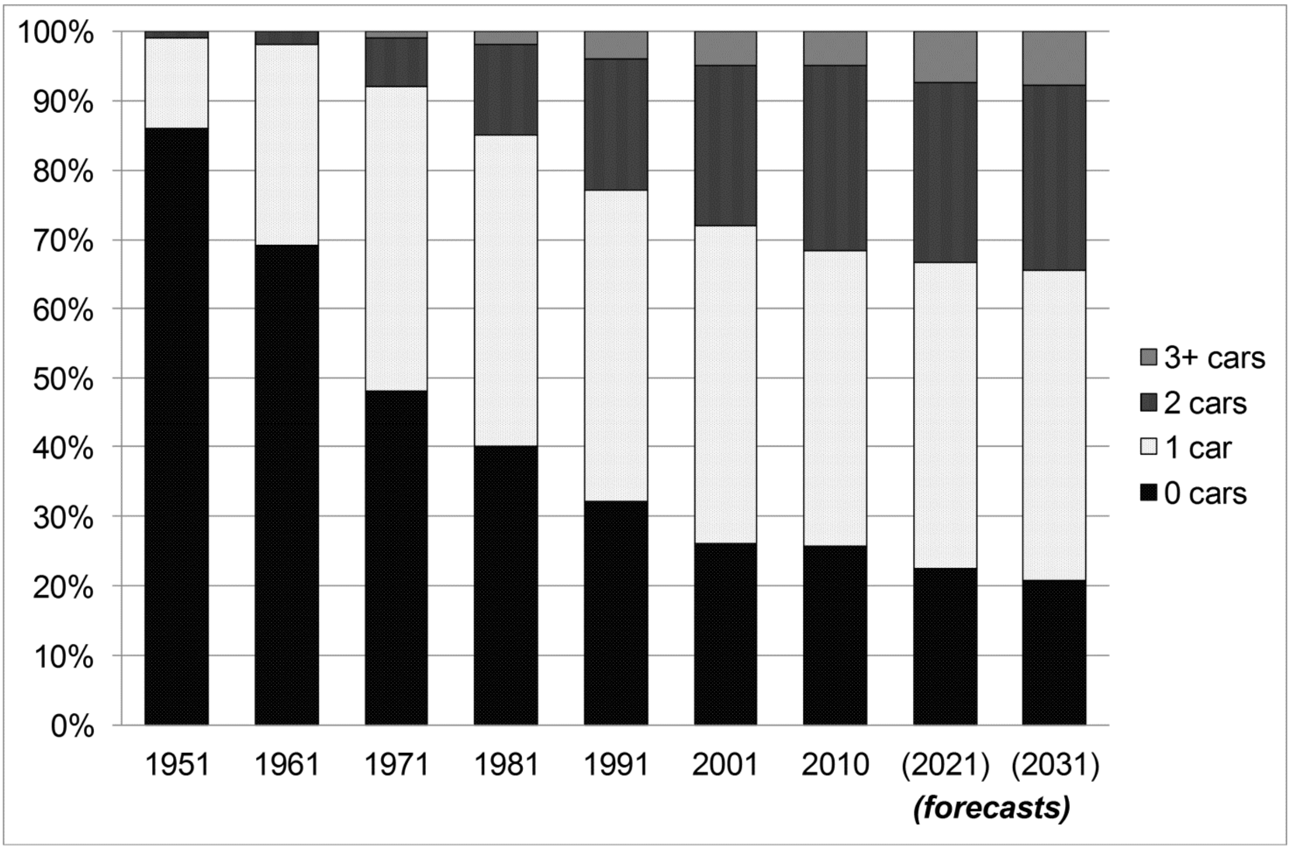

Fig. 5.1 – Household car ownership in Great Britain, 1951-2031. Source: Whelan (2007, p. 206) for the years 1951-1991; own elaboration on NTS 2010 data for the year 2010; Whelan (2007, p. 217) for the years 2021 and 2031.

Despite the slowing down of the motorisation process, Lucas and Jones (2009) point out that, since 1995, car ownership "has spread to what were traditionally non-driving sectors of the population, including lower income households, women between the ages of 18 and 65, and men of 65 years and over" (p. 20). Some of these trends are discussed more in detail below. More recently, Le Vine and Jones (2012) have highlighted that the slowing down of car ownership growth is almost entirely due to a sharp decrease in company car ownership since the mid-1990s, while 'private' car ownership increased steadily throughout this period (p. 40). Indeed, the share of company cars on the vehicle fleet is traditionally higher in the United Kingdom than in other European countries (Dargay et al., 2008, p. 45).

The historical growth in car ownership has obviously been accompanied by huge increases in car use: between 1975/76 and 1999/2001, car use increased by 67%, much to the detriment of the modal share of walking, cycling and bus (Knowles, 2006, p. 411). However, as illustrated in §1.1.4, a recent wave of studies has shown that in recent years the historical trends towards more car use and distance travelled have slowed down and even come to a halt in Great Britain (Kwon & Preston, 2005; Le Vine et al., 2009; Lucas & Jones, 2009; Metz, 2010; Le Vine & Jones, 2012). As car ownership is still increasing, this implies that cars are used less intensively than in the past (Lucas & Jones, 2009, p. 144) and that the historically strong relationship between car ownership and average car travel per capita is getting weaker[67] (Le Vine et al., 2009, p.8).

In the remainder of this section, based on a literature review, I illustrate how the trends towards increasing car ownership of the last two decades vary according to key variables such as income, type of area, age and gender.

[67] This trend has been observed also in Germany (see §4.2.1).

With regard to *income*, the study of Dargay et al. on the dynamics of car ownership in EU countries (2008) suggests that in 1994 the UK had a higher than average inequality in the distribution of households with access to a car by income quintile. Also, the percentage of households in the lowest income quintile who said that they “would like a car but cannot afford one” was 23%, higher than in all other countries considered except Ireland, Spain and Portugal (that however, had lower GDP per capita). This is consistent with higher income inequality levels in the UK as compared to other European countries (Wilkinson & Pickett, 2010). However, the increase in car ownership in the last 15-20 years has been considerably stronger for low-income households: as a result, the differences in car ownership across income quintiles are reducing (Le Vine et al., 2009; Lucas & Jones, 2009; DfT, 2010b; Stokes & Lucas, 2011). Stokes and Lucas (2011) show that ownership rates have increased even more rapidly (from 20% in 1995 to 50% in 2008) among those with the lowest income in absolute terms (£5,000 per year or less) (p. 39). According to Lucas and Le Vine (2009), “this trend of increasing car ownership even amongst the lowest income groups can be taken as an indication of the basic social and economic need to own and use cars in (..) the UK” (p. 8).

Such trends have raised concerns about the incidence of car-related economic stress (§2.2.2) among low-income motorised households. On this point, the evidence is complex. Indeed, while the share of household expenditure spent on transport has increased in the second half of the twentieth century (Bayliss, 2009, p. 20), it has remained stable at around 15% since the mid-1980s (Metz, 2010, p. 663). However, this trend played out differently across income quintiles: indeed, Bayliss (2009) shows that differences in absolute spending on transport between low and high income quintiles have reduced over the period 1974-2007, and that by 2007 spending on motoring dominates in all income ranges (p. 20). Based on data for 1998/99, Lucas and colleagues (2001, p. 11) show that low-income households as a whole are those who spend the least on motoring, because of lower car ownership rates; however, if only car-owning households are taken into account, the share of expenditure spent on motoring is highest (24%) for the lowest income quintile, and lowest (15%) for the highest. This conclusion is broadly confirmed by Bayliss (2009) based on figures for 2007; also, he points out that poorer households tend to spend more on maintenance and running than other households, because they buy cheap, used vehicles and tend to keep them much longer (p. 21-22).

Overall, existing evidence suggests that the low-income group is very diverse with respect to travel behaviour and (therefore) expenditure. Based on a cluster analysis of NTS travel diary data, Stokes and Lucas (2011) show that a large part of the low-income group consists of young and older people in carless households who make little travel; however, there is also a small group of working people who commute by car, but make few other journeys, suggesting that “they need a car for their work, but do not have the resources to use it for much else” (p. 55). According to their analysis, the size of this group is increasing over time (p. 7). Bayliss (2009) also observes huge differences in travel expenditure between car-owning and carless households in the two lowest income quintiles (about eight times higher) (p. 8-11), suggesting that this might be a by-product of the high share of people who are eligible for concessionary fares on public transport (p. 23). The author also finds evidence in support of the hypothesis that low-income households rely on car-lifts more frequently (p. 18-19).

Overall, existing evidence suggests that car-related economic stress is an increasingly common experience for low-income households in Britain. Based on the analysis of car ownership data, Stokes and Lucas (2011) suggest £10,000 per year as a threshold under which car ownership is likely to result in financial stress (p. 64). This is plausible, since the cost of running a mid-range family car for 10,000 miles a year has been estimated at £6,000 (Sustainable Development Commission, 2011, p. 15). The results of qualitative research tend to confirm these conclusions. In the focus groups conducted for their research on motoring in Britain, Lucas and Jones (2009) have found high levels of concerns for the costs of motoring, that was referred to by participants as the most significant disbenefit of car ownership; also, participants reported that they were ready to cut other areas of expenditure in the event of increased fuel costs, rather than give up their cars. This is consistent with the findings of a recent qualitative study on the travel needs of low-income households in the UK (Taylor et al., 2009), concluding that car costs are attributed “a high level of priority compared to other household costs” (p.7).

With regard to differences across *types of area*, it has been observed that in the last two decades car ownership has increased faster in rural areas, as compared to other types of area, notably London (Lucas & Jones, 2009; Le Vine & Polak, 2009). Fig. 5.2, based on published data and own elaboration of NTS data, illustrates this widening spatial gap in motorisation.

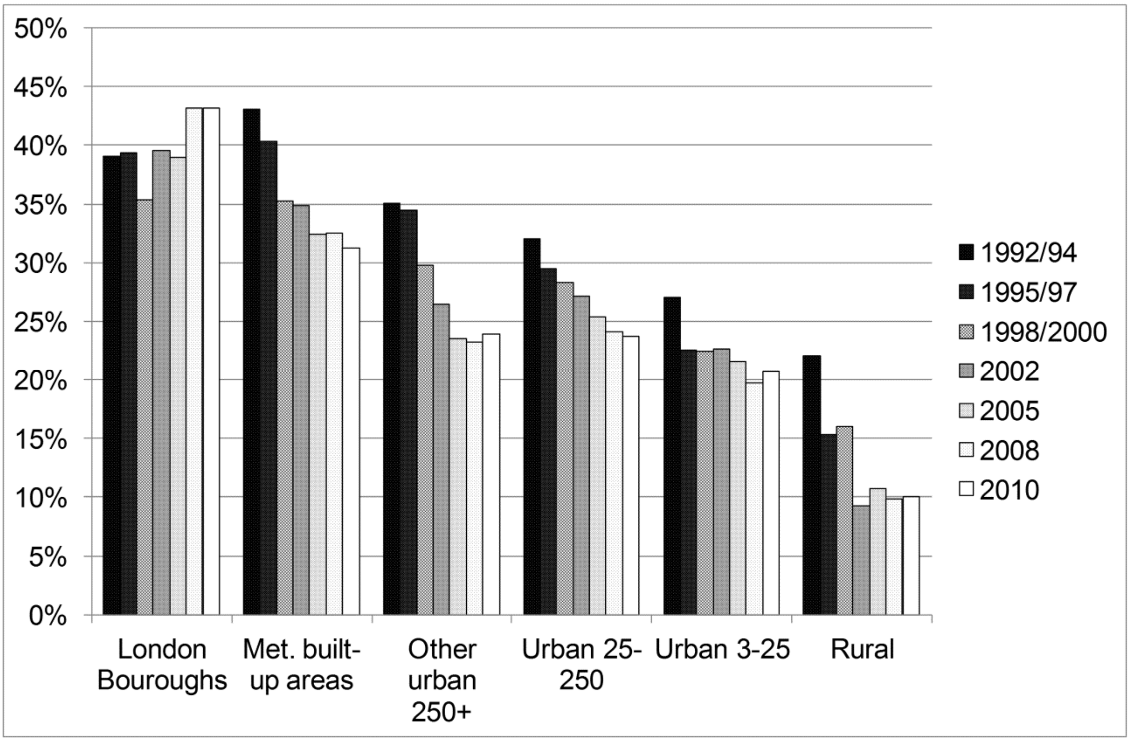

Fig. 5.2 – Households without cars in Great Britain, 1992-2010, by type of area[68] (percentage values). Unit of analysis: households. Sources: Department for Transport (2004f, p. 4) for the years 1992/94; own elaboration on NTS 1995-2001 and NTS 2002-2010 data (interview sample) for subsequent years.

Fig. 5.2 shows how the decreasing trend of non-car ownership over the period 1992-2010 varies according to the type of area: while the proportion of carless households has dramatically decreased in rural areas (-54% percent change over the period), it is stable at around 40%, and even perhaps increasing in recent years in London. In all other types of areas the reduction amounts to -20/-30% percent change between 1992/94 and 2010. In a nutshell, it appears that over time differences between areas are deepening: in other words, in very large cities like London motorisation has progressed the least in the last decades. By contrast, it is in peripheral and rural areas that car ownership has increased the most[69].

Arguably, this is the continuation of a long-term trend, as confirmed by a comparison of current figures for non-car ownership with those reported in an early research paper by Paaswell (1973, p. 356): in 1973, the percentage of carless households was 58% in Southeastern UK; in detail, the values were 58% in 'Greater London', 41% in the 'Outer Metropolitan Area' and 52% in the 'remainder'. The author commented the data observing that, while "in the U.S. those without cars live principally in the larger cities, in the denser central areas (..) the U.K. figures do not show as dramatic a difference between central city and suburb" (p. 357-358, emphasis added). Figures for 2010 suggest that in the last 40 years non-car ownership has decreased dramatically in the South-East region around London (15% of households without cars), but not in the British capital (43% in Greater London).

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[68] The variable 'type of area' in NTS has been updated since 2001.

[69] A similar trend has been observed for car modal share, that has increased in rural areas since the mid-1990s, while it has remained stable in other types of area (Lucas & Jones, 2009, p. 74).

With regard to the last two decades, Le Vine and Polak (2009) also show that car ownership has increased most in areas with poor public transport accessibility (p. 48), concluding that "the "location" relationship with car ownership broadly strengthened whilst the "income" effect weakened" (p. 50).

In this context, the situation of London is worth noting. In the British capital, motorisation has remained stable and even slightly declined in the last 15 years (Whelan et al., 2010), with larger drops for wealthier households (Le Vine & Jones, 2012, p. 63). In a recent car modelling study, Whelan and colleagues (2010) observe that this might be (also) the result of policies implemented in London (see §5.1.2 above), as variables such as public transport levels of service, and walk/cycle accessibility to key attractions turned out to be significant predictors of car ownership (p. 20). However, they also predict that the total volume of cars will increase by 40% between 2008 and 2036, partly as a result of population growth and demographic change (in terms of household structure, income and age).

Given large (and increasing) differences in car ownership levels, some scholars have focused on the high level of car dependence of British rural areas. As illustrated in §1.3.4, in a study focused on elasticity Dargay (2002) has observed that car ownership in British rural areas is considerably less sensitive to changes in motoring costs and income (as compared to urban areas). She concludes that the car is "more of a necessary good" there (given the poor provision of alternative modes of transport), and thus "the possibility to adjust to increasing in motoring costs will be more limited" (p. 352). A similar conclusion is reached by Smith and colleagues (2012), whose focus group data show that when members of the public in British rural areas are asked to reach consensus about a minimum acceptable living standard, they generally agree that the car is necessary: this stands in contrast with other areas, where a vehicle is not mentioned.

With regard to differences between *age groups*, several authors have observed that, since the 1990s, new cohorts of young people (aged 29 or less) are becoming less car-oriented in terms of driving licence ownership, car availability and car use (Noble, 2005; Lucas & Jones, 2009; Kuhnimhof et al., 2011; Le Vine & Jones, 2012). This is consistent with what observed in other developed countries, including Germany (infas, 2010c; Kuhnimhof et al., 2011; Kuhnimhof, Armoogum et al., 2012; Kuhnimhof, Buehler et al., 2012; see §1.1.5 and §4.2.1). However, this trend is offset by a strong increase in the number of older drivers over the same period (Lucas & Jones, 2009; Le Vine & Jones, 2012): indeed, between 1995/97 and 2008, "the proportion of people aged 70 and over who held a full driving licence increased from 38 per cent to 53 per cent" (DfT, 2010b, p. 27). Also this development is consistent with trends observed in other countries (see §1.1.5 and §5.2.1).

Disaggregate analysis has shown that this change of trend for younger cohorts is mostly attributable to young men, while key indicators for young women continue their historical upward trend. As a result, the gender gap in car availability has virtually disappeared among young adults (Lucas & Jones, 2009; Kuhnimhof et al., 2011). Yet the gap remains significant (albeit reducing) for older cohorts: notably, "women are twice as likely to be a non-driver in a household with a car than are men" (Lucas & Jones, 2009, p. 31); this demonstrates that the issue of gender inequality in car access in low car ownership households (see §2.2.1, §3.2.3) applies to the UK. In an effort to explain the downward trend of car use among young men in their 20s, Le Vine and Jones (2012, p. 45-51) have concluded that half of it should be attributed to decreasing car availability, while the other half is the result of decreasing car use among young men with car access (i.e. increasing multimodal behaviour). This is also consistent with what observed in other countries (Kuhnimhof et al., 2011).

There is no certainty about the reasons for this trend change among young adults. The following reasons are cited in the literature: economic reasons, including increasing cost of motoring (and of learning to drive), increasing cost of higher education and decreasing income among young adults (Bayliss, 2009, p. 5; Leibling, 2010b, p. 6; DfT, 2010b, p. 27; Metz, 2012, p. 24); the postponement of adulthood and family formation, as indicated by the increasing proportion of young people living with their parents, decreasing likelihood of marrying, increasing participation in higher education and decreasing workforce participation (DfT, 2010b, p. 27; Metz, 2012, p. 24; Le Vine & Jones, 2012, p. 48-50; Kuhnimhof et al., 2011); increasing urban living (notably in London), partly related to increasing participation in higher education (Le Vine & Jones, 2012, p. 90-92); substitution of physical travel by ICTs (Kuhnimhof et al., 2011). Le Vine and Jones

(2012) also mention increasing incidence of part-time work and home renting among the possible determinants (p. 50, 92-93). Overall, Kuhnimhof et al. (2011) argue that, since this trend is observed in several countries, the reasons must be found in “structural changes leading to an increasing share of young people belonging to a segment of society that is less auto-orientated” (p. 17), rather than in country-specific factors.

It is still unclear whether these changes have lasting effects on the travel behaviour of new cohorts. While car ownership and use (just like family formation and suburban living) might just be ‘postponed’, Noble (2005) puts forward the hypothesis that “young people may get used to using alternatives to the car (..) and never choose to drive” (unpaginated). This would have a considerable impact on future trends in travel behaviour (Noble, 2005; Kuhnimhof et al., 2011).

Finally, existing evidence highlights the difficulties involved in reducing car ownership and use in the UK. Attitude surveys show that a large majority of British motorists (approximately 80%, stable in the last 20 years despite increasing motorisation) agrees that they would find it very difficult “to adjust their life to being without car” (Leibling, 2007, p. 11-13; Lucas & Jones, 2009, p. 89-90), pointing at the location of home and work and shopping trips as the main reasons (Lucas & Jones, 2009, p. 82). This contrasts with the high percentage of motorists (66%) agreeing that everyone should reduce their car use for the sake of the environment (p. 86). Lucas and Jones (2009) conclude that “people’s attitudes to driving have remained fairly consistent over the last twenty years (..). Currently, the majority of the population (even those who do not themselves own cars) tend to favour car travel over any other mode of transport” (p. 106). The findings of research into minimum income standard for the UK by Smith and colleagues show that the car is considered as an essential part of a minimum acceptable living standard by rural households (Smith et al., 2012) and, since 2012, by families with children regardless of location (Davis, Hirsch et al., 2012), but not by other social groups.

5.2.2. Households without cars: existing research

Unlike in the German case (§4.2.2), to the knowledge of this author there is no monographic study of households without cars in the UK. In this section, I briefly outline some studies of non-car ownership. In doing this, I illustrate the findings and I highlight the limitations of existing studies: the goal is to illustrate how the present thesis adds to existing knowledge on carless households in the UK.

In their report on the car in British society, Lucas and Jones (2009) have investigated car use among non-car owning households, based on NTS and focus group data (p. 45-50, 95-106). They conclude that many carless households rely on lifts by friends and family, notably for food shopping trips and in rural areas. This leads carless people to feel like a burden for others and to feel the need to reciprocate in some way (p. 105-106). With regard to trends, Lucas and Jones highlight that the proportion of non-car drivers in non-car owning households has declined strongly, but only in the two lowest income quintiles (p. 45); however, the share of daily trips made by car (mostly as passengers) in carless households has not increased substantially, oscillating between 12% and 17% between 1989 and 2006 (p. 72). The extent of car use among non-car owning households might explain why in a previous qualitative study on the transport concerns of disadvantaged groups and communities in Great Britain, Lucas et al. (2001) found “a deep anger (..) about measures to restrict car usage or to charge motorists in various ways, even among those without cars” (p. 19).

With regard to the *composition* of the carless group, three studies are worth mentioning. Anable (2005), based on the results of a mail-back questionnaire survey of 666 visitors to National Trust properties in the northwest of the UK in 2002, has used Likert-scale attitude items to segment non-car owning individuals (7% of the total sample) into two clusters (p. 69-74):

- *car-less crusaders* (4% of the total sample), “have sacrificed car ownership for environmental reasons and have positive evaluations of all other modes” (p. 70). They are more likely to use modal alternatives and less likely to use the car than other carless individuals. This corresponds also to lower levels of driving licence and vehicle availability (p. 73)

- *reluctant riders* (3%) are "involuntary users of public transport due to health or financial reasons (..) would prefer to travel by car and either aspire to owning a car in the future or accept lifts by car when possible" (p. 70). With regard to socio-demographics, females, over 65s, pensioners and low income and low education individuals are overrepresented (as compared to car-less crusaders). This group also shows higher driving licence ownership and car availability, which is reflected in the higher modal share of the car (25% of trips). Overall, they are characterised by lower use of modal alternatives, both in the past and in the future (self-reported intention) (p. 74)

Overall, Anable seems to overlook the socio-demographic differences between the two groups, arguing that "any differences that do exist within the sample do not appear to be reflected in the cluster solution apart from between the car-owner and non-car-owner groups" (p. 71). This is consistent with her main argument that "socio-demographic factors (have) little bearing on the travel profiles of the segments, suggesting that attitudes largely cut across personal characteristics" (p. 65), but contrasts with the figures reported in the paper (p. 73). Furthermore, the study is not based on a representative sample, and the survey strategy (focused on visitors of National Trust properties) clearly led to a strong underrepresentation of non-car owning individuals (7% as compared to 20% at the national level in 2002; source: own elaboration on NTS data, see Tab. 7.26 in §7.2.1). Since carless individuals differ in their propensity to visit National Trust properties as well as in their ability to reach them, it is likely that the sample is biased towards more mobile non-car owners.

In a similar study of public perceptions of travel awareness, Dudleston et al. (2005), based on a survey of approximately 1,000 adults in Scotland, have put forward a segmentation of the group of (self-defined) non car users (25% of the total sample), based on 22 attitude items measuring attachment to the car, willingness to change travel behaviour and environmental beliefs (2005, p. 45-51). Their typology consists of three groups (*ibidem*):

- *car sceptics,* accounting for 9% of the total sample, are characterised by high environmental responsibility, awareness of travel and transport issues and initiatives ('travel awareness') and agreement with anti-car policies, as well as low liking of car travel. With regard to socio-demographics, young adults, students and disabled are overrepresented in this group. With regard to travel behaviour, this cluster is the most mobile and relies more on cycling and car use (but less on public transport) than the rest of the carless (p. 49-50)
- *reluctant riders* (7%), are characterised by appreciation of car travel, moderate environmental responsibility and low travel awareness. In this group, retired, disabled and low-income subjects are overrepresented. With regard to travel behaviour, while they rely mostly on public transport, they appear to "carry out a significant number of their journeys as a car passenger when they can" (p. 50)
- *car aspirers* (9%)*,* are characterised by a strong desire for car ownership (although not for status or hedonistic reasons) and low environmental responsibility and travel awareness. The unemployed are overrepresented in this group. With regard to travel behaviour, they are strongly reliant on buses and have the lowest car use (p. 50)

The report also shows that car use is quite frequent among non-car users, with at least 30% reporting car use 'at least some times' for the following activities: leisure activities at the weekend, visiting friends and relatives, evenings out, supermarket shopping and taking children to leisure activities (p. 25).

A recent study by Melia, Barton and Parkhurst (2011) has tried to assess the potential consumer demand for housing in carfree developments in the UK. The survey targeted members of environmental and utility cycling organisations and residents of the Inner London wards with the low car ownership and high median income, as these populations were expected to contain high concentrations of "carfree choosers" (defined as non-car owners who "do not own a car by choice") and "carfree possibles" (defined as car-owners who "would like to give up car ownership under foreseeable and feasible circumstances") (p. 7). The results show that self-described carfree chosers are young and significantly wealthier than other non-owners, and also tend to use buses less and cycle more than them (p. 8). With regard to the main reasons for not owning a car, 61% of carfree choosers cited environmental factors (*ibidem*). Also, virtually all members of this group (91%) lived in urban areas, and most of them valued the proximity to public transport, local services and town centres, although 40% stated that they would like to live 'near the countryside' at a later stage in life (e.g. after getting married) (p. 9). The authors conclude that the "greatest potential demand for housing in carfree areas, at least in the short-term, is found amongst Carfree Choosers living in, and preferring to remain living in, larger urban areas" (p. 12), but little is said about the propensity of other non-owners to move to carfree areas.

Overall, this short overview of British literature on the carless suggests that existing research has focused mainly on the attitudes that motivate non-car ownership, while travel behaviour and socio-demographic characteristics have received comparatively less attention. Also, the attempt to distinguish those who 'choose' from those who are 'forced' to live without cars is apparent in the three empirical studies reviewed in this section (Anable, 2005, Dudleston et al., 2005; Melia, Barton and Parkhurst, 2011). This is consistent with what Shove (2010), with reference to the British context, has defined as the dominant 'ABC' paradigm of climate change policy and research[70] (see §1.4.1). Also, the studies that propose segmentations of the carless group (Anable, 2005, Dudleston et al., 2005) are based on the analysis of small scale *ad-hoc* surveys, rather than of available transport survey data; this is arguably explained by the need to include attitude items that are absent from the NTS questionnaires. As a result of small sample size and lack of representativeness, however, none of the authors is able to illustrate how the composition of the carless group varies across different types of area. Accordingly, the spatial dimension of non-car ownership is virtually absent from the studies.

In contrast with existing research on non-car owners in the UK, my goal in this thesis is to show how the composition of the carless group varies across different types of area, based on a secondary analysis of travel survey data that are representative at the national level. In doing this, I focus on socio-demographic characteristics, travel behaviour and (to a lesser extent) accessibility to services and opportunities. As illustrated in §3.4.3, the research hypothesis about the reasons for not owning cars is explored for the German case, but not for Great Britain, given the lack of questions about it in the NTS questionnaire.

5.3. "National Travel Survey": the survey

The British National Travel Survey (NTS) is one of the oldest of its kind, having begun in 1965/66. Further surveys were carried out in 1972/73, 1975/76, 1978/79 and 1985/86. Since 1988, the NTS is carried out on a continuous basis and since 2002 the sample has been increased to about 9,000 households per year (corresponding to approximately 21,000 individuals and 300,000 trips). All households 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 and not for the UK as a whole, since Northern Ireland is not included.

The NTS 2002-2010 has been conducted by the National Centre for Social Research (NatCen), an independent social research institute, 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.

For the analyses reported in §7, I use pooled data from the NTS 2002-2010 database[71] (DfT, 2012). This allows me to work with a larger sample size: this is crucial since the carless, which are the focus of this study, are only a small subset of the total sample. Pooling the data allows for more disaggregate analysis and more robust estimates than would be possible for individual years – notably when the sample is further

[70] As illustrated in §4.2.2, an 'ABC' approach is recognizable also in the German research literature on non-car ownership.

[71] As explained in §C.1.5, a few PSU-level variables used in the analysis are drawn from a previous release of the NTS (2002-2008) (DfT, 2010c). This was also kindly provided by the Economic and Social Data Service (ESDS) through the UK Data Archive at the University of Essex, Colchester.

divided across types of areas. On the other hand, of course, this obscures differences between years. These however are the object of the analysis reported in §7.2.

Tab. 5.1 shows the unweighted sample size for each wave of the NTS 2002-2010 database, with regard to the household, individual and trips datasets.

	2002	2003	2004	2005	2006	2007	2008	2009	2010	Pooled sample
Households	8,849	9,196	8,991	9,453	9,261	9,278	8,924	9,128	8,775	81,855
Individuals	20,827	21,990	21,588	22,702	22,141	21,931	21,165	21,835	20,839	195,018
Trips	278,916	314,845	310,065	322,500	312,347	305,077	295,791	306,743	290,803	2,737,087

Tab. 5.1 – Sample sizes for NTS 2002-2010

For a few analyses in §7.2, in order to take into account longer term trends, I use also data from the NTS 1995-2001 database (DfT, 2010d). The NTS 1995-2001 has been conducted by the ONS 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. Tab. 5.2 shows the unweighted sample size for each wave of the NTS 1995-2001 database, with regard to the household and individual datasets.

	1995	1996	1997	1998	1999	2000	2001
Households	3,631	3,505	3,461	3,307	3,362	3,722	3,768
Individuals	8,901	8,446	8,448	7,963	7,989	8,908	8,853

Tab. 5.2 – Sample sizes for NTS 1995-2001

Further details about the NTS 2002-2010 and 1995-2001 datasets are provided in Appendix C.

PART III – EMPIRICAL STUDY

6. Carless households in Germany: empirical results

In this chapter, I present the empirical results of the secondary analysis for the German case study. The chapter is structured as follows: §6.1 illustrates the findings for Question 1 (§3.3.2), and §6.2 for the second question (§3.3.3).

6.1. Question 1

This section illustrates the empirical results for Question 1 (§3.3.2): the focus is therefore on how the composition of group of households without cars changes across different types of area, with reference to the most recent MiD sample (2008). The section is structured as follows: section §6.1.1 illustrates the systematic differences between households with and without cars. This preliminary step has two goals: first, it allows to interpret correctly the differences between clusters of carless households, that constitute the focus of subsequent steps. Second, it allows me to explore whether and how the determinants of non-car ownership vary across different types of area, thus addressing Question 1 from a different angle. In section §6.1.2, a variety of data analysis techniques (descriptive analysis, odds ratios, logistic regression models) are used to illustrate evidence about how the socio-demographic composition of the carless group varies systematically across different types of area, thus addressing hypothesis H1.1 (see §3.3.2). In section §6.1.3, I focus on the stated reasons for not owning a car, thus addressing hypothesis H1.2: in doing that, I put forward a typology of households without cars, and discuss it at length. In section §6.1.4 I focus on hypotheses H1.3 and H1.4, showing how the composition of the carless group in terms of travel behaviour and accessibility to services and opportunities changes across different types of area. Finally, in section §6.1.5, I discuss the results at a substantive level, in light of the research questions set out in §3.3.2.

6.1.1. Systematic differences between households with and without cars

Of the 25,912 households surveyed in MiD 2008, 2,593 do not own a car. This corresponds to 4,302 individuals and 10,996 trips recorded in the travel diary. Overall, carless households represent 17.73% of the sample, as illustrated in Tab. 6.1[72].

Number of household cars	***Households***		***Individuals***	
	%	***N***	***%***	***N***
0	17.73	2,953	11.25	4,302
1	53.02	13.095	47.26	27.565
2	24.19	8,083	33.80	22.778
More than 2	5.06	1,781	7.69	6,051
Total	100.00	25,912	100.00	60,696

Tab. 6.1 – Number of household cars (percentage values and number of observations). Unit of analysis: households, individuals. Source: own elaboration on MiD 2008 data.

The table also shows that the percentage of individuals living in households without cars is significantly lower (11.25%). Clearly, this indicates that the size of non-car owning households is significantly smaller than that of the average German household. As a result, only slightly more than one in ten people were living in a household without cars in Germany in 2008. The opposite is true for multi-car households, accounting for

[72] In Tab. 6.1, the percentage values do not correspond exactly to the number of observations, because weighting has been applied (see §B.1.2).

approximately 29% of households, but for more than 41% of individuals. Finally, the relative majority of Germans live in one-car households.

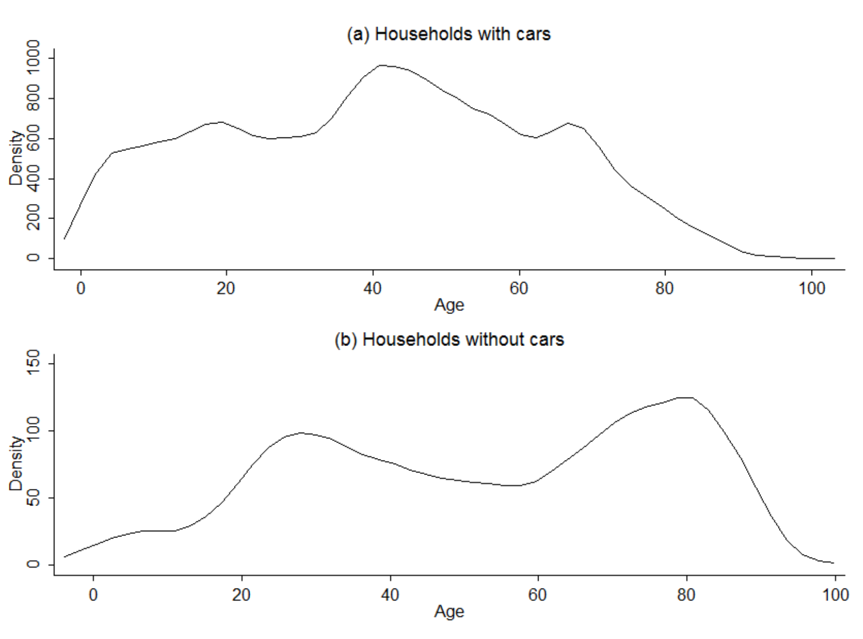

Fig. 6.1 – Smoothed age distribution for households with and without cars. Unit of analysis: individuals. Source: own elaboration on MiD 2008 data.

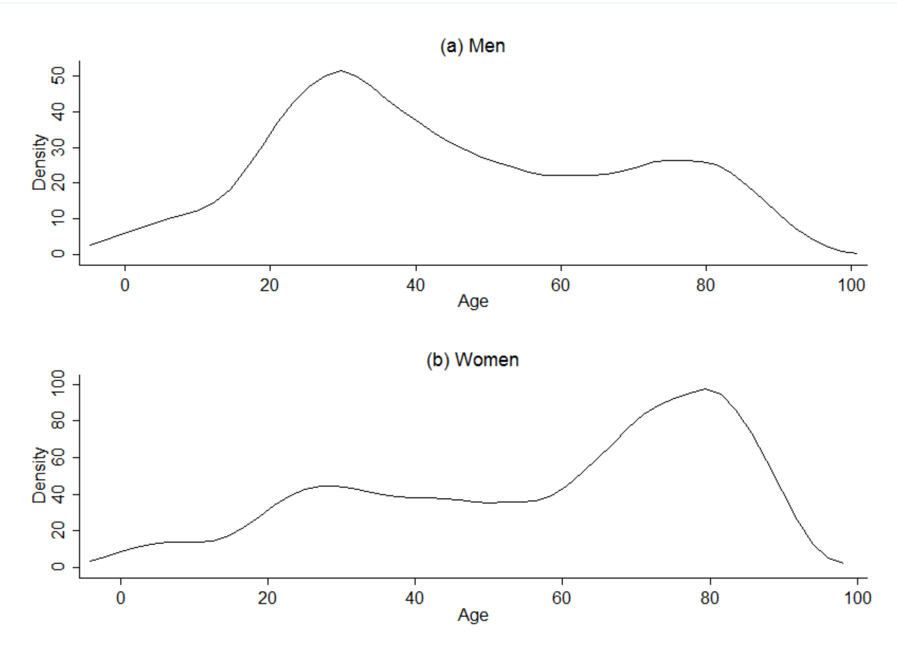

Fig. 6.2 – Smoothed age distribution for men and women living in households without cars. Unit of analysis: individuals. Source: own elaboration on MiD 2008 data.

Household size is not the only socio-demographic difference between the carless and the rest of the population. Another major difference is the age of household members. Fig. 6.1 compares the smoothed age distribution for individuals living households with and without cars, showing that the curve for the carless has a bimodal shape, which contrasts with the more normal distribution of motorised households. The two modes correspond to approximately 30 and 80 years, suggesting that households without cars are overrepresented among people in the phases preceding and following employment and family formation.

Disaggregated analysis by gender (Fig. 6.2) shows that the bimodal age distribution of the carless group as a whole is the combined result of two very different age distributions: skewed towards young adults for men, but skewed towards older people for women.

		Households without cars	Households with cars	Total
Mean age of adults	18-29	8.8	4.4	5.2
	30-64	38.0	70.0	64.4
	65+	53.2	25.6	30.5
	Total	*100.0*	*100.0*	*100.0*
Household type[73]	retired single	47.1	11.3	17.6
	retired HH	7.7	17.1	15.5
	Single	33.7	18.5	21.2
	Other	11.5	53.1	45.7
	Total	*100.0*	*100.0*	*100.0*
No. of adult men	0	62.0	17.4	25.3
	1 or more	38.0	82.6	74.7
	Total	*100.0*	*100.0*	*100.0*
No. of employed members	0	73.3	33.0	40.1
	1 or more	26.7	67.0	59.9
	Total	*100.0*	*100.0*	*100.0*
All adults unemployed	Yes	4.7	0.8	1.5
	No	95.3	99.2	98.5
	Total	*100.0*	*100.0*	*100.0*
Student household[74]	Yes	5.7	0.8	1.6
	No	94.3	99.2	98.4
	Total	*100.0*	*100.0*	*100.0*
No. of minor children	0	95.5	78.0	81.1
	1 or more	4.5	22.0	18.9
	Total	*100.0*	*100.0*	*100.0*
Economic status[75]	very low	14.8	6.9	8.2
	low	27.7	8.6	12.0
	medium	37.4	41.6	40.9
	high	17.5	31.9	29.4
	very high	2.6	11.0	9.5
	Total	*100.0*	*100.0*	*100.0*
No. of members with a university degree	0	81.1	79.0	71.1
	1 or more	18.9	31.0	28.9
	Total	*100.0*	*100.0*	*100.0*

Tab. 6.2 – Distribution of key socio-demographic variables for households with and without cars (percentage values[76]). Unit of analysis: households. Source: own elaboration on MiD 2008 data.

Tab. 6.2 shows the distribution of key socio-economic variables for households with and without cars, as well as for the sample as a whole. The variables show the most striking socio-demographic differences between households with and without cars and the average German population. Firstly, as noted above, both younger and older households are overrepresented among the carless. Importantly, for more than half of German households without cars, the mean age of adults is over 65. By contrast, households in the middle age

[73] The details concerning the variable “household type” are illustrated in §B.2.1.

[74] In this context, I define as ‘student household’ an household where all members aged 18 or more are students.

[75] The achievement of a university degree is assessed by the variable “*Fachhochschul- oder Universitätsabschluss*” (university or technical college degree) in the MiD 2008 individual database.

[76] All row and column variables in Tab. 6.2 are significantly associated at the 5% level (chi-square tests).

groups (30-64), corresponding to approximately two thirds of the whole sample, amount to only 38% among households without cars. In terms of household type, there is a strong overrepresentation of singles (about 80% of households in the group of households without cars compared to approximately 39% in the population). Similarly, households with minor children, which account for almost 19% in the whole sample, are less than 5% among carless households, meaning that more than 95% of households without cars do not include any member under 18. Clearly, German households without cars are smaller than average and only very rarely include minor children. This is consistent with the share of student households – which is higher among households without cars than in the whole sample, and is confirmed by figures for employment status: while households without any employed member are 40% of the sample, they represent more than 73% of carless households. Overall, singles, retired singles and retired households form the large majority of households without a car (more than 88% as compared to approximately 54% in the whole sample), and are thus strongly overrepresented. Similarly, households where all adults are female account for almost 62% of households without cars, compared with only 25% in the whole sample. Not surprisingly, households without cars stand out as significantly poorer than their motorised counterparts: about 42% of them are in a low or very low economic condition[77], compared with little more than 20% of the whole sample fit. Conversely, households with a high or very high economic status account for only 20% of carless households, about half their share in the whole sample (almost 39%). Similarly, households without cars are also characterized by lower education: only about 19% of them includes at least one adult with a university degree (compared to almost 29% in the whole sample). Overall, descriptive analysis for socio-demographics confirms theoretical expectations about households without cars (§1.3.4), as they are smaller in size, with lower income, less employed and with an overrepresentation of women.

		Households	Individuals
Municipality size (thousands of inhabitants)	**500 or more**	34.7	26.1
	100 to 500	24.2	17.5
	50 to 100	15.5	10.3
	20 to 50	14.5	8.5
	5 to 20	11.0	5.9
	less than 5	10.4	5.6
Type of district (*Kreis*[78])	**core city**	29.1	21.3
	dense district	12.3	7.3
	rural district	13.7	7.6
Population density at the municipal level (inhabitants/km²)[79]	**2,000 or more**	32.1	24.0
	1,500 to 2,000	24.2	16.6
	1,000 to 1,500	20.0	13.9
	500 to 1,000	15.1	9.9
	200 to 500	12.7	7.1
	less than 200	10.3	5.4
Population density (1x1km pixel)	**10,000 or more**	45.6	38.8
	5,000 to 10,000	32.4	25.0
	2,000 to 5,000	18.8	12.2
	1,000 to 2,000	14.1	8.4
	500 to 1,000	11.8	6.2
	250 to 500	11.1	5.7
	100 to 250	6.5	3.3
	0 to 100	6.4	3.7

Tab. 6.3 – Households and individuals without cars across different types of area (percentage values[80]). Unit of analysis: households and individuals. Source: own elaboration on MiD 2008 data.

[77] Details about the variable 'economic status' are provided in §B.2.2.

[78] The *Kreis* is a type of country subdivision that corresponds roughly to the Italian *provincia* or the French *département*. However, unlike in those two countries, only rural *Kreise* are further subdivised into *Gemeinden* (municipalities), whereas about 112 municipalities are *Kreisfreie Städte* (or *Stadtkreise*) , i.e. cities which constitute a district in their own right.

[79] More details about the geographical variables in MiD are provided in §B.1.4.

		Households without cars	Households with cars	Total
Car available as driver[81]	**always/sometimes**	22.8	93.4	82.9
	Never /not a licensed driver	77.2	6.6	17.1
	Total	*100.0*	*100.0*	*100.0*
Car available on travel diary day[82]	**All the time / to some extent**	23.2	93.5	83.2
	Not at all	76.8	6.5	16.8
	Total	*100.0*	*100.0*	*100.0*
Bicycle owner	**Yes**	59.3	81.0	78.2
	No	40.7	19.0	21.8
	Total	*100.0*	*100.0*	*100.0*
Public transport ticket ownership (at least week ticket)[83]	**Yes**	36,3	13.5	16,8
	No	63.7	86.5	13.2
	Total	*100.0*	*100.0*	*100.0*
Driving licence (cars)	**Yes**	46.4	76.4	73.0
	No	53.6	23.6	27.0
	Total	*100.0*	*100.0*	*100.0*
Driving licence (motorcycles)	**Yes**	17.0	30.2	28.7
	No	83.0	69.8	71.3
	Total	*100.0*	*100.0*	*100.0*
Distance from closest bus stop[84]	**less than 400m**	64.9	54.1	55.6
	400m or more	35.1	45.9	44.4
	Total	*100.0*	*100.0*	*100.0*
Distance from closest local train station[85]	**less than 1km**	53.9	28.8	32.3
	1km or more	46.1	71.2	67.7
	Total	*100.0*	*100.0*	*100.0*
Health-related mobility problems	**Yes**	20.0	5.9	7.7
	No	80.0	94.1	92.3
	Total	*100.0*	*100.0*	*100.0*
Internet access[86]	**Yes**	42.5	77.1	72.1
	No	57.5	22.9	27.9
	Total	100.0	100.0	100.0

Tab. 6.4 – Mobility capital indicators for households with and without cars (percentage values[87]). Unit of analysis: individuals. Source: own elaboration on MiD 2008 data.

Another crucial factor for car ownership, according to existing research (§1.5.4), is the type of area of residence. Descriptive analyses for the MiD 2008 sample, illustrated in Tab. 6.3, confirm theoretical expectations of a positive relationship between the degree of urbanity, centrality and density of the residential area and the percentage of non-motorised households. For example, while approximately 35% of households living in municipalities with more than 500,000 inhabitants do not own a car, this is true for only 10% of households in very small municipalities (with less than 5.000 inhabitants). The same trend is apparent for other geographical variables reported in Tab. 6.3, such as the type of district and population density at the municipal level and in the proximity area. Tab. 6.3 also shows that the proportion of carless individuals is regularly lower than the proportion of households (indicating smaller than average household

80 The percentage differences across areas reported in Tab. 6.3 are are significant at the p<0.05 level (chi-square tests).

81 This question was asked only to household members aged 14 or more.

82 This question was asked only to household members aged 14 or more.

83 This question was asked only to household members aged 14 or more.

84 This question was asked only to household members aged 14 or more.

85 This question was asked only to household members aged 14 or more.

86 This question was asked only to household members aged 14 or more.

87 All row and column variables in Tab. 6.4 are significantly associated at the 5% level (Chi-square tests).

size for the carless). However, this difference is greater in peripheral, low-density areas, suggesting that households without cars are larger in size in compact core cities.

Non-car ownership is not only associated with socio-demographic characteristics and spatial features of the residential area. In fact, the presence or absence of a household car is also strongly related to extent to which household members have the potential for mobility. This is illustrated in Tab. 6.4, showing differences between households with and without cars on nine 'mobility capital' indicators.

As discussed in §2.1.3, the idea that mobility can be considered as a form of capital has been put forward by Kaufmann et al. (2004), and has been discussed using the so-called 'motility' theoretical framework. In a nutshell, these concepts invite scholars to look beyond actual travel behaviour, highlighting the relevance of the pre-conditions that allow individuals to be mobile. These factors are diverse and include not only the availability of transport means (e.g. cars, bicycles, etc.) and titles (driving licenses, tickets, etc.) and the access to transport infrastructure (e.g. public transport), but also the physical capability to move and/or use transport modes (e.g. disabilities, etc.) as well as the skills and competences that mobility requires (see §2.1.3). Tab. 6.4 shows the performance of individuals living in households with and without cars on some of these indicators, gathered under the label of 'mobility capital' indicators. Obviously, I do not claim that the variables reported here enable me to tap the concept of 'mobility capital' as a whole; however, they allow me to highlight differences in the potential for mobility (as opposed to actual travel behaviour) between carless households and the rest of the German population[88].

A first conclusion that can be drawn from Tab. 6.4 is that living in a non-car owning household is associated with lack of car access, both on average and on travel diary day. In both cases, only 23% of individuals over the age of 13 living in carless households report access to cars, as compared with more than 93% among car-owning households members. This demonstrates that, as argued in §3.2.3, even though *in theory* lack of household car ownership is not equivalent to lack of individual car availability, *in practice* there is a considerable degree of overlap. Notably, the figures show that the share of carless households members who have car access is greater than the share of motorised households members who do not (at least among individuals over the age of 13). This is reassuring, because the analysis conducted in this thesis allows me to investigate the former, while focusing on households without cars obscures the latter (see §3.2.3). In terms of driving licence ownership, unsurprisingly a much lower share of individuals living in carless households are licensed drivers (46%) as compared to their motorised counterparts (76%).

Tab. 6.4 also presents some indicators of access to alternative means of transport, such as bicycles, motorcycles and public transport. This allows me to investigate whether the lack of a household car is associated with greater access to alternative modes, thus potentially compensating the reduction of 'mobility capital'. The results here are mixed: on one hand, German carless tend to live in closer proximity to public transport services, notably local train stations, than their motorised counterparts. This is also a result of the fact that households without cars are disproportionately concentrated in dense urban areas (see Tab. 6.4). They also tend to own public transport tickets (with a validity of at least one week) more often. On the other hand, they are significantly less likely to own a functioning bicycle and to be licensed motorcycle drivers. While this might seem surprising, it is probably related to the substantial proportion of older people among the carless, as well as to their concentration in large cities (where bicycle ownership is slightly lower than in small municipalities).

It is sometimes suggested in the literature, that increased access to ICTs might make up for factors conducive to transport disadvantage such as non-car ownership (see §2.4.5). In that sense, new forms of 'virtual mobility' (such as online shopping, telecommuting, etc.) can be considered as forms of 'mobility capital'. The last row of Tab. 6.4 shows the percentage of individuals who have a home computer with internet access: it shows that while only 23% of individuals in motorised households do not have internet access, this figure is as high as 57% among their carless counterparts. This is probably also due to the substantial proportion of older people among the carless, given their lower rate of internet access. This

[88] For a similar use of the notion of 'mobility capital' in the analysis of quantitative data see Castrignanò and Melzi (2012) and Colleoni (2013).

shows, however, that for a substantial proportion of the carless 'virtual mobility' is not (yet) a realistic alternative to physical travel. The relative concentration of non-car ownership among the elderly probably also explains the higher incidence of health-related mobility problems among the carless (20% of individuals).

To sum up, Tab. 6.4 shows that, with the exception of access to public transport, individuals in households without cars perform worse on all indicators of 'mobility capital'. However, the descriptive analysis also suggests that the confounding effect of other variables (type of area, age) is likely to be relevant.

		Value	Households without cars	Households with cars	Total
At least one trip[89]	Yes	%	83.8	90.5	89.7
	No		16.2	9.5	10.3
	Total		*100.0*	*100.0*	*100.0*
Trips	Generic mean[90]	Mean	2.94	3.48	3.42
	Specific mean		3.51	3.84	3.81
Travel distance (km)	Generic mean	Mean	22.4	41.1	39.1
	Specific mean		26.9	45.5	43.6
Travel time (h:min)	Generic mean[91]	Mean	1:18	1:19	1:19
	Specific mean		1:33	1:27	1:28
Average length of trips (km)		Mean	7.7	11.8	11.5
CO_2 emissions (kg)[92]		Mean	1.7	4.8	4.5
Modal split (basis: trips)	Walking	%	44.1	21.9	24.0
	Cycling		17.3	9.3	10.1
	Car / van driver		3.8	45.6	41.6
	Car / van passenger		8.8	15.8	15.1
	Motorbike/ other private		0.6	0.6	0.6
	Taxi / Minicab		0.8	0.1	0.2
	Public Transport		24.6	6.7	8.4
	Total		*100.0*	*100.0*	*100.0*
Modal split[93] (basis: distance)	Walking	%	6.8	2.7	3.0
	Cycling		7.3	2.6	2.9
	Car / van driver		13.4	55.9	53.3
	Car / van passenger		22.8	24.7	24.5
	Motorbike / other private		0.5	0.7	0.7
	Taxi / Minicab		0.5	0.1	0.2
	Public transport		48.7	13.2	15.4
	Total		*100*	*100*	*100.0*

Tab. 6.5 – Travel behaviour on the travel diary day for households with and without cars (percentage values and means[94]). Unit of analysis: individuals, trips. Source: own elaboration on MiD 2008 data.

Tab. 6.5 shows the differences between individuals in households with and without cars with regard to actual

89 All observations where the mobility on the travel diary day was 'unknown' were recoded as missing. The row and column variables are significantly associated at the p<0.05 level (Chi-square tests).

90 Here and in the following, adopting the terminology used in time-use studies (Gershuny, 2000), I define as 'generic mean', the mean computed for the whole sample. The 'specific mean' is referred instead only to those who have made at least one trip on the travel diary day.

91 According to the adjusted Wald tests of means, it cannot be ruled out that there is no difference in the generic mean of travel time between individuals in households with and without cars.

92 Details about how travel-related CO_2 emissions on the travel diary day are computed are provided in infas (2010c, p. 156).

93 Details about the recoded variable 'main travel mode' are provided in §B.2.4.

94 All differences between means in Tab. 6.5 have been tested with adjusted Wald test and are significant at the 5% level, unless otherwise noted in the text.

travel behaviour. With few exceptions, most indicators show that individuals in carless households are less mobile than their motorised counterparts. For instance, the proportion of people who took no trips on the travel diary day is considerably higher among the carless (16%). Individuals in car-owning households also report more trips on average, even though this difference is reduced (albeit still statistically significant) when only mobile individuals are taken into consideration. The difference is even greater for the average daily travel distance, that is almost double for the members of motorised households. This is due to the fact that carless individuals not only carry out less trips, but their trips also tend to be on shorter distances (7.7 km on average). A relevant exception is travel time: there are no statistically significant differences between the average travel time for individuals living in carless and motorised households (approximately one hour and 20 minutes). If only mobile respondents are taken into consideration, individuals living in carless households even spend *more* time travelling than their motorised counterparts.

These results can be attributed to the greater reliance on slower modes of transport on the part of carless households: indeed, individuals in carless households carry out a higher proportion of trips (and a greater share of distance) walking, cycling and using public transport, as compared to their motorised counterparts, who use the car for more than half of their trips (and travel distance[95]). Conversely, car use among the carless is considerably lower, accounting for just 4% of trips and 13% of travelled distances. Incidentally, it can be noted that this confirms what argued in §3.2.3, namely that, even though *in theory* household car ownership is not equivalent to individual car use, *in practice* there is a considerable degree of overlap. The greater reliance on active travel and public transport explains why carless individuals end up spending on average the same amount of time to travel distances that are shorter, as compared to their motorised counterparts. Tab. 6.5 also shows that, while carless individuals use the car as passenger for a lower share of their trips (8.8%), as compared to car-owning household members (15.8%), this difference is greatly reduced if distances are taken into consideration (22.8% and 24.7% respectively). This suggests that carless individuals rely on car lifts more rarely, but when they do it they cover longer distances[96].

In a nutshell, the data reported in Tab. 6.5 show that carless individuals are characterised by lower mobility levels (at least in terms of trips and travel distance) and by a greater reliance on both active travel and public transport. Accordingly, they also produce significantly less travel-related CO_2 emissions (less than half than the average German).

In the context of this thesis, it is interesting to observe how households with and without cars evaluate the accessibility to services and opportunities. The MiD 2008 database includes variables measuring accessibility levels for key destinations (shops for the daily shopping, workplace, place of apprenticeship, school) with different transport means (car, public transport, walking and cycling), as evaluated by the respondents on a six-point scale. This allows the computing of accessibility indexes, even though the limitations of these indicators have to been taken into account when interpreting the results[97]. Tab. 6.6 shows the mean values of the indexes for individuals in households with and without cars.

A first result drawn from the table is that the average accessibility by travel modes alternative to the car is higher for individuals living in households without cars. This can be explained by the disproportionate concentration of the carless in dense urban areas, where distances are shorter and public transport services more efficient. However, since the indexes have been computed with reference to the essential destinations relevant to the person in question (see §B.2.3), this result can be explained also in another way: employed adults are strongly underrepresented among the carless, and workplaces are often located in places that are further away and more difficult to access by alternative modes (as compared to basic shops and schools). Therefore, the accessibility advantage of the carless with 'alternative modes' might be explained by the different services and opportunities that they are assumed to need to access[98].

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95 It is worth noting that, while the carless own on average less bicycles (Tab. 6.4), they tend to use them more.

96 This hypothesis is not confirmed by adjusted Wald tests of means, probably because of small sample size when the trips as car passengers made by individuals in households without cars are considered.

97 A detailed discussion of how the indexes are computed and their substantive interpretation and limitations is found in §B.2.3.

98 This hypothesis, however, is not confirmed by more in-depth analyses, showing that even employed individuals in households without cars evaluate the accessibility of the workplace by all modes (bike, public transport and car) better than employed individuals in

		Households without cars	Households with cars	Total
Accessibility	Walking	3.99	3.54	3.60
	Cycling	3.66	3.41	3.44
	Public transport	3.13	2.47	2.57
	Car	3.68	4.42	4.31
All modes	Max	4.60	4.68	4.67
	Mean	3.59	3.42	3.44
Alternative modes (car excluded)	Max	4.38	3.88	3.95
	Mean	3.55	3.02	3.09
Accessibility & mobility capital index		2.30	3.28	3.13
Available transport modes	Max	4.32	4.67	4.62
	Mean	3.45	3.61	3.47

Tab. 6.6 – Indexes for the accessibility to essential services and opportunities (mean values[99]). All indexes range between 0 (min.) and 5 (max.). Unit of analysis: individuals. Source: own elaboration on MiD 2008 data.

The opposite is true for accessibility by car, with individuals living in motorised households reporting on average a higher score than their carless counterparts. This might also be explained by the relative concentration of carless households in dense urban areas, where several factors tend to make car use more difficult (congestion, parking restrictions, etc.).

If all modes are taken into account, individuals living in motorized households report a higher level of maximum accessibility. By contrast, members of motorized households score worse than the carless if the mean level of accessibility is considered. I interpret this finding in the following way: motorised households tend to be overrepresented in car dependent areas, were accessibility is often bad with all means of transport except the automobile – as a consequence, their higher degree of maximum (car-provided) accessibility is often traded off against lower levels of accessibility by alternative modes. This tends to offset the high values of car accessibility when mean values are computed (as discussed in §B.2.3). By contrast, if only available transport modes are considered, accessibility levels are higher for motorised individuals, regardless of the computing method used (mean or maximum), even though the differences are not huge and the score for carless households is above the middle point of the scale (3)

Finally, the 'accessibility and mobility capital' index (taking into account both the availability of transport modes and the subjective evaluation of accessibility) shows an advantage for individuals in motorised households. This is to be expected, since in this index the lack of a household car necessarily results in a lower score (see §B.2.3).

Overall, the accessibility indexes reported in Tab. 6.6 suggest that individuals in households without cars experience lower levels of accessibility to basic services and opportunities, as compared to individuals living in households with cars. However, differences are not so large, and much depends on how the indexes are computed. Moreover, given limitations in the available data (see §B.2.3), this conclusion should be considered with care.

Up to this point in this section I have shown how non-car ownership is associated with other variables in key areas, without making explicit reference to the order of causal priority. However, there is clearly a difference between variables, such as socio-demographics, that are antecedents of household car ownership, and

motorised households (the results of these analyses are not reported here for the sake of brevity). This suggests that employed individuals in households without cars are highly self-selected and tend to live closer to the workplace (see §6.1.2 below).

[99] All differences between means in Tab. 6.6 have been tested with adjusted Wald test and are significant at the 5% level.

others, such as travel behaviour, that are consequences of car ownership[100]. In the remainder of this section, I focus more specifically on the determinants of car ownership.

Overall, the results of the data analysis illustrated in Tab. 6.2 to Tab. 6.6 show that non-car ownership is strongly associated with certain socio-demographic characteristics, with residential location, as well as with access to public transport infrastructure. This is consistent with existing research, reviewed in §1.3.4 and §1.5.4. To illustrate how these factors interplay in a more systematic way, I present a logistic regression model[101] (Tab. 6.7) whose dependent variable is the ownership of at least one household car (0=no, 1=yes).

The list of predictors includes, as it is often the case for models of car ownership (see §1.3), a set of socio-demographic variables and one of territorial variables. The fundamental difference between the two is that socio-demographic variables are household attributes, while territorial variables are attributes of its residential location. Additionally, the model also includes an index labelled *car related accessibility advantage*. The value of this index can be interpreted as an estimate of the perceived accessibility advantage that is (or would be) provided by a car for accessing basic services and opportunities that are relevant for household members. A higher value indicates that the accessibility advantage is greater[102] (see §B.2.3).

The list of socio-demographic variables includes: household size, number of minor children, a dummy variable identifying households where all adults are female, the mean age of adults, the number of household members in employment, a dummy variable identifying households with at least one member with a university degree, a three-category variable assessing the presence of members with health-related mobility problems (none, some, all members) and a variable identifying the economic status of the household (see §B.2.2). Squared terms have been used (in addition to simple ones) for the number of household members and the average age of adults, to take into account the non-linear relationship of these variables with the outcome (see §A.1.1).

The list of territorial variables includes a dummy identifying former GDR states (with the addition of former West Berlin), the population density at the municipality level, the population density in proximity area (1x1km pixel) and the distance between the residence and closest public transport stops (bus stop and local train station). Other territorial variables (such as municipality size, type district and type of region) have not been included in the model presented here for the sake of simplicity, as they are not significant after controlling for population density (see §B.3.1).

As shown in Tab. 6.7, model fit is very good (McFadden's pseudo-R^2=0,40): therefore, the model is a good representation of the data[103]. Almost all logit parameters associated with the predictors are significant at (at least) the 0.05 level and exceptions are interpreted as follows. First, performing hierarchical regression (see Cohen et al., 2003) the predictor 'number of employed household members' has a significant negative effect on the outcome until the index 'car related accessibility advantage' is added to the model. This might be interpreted as follows: households with employed members are more likely to own a car, because workplaces tend to be distant from the household residence, and thus are more likely to be less accessible with transport modes alternative to the car. Once this accessibility effect is controlled for, however, the effect of the number of employed members has no independent effect on the outcome. A similar explanation can

[100] Of course, this distinction is not as clear-cut as it appears. For example, employment status, here considered as a socio-demographic determinant of household car ownership, can in turn be influenced by car access, as discussed at length in §2.2.1. Even residential location can be influenced by car ownership, as discussed by the literature on residential self-selection (§1.5.3). This same literature also highlights how travel behaviour is not just a consequence of household car ownership, as travel preferences can influence both travel behaviour and the purchase of a vehicle. To analyse these complexities properly, however, longitudinal data or questionnaires with retrospective questions are required (see §1.5.3). For this reason, in the empirical analyses that follow I will move from the assumption that socio-demographic characteristics and residential location are antecedents of car ownership, while travel behaviour is a consequence.

[101] On logistic regression see §A.1.

[102] Unlike the two other sets, this variable is the result of a subjective evaluation of accessibility, on the part of household members. This in turn is strongly influenced both by individual attributes (e.g. health-related mobility problems) and by the residential location of the household (e.g. in terms of distance from public transport networks, etc.). For this reason, it is presented as a separate variable set in Tab. 6.7.

[103] Details about model selection are provided in §B.3.1, model fit statistcs for logistic regression are illustrated in §A.1.6.

be put forward for the distance between residence and bus stop: the proximity of bus routes is reflected in the score given by respondents to public transport accessibility to services and opportunities. Therefore, once the effect of the car related accessibility advantage is controlled for, the distance from the bus stop has no independent effect (over and above control variables). Thus, households who live further from bus stops are actually less likely to own cars, but this effect is fully mediated by control variables.

Functional set of variables			Coef.	Robust Std. Error
Socio-demographic variables	**No. of HH members**		-1.947***	(0.100)
	No. of HH members (squared)		0.153***	(0.0132)
	No. of minor children		0.711***	(0.110)
	No adult men in HH (dummy)		0.783***	(0.0884)
	Mean age of adults		-0.136***	(0.0146)
	Mean age of adults (squared)		0.00135***	(0.000137)
	No. of employed HH members		-0.103	(0.0723)
	At least one member with university degree (dummy)		-0.218*	(0.0870)
	Members with health-related mobility problems (ref.cat.: None)	Some	0.476***	(0.112)
		All	0.984***	(0.122)
	Economic status (ref.cat.: Very low):	Low	-0.441***	(0.120)
		Medium	-1.515***	(0.0982)
		High	-2.037***	(0.121)
		Very high	-2.787***	(0.194)
Territorial variables	**East Germany (dummy)**		0.483***	(0.0699)
	Population density (municipality) (ref,cat,: >2,000 in./km^2)	1,500-2,000	-0.246*	(0.114)
		1,000-1,500	-0.349*	(0.138)
		500-1,000	-0.674***	(0.137)
		200-500	-0.711***	(0.126)
		<200	-0.818***	(0.148)
	Population density (1x1km pixel) (ref,cat,: >10,000 in.)	5,000-10,000	-0.420**	(0.148)
		2,000-5,000	-0.607***	(0.152)
		1,000-2,000	-0.507**	(0.174)
		500-1,000	-0.555**	(0.198)
		250-500	-0.551*	(0.219)
		100-250	-0.980**	(0.308)
		1-100	-1.182**	(0.361)
		0	-1.549*	(0.727)
	Distance residence – closest bus stop (meters)[104]		-0.0000673	(0.0000435)
	Distance residence – closest local train station (meters)[105]		-0.0000421***	(0.0000119)
	Car-related accessibility advantage		-0.446***	(0.0267)
	(constant)		6.391***	(0.382)
	N		24,442	
	McFadden's pseudo R^2		0.405	

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Tab. 6.7 - Logistic regression model for the probability of not owning a household car (logit coefficients and robust standard errors). Unit of analysis: households. Source: own elaboration on MiD 2008 data.

Virtually all logits have the sign that is expected, according to the literature (see §1.3.4, §1.5.4), and exceptions are interpreted as follows. The number of minor children is associated with an *increase* in the

[104] See §B.2.5.

[105] See §B.2.5.

probability of being carless, when all other predictors are held constant. This goes against the results of descriptive analysis (showing a strong underrepresentation of the carless among households with minors) and existing research (showing that the car is essential when there are children). This result can be explained as follows: when households with the same size are considered, households with minor children are actually less likely to own cars, because by definition they include less licensed members. For example, a young couple is more likely to own cars than a family unit including a single parent and a young child. However, given that households with minor children are usually larger, the number of minor children in the household is associated with a higher propensity to be without cars, when household size is not controlled for[106]. The presence of at least one household member with a university degree reduces the probability of not owning cars, even when other factors (such as economic status) are controlled for. While this goes against the assumption of a greater diffusion of 'green' lifestyles among the more educated, it is consistent with the observation that highly-qualified workers are less likely to find a job in the local area, and more likely to rely on the car to cover longer commuting distances and to deal with flexible working hours.

The predictor 'East Germany' requires explanation. As illustrated in Chapter 4, the motorisation rate in the GDR was lower than in West Germany. While in the twenty years since the reunification the number of cars has increased rapidly, it is reasonable to assume that growing up in the GDR is associated with higher likelihood to live in a carless household, even when other factors (such as the low population density of large parts of Eastern German *Länder* and the lower average income) are controlled for. This is confirmed by the logit in Tab. 6.7, that is positive and statistically significant.

A common data-analysis strategy for multiple regression or correlation is "the sequential or hierarchical analysis of a set of independent variables" (Cohen et al., 2003, p. 158), often referred to as 'hierarchical regression'. This strategy allows for the answering of questions concerning the relative importance of different functional sets of independent variables in accounting for the outcome (p. 163). In the case of the present work, it is interesting to explore more in depth the relative importance of socio-demographic and territorial variables in accounting for non-car ownership. This has been assessed in the following way: the two sets have been entered cumulatively, and upon the addition of each set the pseudo-R^2 has been determined, as well as the increase thereof (Tab. 6.8). The hierarchical order for entry of the two sets has been determined on the basis of considerations of causal priority and the removal of confounding or spurious relationships (p. 158): accordingly, the set of socio-demographic variables precedes the set of territorial variables, while the index 'car related accessibility advantage' has been entered as last[107]. In this framework, the increase in the pseudo-R^2 that follows the entering of an additional set in Tab. 6.8 can be interpreted as the gain in prediction associated with this group of variables (2003, p. 508).

Step	Sets of variables	Pseudo R^2	Increase in Pseudo R^2
1	*Socio-demographic variables*	0.3067	+0.3067
2	*Socio-demographic variables + territorial variables*	0.3692	+0.0625
3	*Socio-demographic variables + territorial variables + car related accessibility advantage*	0.4048	+0.0356

Tab. 6.8 - Hierarchical regression for the logistic regression model reported in Tab. 6.7 (McFadden's pseudo-R^2 and relative increases). Source: own elaboration on MiD 2008 data.

The table shows clearly that socio-demographic variables account for a large share of the prediction power of the model (0.31 of the pseudo R^2). Conversely, territorial variables have only a secondary role, accounting

[106] This is confirmed by the value of the logit associated with the number of minor children in a logistic regression model not including the variable 'number of household members'. The relative results are not reported here for the sake of brevity.

[107] As stated by Cohen et al. (2003, p. 159-160) "of course it will frequently not be possible to posit a single sequence that is uncontroversially in exact order of casual priority". This is problematic because, in principle, "a different order would result in different increments" (*ibidem*). Under these circumstances, a good strategy is therefore the "examination of alternative hierarchical sequences of independent variable sets" (*ibidem*). As I acknowledge that in the present case the entering order is not theoretically unambiguous, I have experimented alternative entering orders: the results (not reported here for the sake of brevity) do not change the conclusions reported in the main text.

for only 0.06. The substantive interpretation of these results is the following: not owning an household car is mainly a question of socio-demographics and economic status, while spatial features of the residential area (such as population density, distance from public transport, etc.) play only a secondary role. With regard to the 'car related accessibility advantage' index, alternative entering orders for hierarchical regression (whose results are not reported here for the sake of brevity) show that there is a great degree of overlap between the pseudo R^2 that is accounted for by this index and that attributed to territorial variables. This can be interpreted as follows: most of the effect of population density in the local area and access to public transport services is mediated by differences in accessibility to basic services between the different modes of transport. In short, this means that in areas where population density is lower and public transport access is difficult, the differential between the accessibility to relevant services and opportunities provided by the car and that provided by alternative modes is positive and of greater magnitude than in dense areas with a good public transport network. This, in turn, is associated with a lower probability of being carless. However, since the set of territorial variables arguably precedes car-related accessibility gain in the order of causal priority, the latter is entered last in the hierarchical regression reported in Tab. 6.8. Yet the table shows that, even after the effect of the territorial characteristics of the residential area is controlled for, the 'car-related accessibility advantage' index still appears to account for an additional increase in prediction power (0.04), suggesting that this variable captures also differences in perceived accessibility that cannot be reduced to spatial features of the residential area.

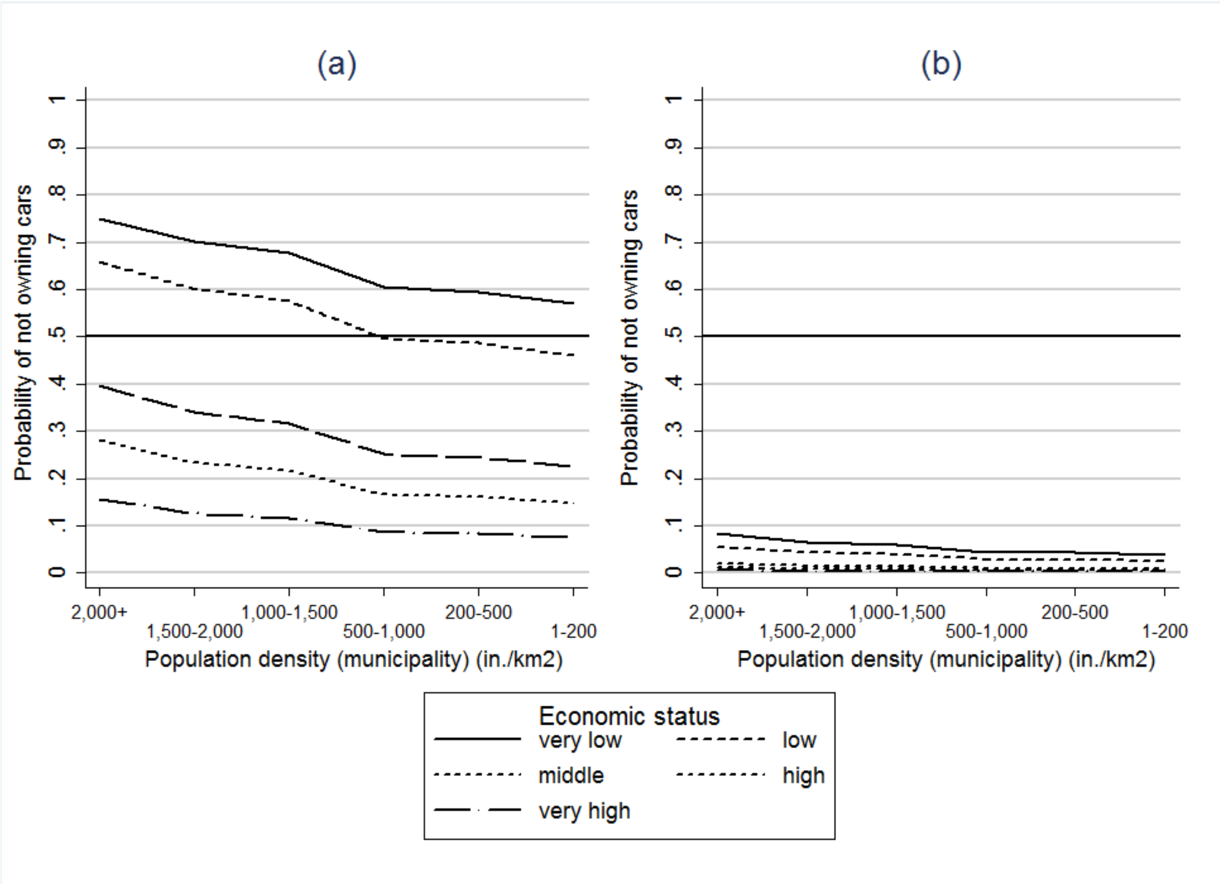

Fig. 6.3 – Predicted probabilities of not owning cars by population density in the municipality and economic status, for two ideal-typical households: (a) single woman, 70 years old, not employed (b) four members household including two working adults (mean age: 40) and two minor children. The probabilities are predicted using the logistic regression model reported in Tab. 6.7. Unit of analysis: households. Source: own elaboration on MiD 2008 data.

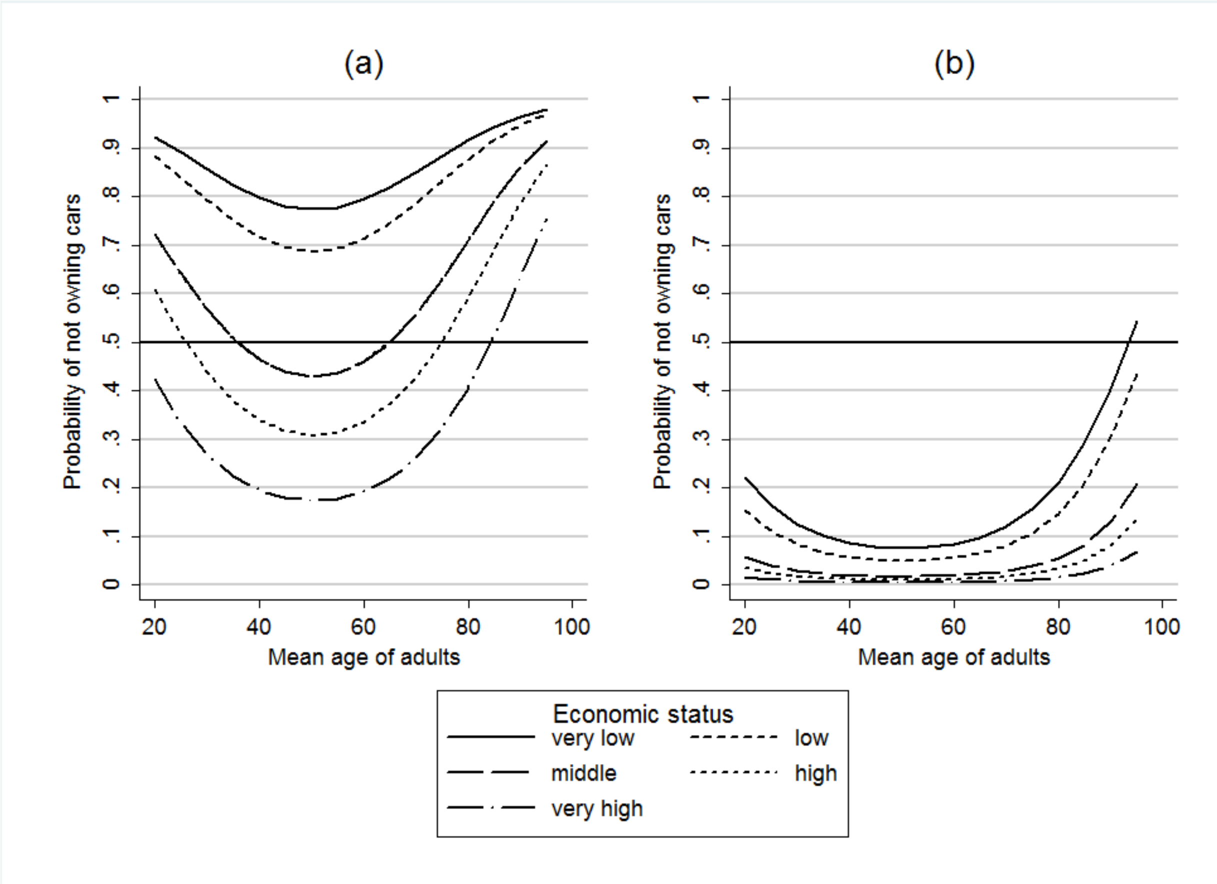

Fig. 6.4 – Predicted probabilities of not owning cars by mean age of adults and economic status, for two opposite ideal-types of residential areas: (a) maximum density scenario (b) minimum density scenario. The probabilities are predicted using the logistic regression model reported in Tab. 6.7. Unit of analysis: households. Source: own elaboration on MiD 2008 data.

As illustrated in Appendix (§A.1.3), the detailed interpretation of a logistic regression model can be challenging, and interpretations based on logits and on odds ratios often run the risk of being misleading and deceptive. Therefore, I will base the discussion of the logistic regression results on the predicted probabilities, showing their values for a series of ideal-typical cases. The goal is to convey in a direct way the substantive results that the model offers[108].

Fig. 6.3a shows the predicted probability of not owning cars (based on the model of Tab. 6.7), for a single woman who is 70 years old and not employed (all other variables have been kept to their mean or mode[109]). In the graph, the probability varies according to two independent variables: population density in the municipality and economic status. The reference line corresponds to a probability of 50% (0.5) of not owning cars, which is the threshold that the model uses as a criterion to assign the case to the motorised (<0.5) or non-motorised group (>0.5) when asked to predict the outcome. Fig. 6.3a clearly shows that both population density and economic status have an impact on the probability of (not) owning cars. As expected, households living in more dense areas are more likely to be carless. Moreover, the curves corresponding to lower income are higher, confirming that income has a negative effect on the probability of owning a car. As a result, the probability of being carless is higher than 0.5 only for households who are in a very low or low economic condition. Among the middle classes the probability not to own cars reaches 0.4 only for those

[108] All predicted probabilities in this and the following chapter were computed in Stata using the 'spostado' package byJ. Scott Long and Jeremy Freese (Long & Freese, 2001).

[109] In detail, all territorial variables have been kept to their mean or mode in the MiD 2008 sample. The two remaining socio-demographic variables (presence of members with a university degree, presence of members with health related mobility problems) have been kept to their mode among the subset of cases identified by the socio-demographic profile examined here (single women, 70 years old, etc.).

living in municipalities with a population density over 2,000 inhabitants per km². For those who fit in the 'very high' category, the probability never even goes beyond 0.2.

Fig. 6.3b presents the same probabilities as Fig. 6.3a, with reference to another ideal-typical household, composed of four members: two working adults (mean age: forty years old) and two minors (all other variables are kept to their mean or mode[110]). Interestingly, neither economic status nor density make (much) difference: the probability of not owning cars is never higher than 0.1, and it (almost) reaches this value only for households who are both in a very low economic condition and live in a very dense municipality. Overall, the curves are squeezed to the bottom of the graph, as if the socio-demographic characteristics of this ideal-typical household were sufficient to prevent non-car ownership. Similar graphs for other ideal-typical households that can be conceived as intermediate (such as a 22 years old single student and a 30 years old working single) would show a progressive flattening of the curves, which get gradually squeezed to the bottom of the graph. They are not reported here for the sake of brevity.

Fig. 6.4a shows the variation of the predicted probability of not having a car in a context of maximum territorial density: that means that all territorial variables and the 'car-related accessibility advantage' index are held constant to values that are specific to this ideal-type, listed in Tab. 6.9[111]. All socio-demographic variables except mean age of adults and economic status are held constant at their mean or modal values in the MiD 2008 sample. On axe x, the mean age of the adults is depicted, while the different lines correspond to different levels of economic status.

	Maximum density (Fig. 6.4a)	**Minimum density (Fig. 4b)**
Population density (municipality) (in./km²)	2,000 or more	less than 200
Population density (1x1km pixel) (in.)	10,000 or more	1-100
Distance residence / bus stop (meters)	400	1,580
Distance residence / local train station (meters)	780	6,910
Car-related accessibility advantage	-0.278	+2.338

Tab. 6.9 – Values of variables held to specific values for Fig. 4a and Fig. 4b. Source: own elaboration on MiD 2008 data.

Fig. 6.4a shows clearly that age and economic status have a considerable impact on the probability of not owning cars, for average Germans living in a maximum-density scenario. For all levels of income, age has a curvilinear relationship with the outcome (with both young and older households more likely to be carless), although this is less pronounced for households in a low and very low income status. Overall, depending on the mean age of adults and economic status, the predicted probability of not owning cars varies between approximately 0.19 and 0.99. Fig. 6.4b is similar to Fig. 6.4a, but shows the predicted probabilities for a minimum density scenario (values held constant to specific values reported in Tab. 6.9, all other values kept at their mean or mode): as expected, the curves are significantly lower than for the previous ideal-type. Moreover, they tend to be much closer to each other (especially in the middle range of age values), meaning that income makes less difference in very low-density areas. Interestingly, for households in a middle, high or very high economic status, the curves are also flatter, meaning that, in low-density contexts, age makes much less difference in terms of (not) owning a household car. Finally, it is worth noting that the predicted probability of being carless is higher than 0.5 only for low and very low income households after the age of 85, while the higher propensity of young households to be carless (observed in the previous graph) is greatly

[110] In detail, all territorial variables are kept to their mean or mode in the MiD 2008 sample. The two remaining socio-demographic variables (presence of members with a university degree, presence of members with health related mobility problems) are kept to their mode among the subset of cases identified by the socio-demographic profile examined here (four members household including two minor children, etc.).

[111] The procedure used to determine the values for maximum and minimum density scenarios is the following: first, extreme values were selected for both population density variables. In a second step, descriptive statistics were computed for the subsample of households who actually live in areas of characterized by those levels of population density. Subsequently, modal or mean values for the other variables listed in Tab. 6.9 (distance from residence to public transport and car-related accessibility advantage) were retained.

reduced in this scenario. Overall, it can be concluded that, for an average German household living in a minimum density scenario, age and income do not have much impact on the probability of not owning cars (with the partial exception of very old households).

The results illustrated in Fig. 6.3 and Fig. 6.4 suggest that when certain independent variables assume values determining a very low proability of non-car ownership, the effects of other variables are small to non-existent. Importantly, this phenomenon arises from assumptions that are in-built in logistic regression models, as explained in §A.1.2. On a substantive level, this suggests that there are two main conditions under which being carless is very unlikely, regardless of other circumstances. Firstly, territorial conditions: for households living in low-density areas, the probability of not owning a car is always extremely low, and increases significantly only when the effects of poverty and old age combine (Fig. 6.4). Secondly, there exist also socio-demographic conditions under which non-car ownership is very rare: working families with children are such an example[112] (Fig. 6.3). As it will be argued later in this chapter (§6.1.5), this conclusion is useful to interpret the findings illustrated in the next section (§6.1.2), namely the fact that, in low-density peripheral areas, carless households tend to be concentrated among marginal social groups.

6.1.2. The changing socio-demographic composition of the carless households group across different types of area

In the previous section, systematic differences between households with and without cars have been described. In this section, I turn my attention to how the socio-demographic composition of the carless group changes across different types of area, thus addressing Question 1 more directly. To that end, I use different data analysis techniques, starting with simple descriptive statistics, then discussing odds ratios and finally logistic regression models. The goal here is to test the hypothesis that the carless households group is more concentrated among marginal social groups in peripheral, low density areas, as compared to compact inner cities.

In the previous section, the results of a logistic regression model for non-car ownership have been illustrated (Tab. 6.7). This has shown that several socio-demographic variables are predictors for the lack of a household car, namely:

- household size, with single-person households more likely than others to be carless
- the presence of minor children, with households including at least one member under 18 more likely to be carless[113]
- the presence of adult men in the household, with family units including only adult women considerably more likely to be carless
- the average age of households, with both older people and young adults more likely to be carless. The probability is however greater for older households than for younger ones
- the number of employed members, with households including no employed member considerably more likely to be carless
- education level, with households with at least one member with a university degree less likely to be carless than the others, even when other factors such as economic status are controlled for
- economic status, with low-income households considerably more likely to be carless
- health-related mobility problems, with household where all members experience such problems considerably more likely to be carless

It is interesting to note that there is a considerable degree of overlap between the socio-demographic characteristics listed above and those that, according to the research literature, are associated with social

[112] Of course, Fig. 6.3 and Fig. 6.4 show that there are also *economic* conditions under which being carless is most unlikely (whatever the other circumstances), namely a very high economic status.

[113] As discussed in §6.1.1, the number of minor children in the household is associated with a decrease in the probability of not owning cars, provided that the number of household members is not controlled for.

exclusion and transport disadvantage. Indeed, young and old people and female-headed households experience a higher risk of social exclusion. Similarly, low-income and low education levels are often associated with limited participation in society (Sparkes, 1999). Arguably, the risk of social exclusion is even higher when several of these characteristics are simultaneously present: so for example, a single woman over 65 with low education, low income and health related mobility problems would undoubtedly be considered at risk of social exclusion. As illustrated in §2.1.5, much of the same is true for transport disadvantage, with young and older people, women, the disabled and low-income households among the 'recurrent characters' of transport and social exclusion research.

There are however two important socio-demographic predictors of non-car ownership that cannot (by themselves) be considered as factors conducive to social exclusion: small household size (solo-living) and lack of minor children. Indeed, industrialised societies are experiencing (to different extents) a trend towards an increasing share of single-person households, that is only partially associated with the rapid ageing of societies (Jamieson et al., 2009). Solo-living is also often associated with emergent lifestyles, especially among young people (Heath, 2009), and thus cannot be associated as such with social exclusion. Similar arguments apply to the increasing rate of households without minor children, a trend that is associated with ageing, as well as with declining fertility rates in many industrialised countries. In a nutshell then, solo-living and lack of minor children are not determinants of social exclusion. However, it can be argued that, when they are added to other of the aforementioned characteristics, solo-living (which necessarily implies lack of members under 18) might aggravate social exclusion: for example, a single person over 65 is arguably more likely to have limited participation in society than an elderly couple, and the same could be argued for unemployed and/or low income singles. This is related to the 'social capital' dimension of social exclusion: since a larger household size is likely to be associated with greater 'bonding' social capital, it might help reducing the risk of social exclusion – even though there no necessary relationship between the two.

In a nutshell, then, lack of car ownership is associated with several socio-demographic characteristics that are also known to be associated with social exclusion and transport disadvantage. In that sense, in the German population as a whole, carless households are indeed concentrated among marginal social groups. In this section, I aim to show how this concentration changes across different types of areas. To that end, I focus the attention on the eight variables listed above. Notably, in the following I focus on households who accumulate several of the characteristics mentioned above.

Fig. 6.5 to Fig. 6.14 show the changing composition of the carless households group across different types of area, defined according to municipality size. However, every trend has been double-checked using three other geographical variables (listed in Tab. 6.3 above): type of district, population density at the municipal level and for the 1x1km proximity area. The results broadly confirm the findings illustrated here with reference to municipality size. The relative figures and tables are not reported here for the sake of brevity.

Fig. 6.5 shows the composition of the carless group by household size, across different types of area. At first sight, this figure seems to contradict the hypothesis of an increasing concentration of carless households among marginal groups in peripheral areas. Indeed, households without cars are disproportionately concentrated among single-person households in all types of area: as reported in Tab. 6.10 below, they account for 80% of households without cars in large cities (over 500,000 inhabitants) and for approximately 84% in very small municipalities (less than 5,000 inhabitants). While this difference is statistically significant, it certainly does not suggest a radically different composition across different types of area. However, Fig. 6.6 shows that this hides considerable differences in the *type* of single: indeed, while 59% of carless households in very small municipalities are *retired singles*, this figure decreases as municipality size increases, reaching 42% in large cities. Conversely, the share of *non-retired singles* goes up from 25% to approximately 38%. This suggests that non-car ownership in peripheral, low density areas is more concentrated among retired singles, as compared to compact inner cities.

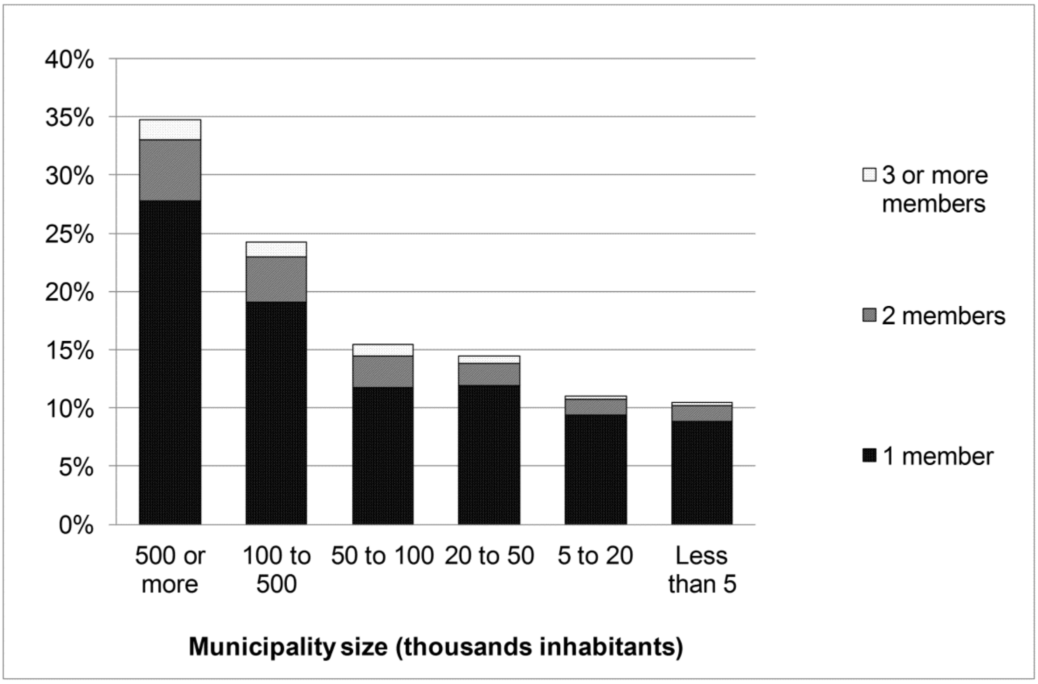

Fig. 6.5 – Composition of the carless households group by household size, across different types of area. Unit of analysis: households. Source: own elaboration on MiD 2008 data.

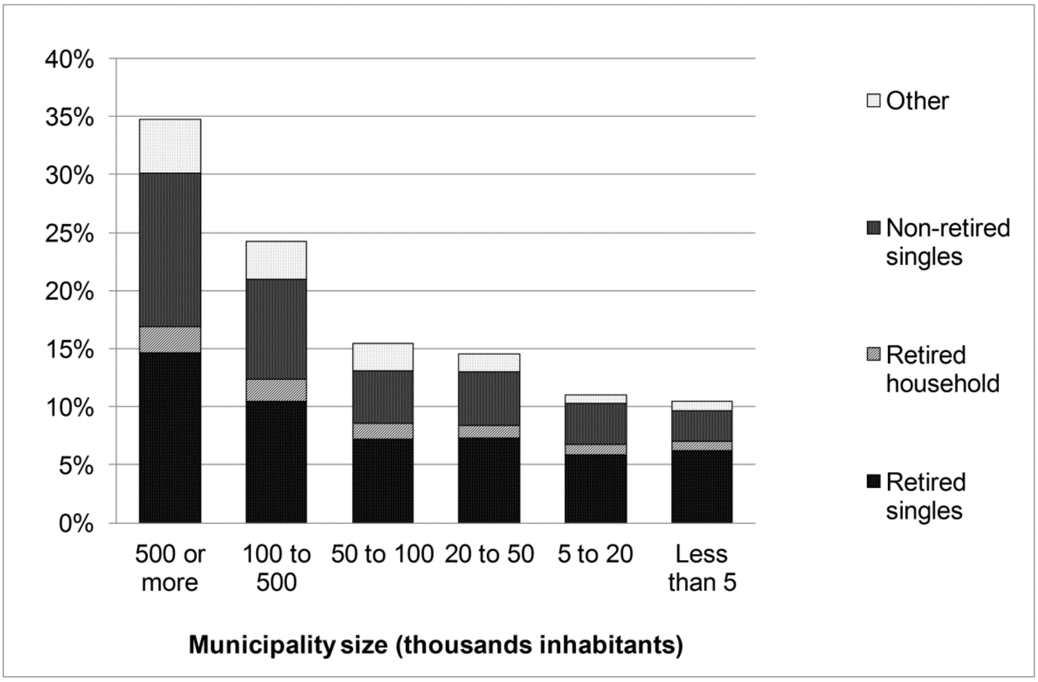

Fig. 6.6 – Composition of the carless households group by household type, across different types of area. Unit of analysis: households. Source: own elaboration on MiD 2008 data.

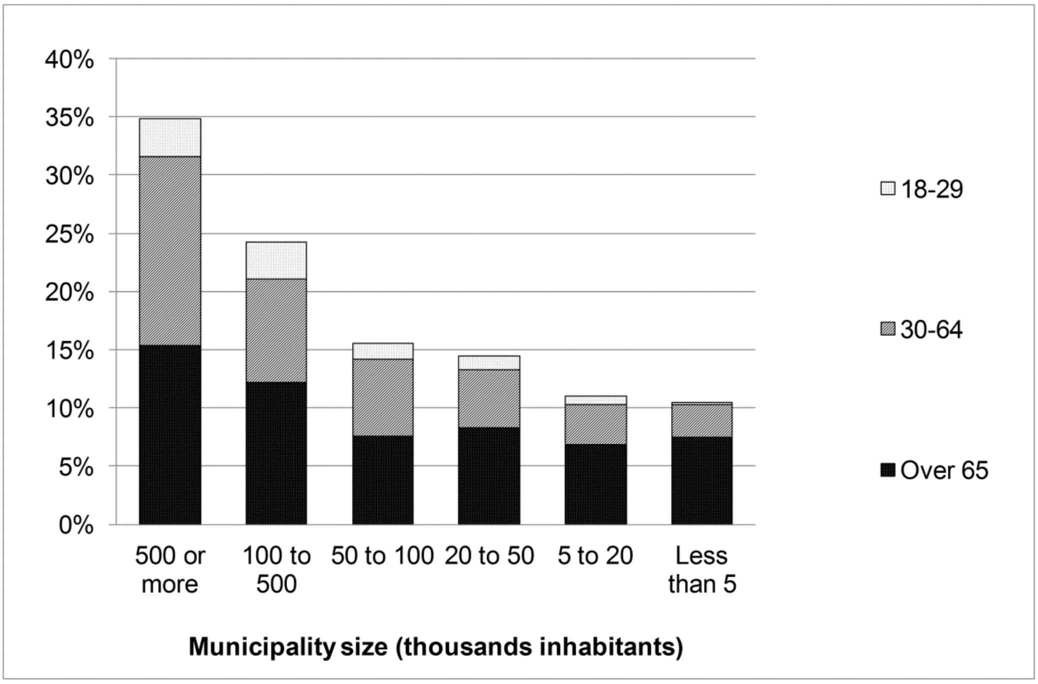

Fig. 6.7 – Composition of the carless households group by mean age of adults, across different types of area. Unit of analysis: households. Source: own elaboration on MiD 2008 data.

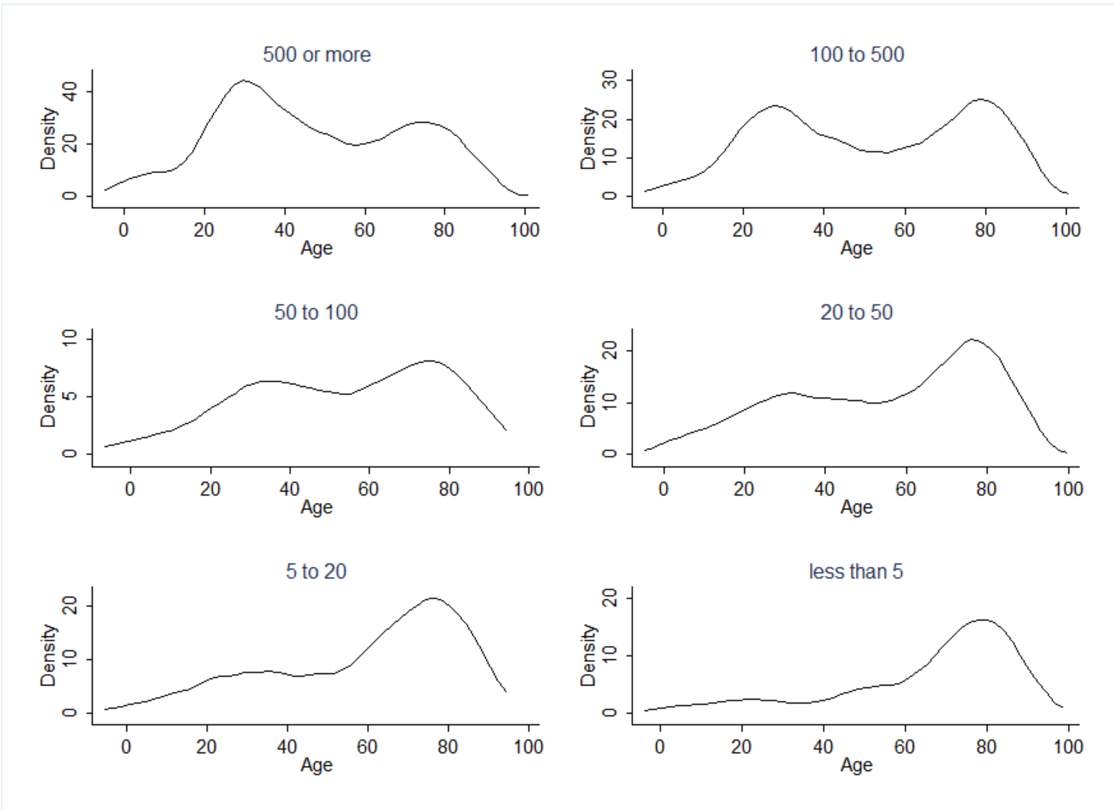

Fig. 6.8 – Smoothed age distribution of individuals living in households without cars, by municipality size (thousands of inhabitants). Unit of analysis: individuals. Source: own elaboration on MiD 2008 data.

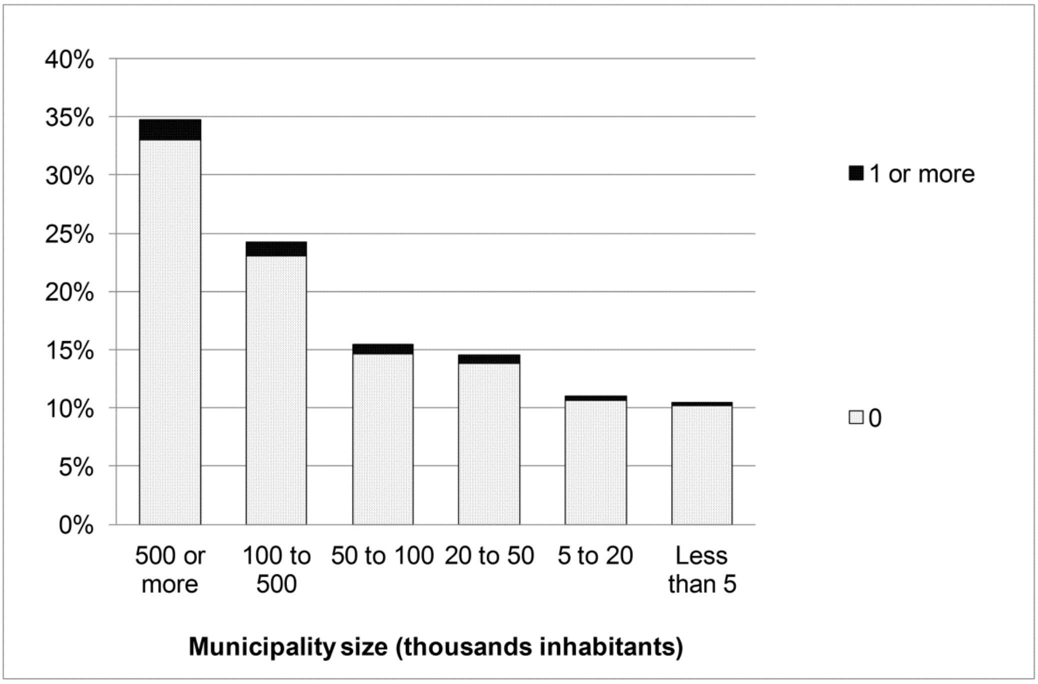

Fig. 6.9 – Composition of the carless households group by number of minor children, across different types of area. Unit of analysis: households. Source: own elaboration on MiD 2008 data.

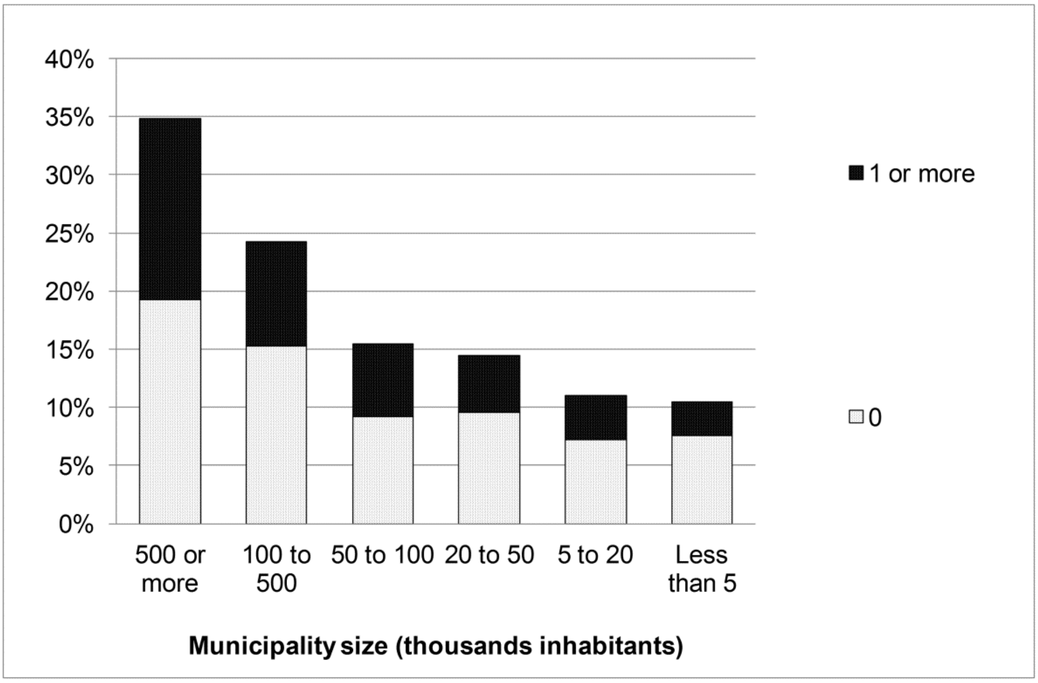

Fig. 6.10 – Composition of the carless households group by number of adult men, across different types of area. Unit of analysis: households. Source: own elaboration on MiD 2008 data.

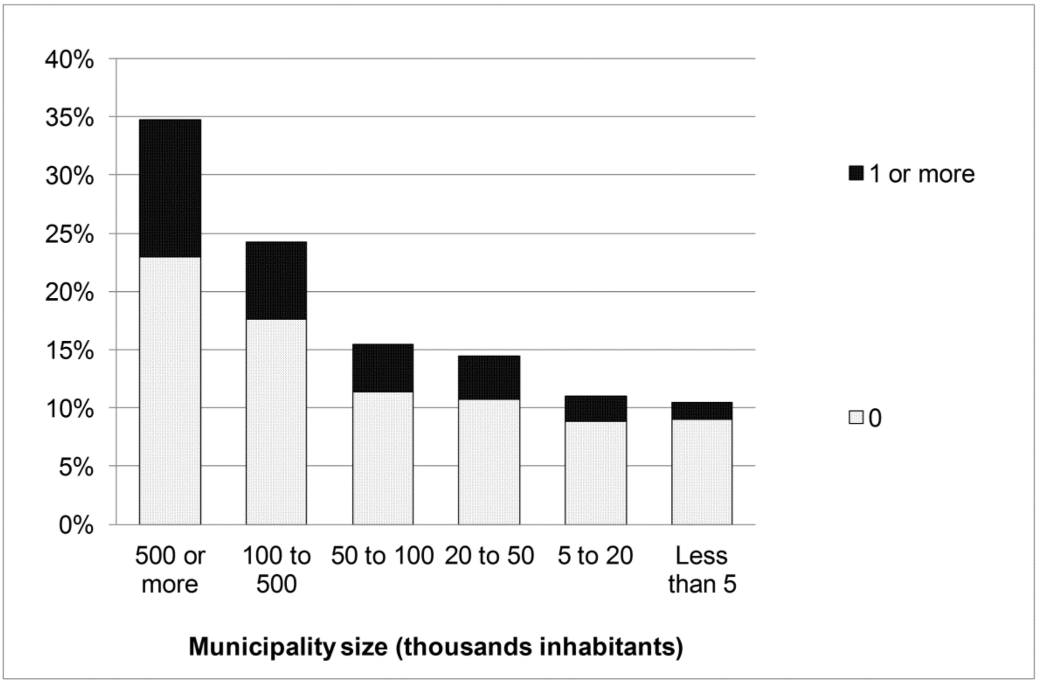

Fig. 6.11 - Composition of the carless households group by number of employed members, across different types of area. Unit of analysis: households. Source: own elaboration on MiD 2008 data.

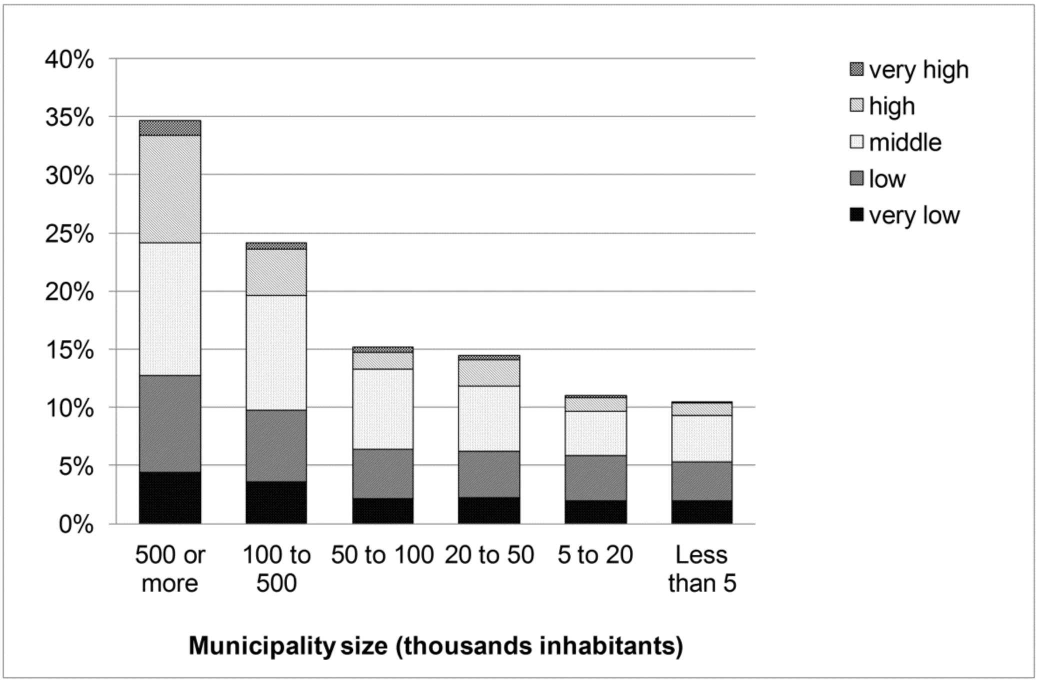

Fig. 6.12 – Composition of the carless households group by economic status, across different types of area. Unit of analysis: households. Source: own elaboration on MiD 2008 data.

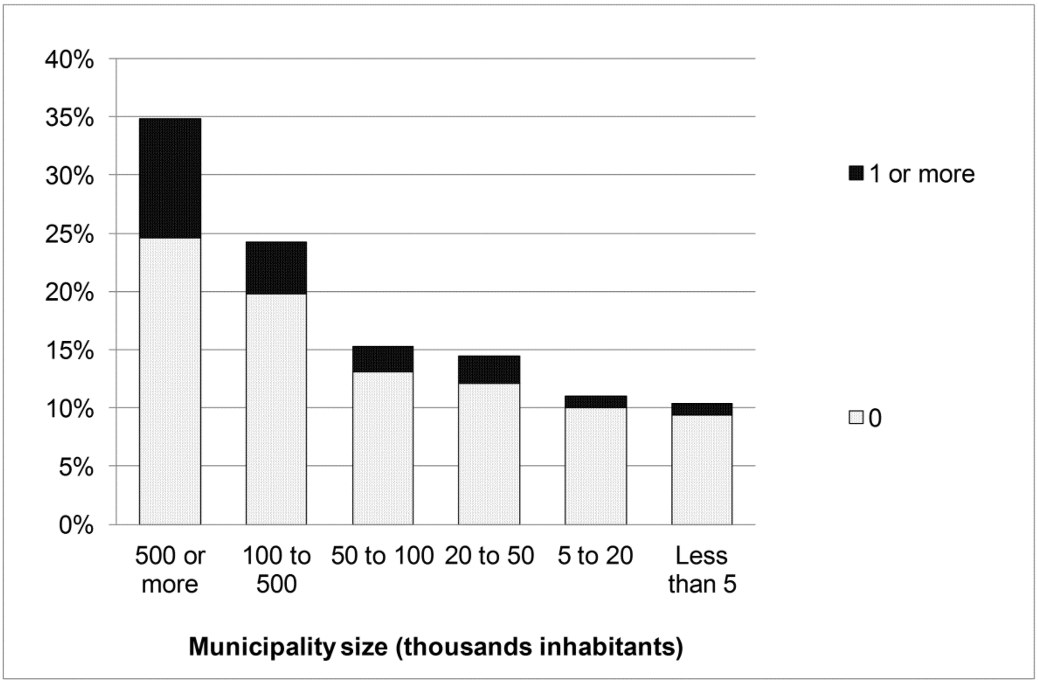

Fig. 6.13 – Composition of the carless households group by number of members with a university degree, across different types of area. Unit of analysis: households. Source: own elaboration on MiD 2008 data.

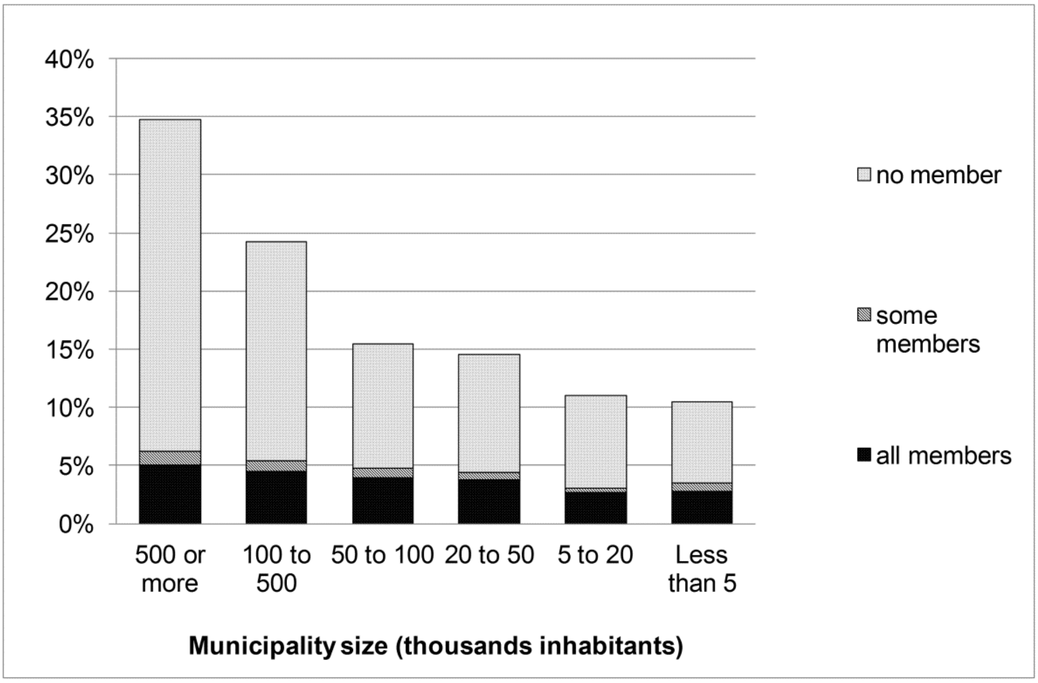

Fig. 6.14 – Composition of the carless households group by number of members with health-related mobility problems, across different types of area. Unit of analysis: households. Source: own elaboration on MiD 2008 data.

		Municipality size (thousands inhabitants)						Total
		500 or more	100-500	50-100	20-50	5-20	Less than 5	
Household size	**1**	80	79	76	82	85	84	81
	2 or more	20	21	24	18	15	16	19
	Total	*100*	*100*	*100*	*100*	*100*	*100*	*100*
No. of minor children[114]	**0**	95	95	94	95	97	97	96
	1 or more	5	5	6	5	3	3	4
	Total	*100*	*100*	*100*	*100*	*100*	*100*	*100*
No. of adult men	**0**	55	63	59	66	65	72	62
	1 or more	45	37	41	34	35	28	38
	Total	*100*	*100*	*100*	*100*	*100*	*100*	*100*
Mean age of adults	**65 or more**	44	50	49	57	62	71	53
	18-64	56	50	51	43	38	29	47
	Total	*100*	*100*	*100*	*100*	*100*	*100*	*100*
No. of employed members	**0**	66	73	73	74	80	86	73
	1 or more	34	27	27	26	20	14	27
	Total	*100*	*100*	*100*	*100*	*100*	*100*	*100*
No. of members with a university degree	**None**	71	82	86	84	91	90	81
	1 or more	29	18	14	16	9	10	19
	Total	*100*	*100*	*100*	*100*	*100*	*100*	*100*
Economic status	**Very low + low**	37	40	42	43	52	50	42
	Middle + High + Very High	63	60	58	57	48	50	58
	Total	*100*	*100*	*100*	*100*	*100*	*100*	*100*
Members with health-related mobility problems	**All**	14	18	25	26	24	27	20
	Some / None	86	82	75	74	76	73	80
	Total	*100*	*100*	*100*	*100*	*100*	*100*	*100*
Additive index	***5 to 8 characteristics***	54	63	66	68	77	81	65
	Less than 5	46	37	34	32	23	19	35
	Total	*100*	*100*	*100*	*100*	*100*	*100*	*100*

Tab. 6.10 – Composition of the carless households group across different types of area (municipality size) (percentage values[115]). Unit of analysis: households. Source: own elaboration on MiD 2008 data.

This is confirmed by Fig. 6.7, showing how the composition of the carless group in terms of age changes across different types of area. It is apparent that, while for the overwhelming majority of households without cars in very small municipalities (71%) the mean age of adults is over 65, this figure decreases as municipality size increases, reaching 44% in large cities. Conversely, the share of households in the middle age groups (30-64) increases from just 26% to approximately 46%. Also the percentage of young households (18-29) increases significantly, from 2 to 9%. Overall, it appears that the proportion of carless over 65 increases as municipality size decreases. This is shown even more clearly in Fig. 6.8, showing that the smoothed age distribution of individuals living in carless households is bimodal in cities over 100,000 inhabitants, but gradually becomes skewed towards older people as municipality size decreases.

The same is not applicable to the presence of minor children, as illustrated in Fig. 6.9. Indeed, there is no statistically significant difference between municipality size classes, with regard to the percentage of carless households including minor children, that is stable around 95% in all types of area (see Tab. 6.10 below).

[114] In this case, the results of the chi-square test indicate that the association between row and column variables is not statistically significant at the 5% level (p = 0.2121). Therefore, it cannot be ruled out that, in the German population, there is no difference between types of area in the proportion of households without minor children.

[115] All row and column variables in Tab. 6.10 are significantly associated at the p<0.05 level (chi-square tests), unless where otherwise noted (see footnotes).

Fig. 6.10 depicts how the composition of the carless households group, according to the presence of adult men, varies by municipality size. It shows clearly that while households including no adult men are the large majority of carless households in very small municipalities (72%) this figure decreases as municipality size increases, reaching 55% in large cities over 500,000 inhabitants. This suggests that non-car ownership is more concentrated among female-headed households in peripheral and rural areas, as compared to core urban areas. Indeed, most of the increase in the size of the carless households group in larger municipalities is due to the increase in the number of carless households including adult men. Fig. 6.11 shows that something similar happens with regard to the presence of employed members in the household: while households without employed members are the majority of carless households in all types of area, the percentage is considerably higher in very small municipalities (86%) as compared to large cities (66%).

Fig. 6.12 suggests that the same pattern is at work for economic status: while in very small municipalities the group is almost equally split between households in the very low and low income classes and households with an economic status that is classified as ‘middle’ or higher, 63% of carless households in large cities belong to the latter category. As a result, most of the increase in the size of the carless households group as municipality size increase can be attributed to the greater number of wealthier households.

Fig. 6.13 represents the carless households group as divided in two classes: households including at least one member with a university degree, and those with none. While only a minority of carless households in every type of area includes at least one member with a university degree, this percentage is considerably higher in large cities (29%), as compared to very small municipalities (10%).

Fig. 6.14 shows how the carless group is composed with regard to the presence of members with health-related mobility problems. Broadly speaking, descriptive statistics (not reported here for the sake of brevity) show that households where all members have health-related mobility problems are strongly overrepresented among the carless: indeed, approximately 56% of these households do not own cars. By contrast, both households without problems and those where some members (but not all) have problems, are underrepresented among the carless. Overall, in one in five German carless households all members have mobility-related problems. However, this percentage varies considerably depending on the type of area: while approximately 14% of households without cars in large cities correspond to this profile, this figure is virtually double in very small municipalities (see Tab. 6.10).

Overall, the descriptive statistics illustrated in Fig. 6.5 to Fig. 6.14 and Tab. 6.10 (along with those produced using alternative geographical variables, not reported here) appear to confirm hypothesis H1.1: the carless group is more concentrated among marginal social groups in peripheral, low density areas, as compared to central dense cities. This is true for all socio-demographic variables considered above, with the exception of household size and the presence of minor children. Overall, in large cities the group of carless households includes also a non-negligible share of young, middle and upper class and non retired households – these types of household are, by contrast, almost non-existent among carless households in very small municipalities.

An interesting question in this context is whether carless households in peripheral, low density areas also accumulate several of the characteristics listed above. As a device to address this question, I have computed a simple additive index, indicating how many of the following characteristics apply to the household: single-person household; no minor children; no adult men; mean age of adults over 65; no employed members; no member with a university degree; low or very low economic status; all members reporting health-related mobility problems. The last row of Tab. 6.10 shows how many of the carless households, in each type of area, accumulate at least five of these eight characteristics. The pattern observed here is consistent with that observed for most of the variables above: while in very small municipalities more than 80% of households without cars accumulate five or more characteristics, this applies to only 54% in large cities. Fig. 6.15 shows graphically how this impacts on the changing composition of the carless households group across different types of area: it shows that most of the increment in non-car ownership observed in larger urban areas is due to households who do not cumulate several of the eight characteristics listed above. This can be considered as a further piece of evidence in support of the hypothesis H1.1.

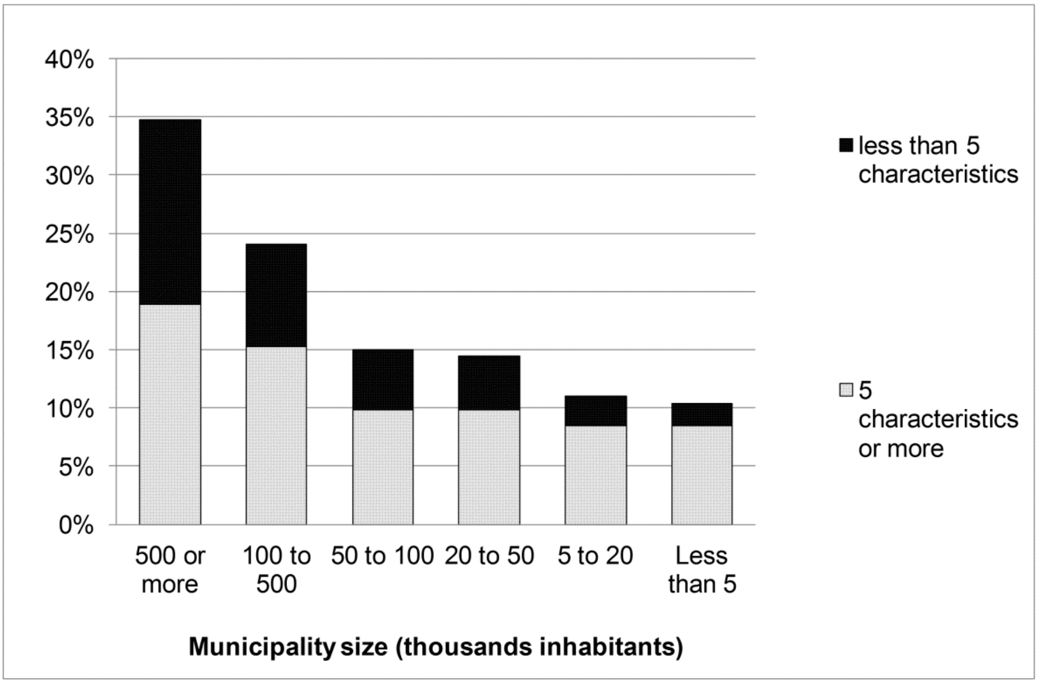

Fig. 6.15 – Composition of the carless households group by score on the additive index of socio-demographic characteristics associated with non-car ownership, across different types of area. Unit of analysis: households. Source: own elaboration on MiD 2008 data.

Up to this point, I have illustrated descriptive statistics: this implies that differences between types of area might be the by-product of socio-demographic differences between them. For example, the carless households group includes a greater percentage of households with at least one member with a university degree in large cities, as compared to smaller municipalities. However, there is a certain degree of correlation between urbanity and education levels, whereby, also in the population as a whole, the percentage of graduated people is higher in large cities.

A simple way to control for this confounding effect is to compute odds ratios. Tab. 6.11 shows odds ratios for the same eight variables as Tab. 6.10, across different types of area (according to municipality size[116]). 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 second row in Tab. 6.11 shows that, in large German cities, the odds of not having a car (rather than having one) are 4.23 times more for households without children compared to households with children. This figure increases steadily as one moves towards less urban areas, to reach a staggering 12.56 in municipalities with less than 5,000 inhabitants.

The same trend is apparent for all other variables, with two exceptions: economic status and presence of a member with a university degree. For both them, the differences between types of area are less pronounced, and the trend is unclear. This is interesting as in Tab. 6.10 I have shown that, according to descriptive analysis, the concentration of carless households among poor and less educated households increases as municipality size decreases. This difference between simple percentages and odds ratio suggests that in fact households without cars are not more concentrated in these categories in small municipalities: if the carless group includes more well-off, graduated people in larger cities, this is just because in these areas they account for a larger proportion of the population.

[116] The same odds ratios have been computed using an alternative geographical variables: population density at the municipal level. The results of this analysis broadly confirm the results illustrated here. The relative table is not reported here for the sake of brevity.

Variable	Odds ratio	Municipality size (thousands inhabitants)						Total
		500 or more	100-500	50-100	20-50	5-20	Less than 5	
Household size	**1 (vs. 2 or more)**	7.29	7.71	7.13	13.30	14.45	11.43	9.96
No. of minor children	**0 (vs. 1 or more)**	4.23	4.08	4.20	6.07	9.58	12.56	6.05
No. of adult men	**0 (vs. 1 or more)**	4.75	7.02	6.14	9.48	10.93	12.19	7.73
Mean age of adults	**65 or more (vs. 18-64)**	1.96	2.37	3.00	3.69	5.07	9.31	3.30
No. of employed members	**0 (vs. 1 or more)**	3.55	4.23	5.46	5.84	9.14	15.04	5.59
No. of members with a university degree	**0 (vs. 1 or more)**	1.94	2.59	3.01	2.12	3.86	2.93	1.93
Members with health-related mobility problems	**All (vs. None or Some)**	-	-	-	-	-	-	7.19
Economic status	**very low + low (vs. middle + high + very high)**	4.83	4.52	4.44	4.26	5.69	3.77	4.03
Additive index	**5 to 8 characteristics (vs. less than 5)**	6.83	8.50	12.55	13.61	19.09	21.55	10.59

Tab. 6.11 – Odds ratios for the odds of not owning cars, rather than owning it. Unit of analysis: households. Source: own elaboration on MiD 2008 data.

The opposite phenomenon is observed for other variables: Tab. 6.10 shows no clear trend in the percentage of singles on the carless population, as the degree of urbanity decreases; in the case of the presence of minor children, the difference between different types of area is not even statistically significant. By contrast, Tab. 6.11 shows that the odds ratios for these variables are considerably higher in small municipalities, as compared with larger cities. In this case, the difference between simple percentages and odds ratios suggests that differences in the socio-demographic structure between different types of area tend to obscure differences in the composition of the carless households group. So for example, while the percentage of households without minor children in the carless group is similar everywhere, there are considerably less of such households in small German municipalities. As a result, we should expect to find *less* carless households without minor children in these areas. The fact that, by contrast, there is no difference between areas suggests that the association between lack of minor children and non-car ownership increases as urbanity decreases, as indicated by the odds ratios in Tab. 6.11. Much of the same applies to household size, as there are considerably more single-person households in large German cities.

The last row in Tab. 6.11 reports the odds ratios for the same additive index reported in Tab. 6.10. The increasing values of the odds ratios as municipality size decreases suggest that the association between the simultaneous presence of several (at least five) of the eight socio-demographic characteristics and non-car ownership increases greatly as the degree of urbanity decreases[117].

Overall, the increasing values of the odds ratios indicate that the positive association between the socio-demographic variables and non-car ownership is substantially greater in peripheral and rural areas. This in

[117] Tab. 6.11 does not report the odds ratios for health-related mobility problems in the different types of area. The reason for this is that, in many areas, the number of observations for households without cars where all households experience these problems is too low to allow the computing of meaningful odds ratios. However, the additive index reported in Tab. 6.11, just like the one in Tab. 6.10, is computed on the basis of all eight socio-demographic variables (including the presence of members with health-related mobility problems).

turn confirms that the carless are significantly more concentrated among marginal social groups where the degree of urbanity is lower.

This conclusion is further supported by more formal analyses: Fig. 6.16 shows the values of McFadden's pseudo R^2 (a goodness of fit statistic) for a series of logistic regression models that have been fitted separately for the different types of area (according to municipality size). The independent variables included are the same reported in the regression model illustrated previously (Tab. 6.7), with the exception of territorial variables and car-related accessibility advantage: therefore, the model includes only socio-demographic predictors. The detailed results for the models are reported in Tab. 6.12, at the end of this section.

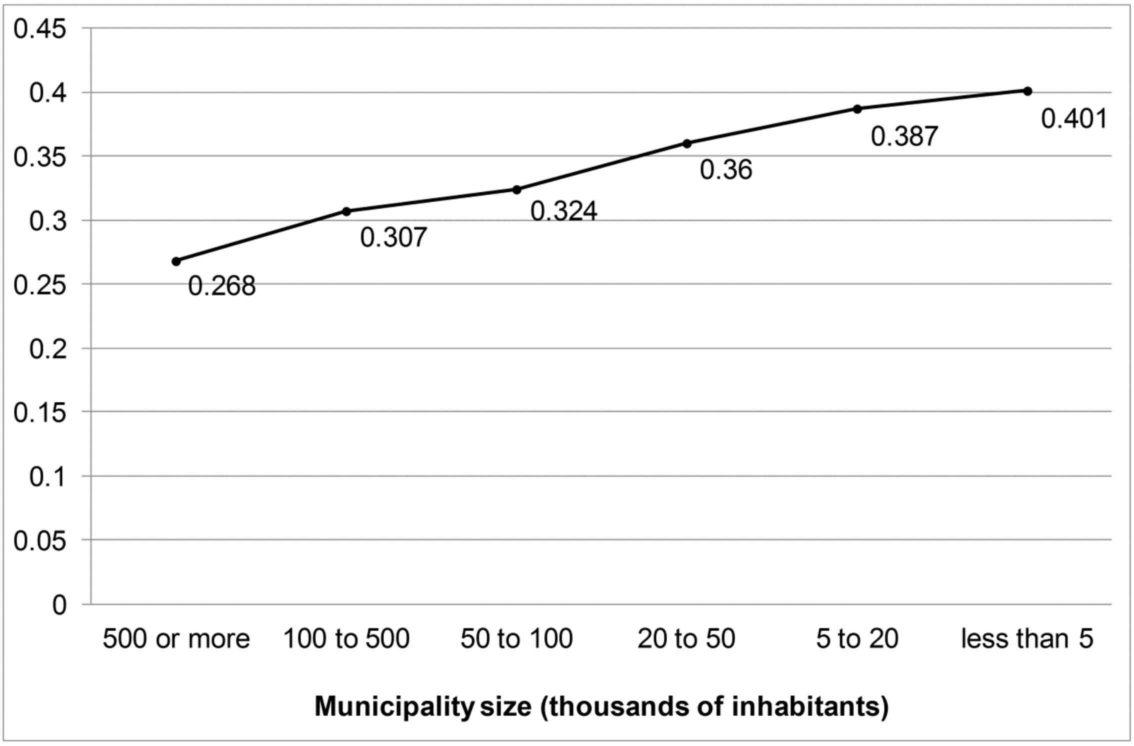

Fig. 6.16 – Values of McFadden's pseudo-R^2 for logistic regression models including only socio-demographic predictors, fitted separately for the different types of area (for details see Tab. 6.12). Unit of analysis: households. Source: own elaboration on MiD 2008 data.

Fig. 6.16 clearly shows that the predictive power of a logistic regression model including only socio-economic predictors increases as municipality size declines. Indeed, the values of McFadden's pseudo R^2 increase considerably, going from 0.27 (in large cities) to 0.40 (in very small municipalities[118]). 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, etc.), which could arguably increase the predictive power even further. This result can be interpreted as follows: predicting which households do not own cars using socio-demographic variables is much easier in peripheral, low-density areas than in large cities. This confirms that the profile of carless households in large urban areas is less one-sided, predictable and marginal than in other areas.

[118] The same models have been computed using three alternative geographical variables: type of district, population density at the municipal level and in the 1x1km proximity area. The results of these analyses broadly confirm the arguments put forward here. The relative tables are not reported here for the sake of brevity.

To sum up, then, in this section the results obtained using different data analysis techniques (descriptive statistics, odds ratios and logistic regression models) suggest that non-car ownership is much more associated with socio-demographic factors (and thus much easier to predict based on the relative variables) in sparse areas than in dense, urban areas. This is consistent with the hypothesis that carless households are much more concentrated among marginal social groups in peripheral and rural areas. However, the odds ratios reported in Tab. 6.11 suggest that this is less true for indicators of *social status* such as economic status and education level, as compared to other socio-demographic indicators.

	Municipality size (thousands of inhabitants)											
	500 or more		100 to 500		50 to 100		20 to 50		5 to 20		Less than 5	
	Coef.	Robust Std. Error	Coef.	Robust Std. Error	Coef.	Robust Std. Error	Coef.	Robust Std. Error	Coef.	Robust Std. Error	Coef.	Robust Std. Error
No. of members	-1.761***	(0.128)	-1.508***	(0.247)	-1.841***	(0.402)	-2.305***	(0.235)	-2.295***	(0.256)	-1.642***	(0.442)
No. of members (squared)	0.126***	(0.0143)	0.100**	(0.0367)	0.203**	(0.0740)	0.178***	(0.0321)	0.228***	(0.0333)	0.112*	(0.0545)
No. of minor children	0.730***	(0.162)	0.625**	(0.203)	0.299	(0.379)	0.899**	(0.292)	0.370	(0.279)	0.600	(0.457)
No adult men (dummy)	0.502**	(0.159)	0.862***	(0.185)	0.681**	(0.258)	0.579**	(0.193)	0.920***	(0.176)	1.273***	(0.326)
Mean age of adults	-0.123***	(0.0245)	-0.116***	(0.0242)	-0.154**	(0.0535)	-0.152***	(0.0361)	-0.110***	(0.0268)	-0.167***	(0.0324)
Mean age of adults (squared)	0.00109***	(0.000217)	0.00115***	(0.000225)	0.00147**	(0.000495)	0.00151***	(0.000333)	0.00115***	(0.000269)	0.00183***	(0.000306)
No. of members in employment	-0.357*	(0.144)	-0.172	(0.130)	-0.477	(0.278)	-0.250	(0.178)	-0.514**	(0.175)	-0.360	(0.226)
At least one member with university degree	-0.0717	(0.118)	-0.179	(0.143)	-0.511	(0.268)	0.218	(0.230)	-0.428*	(0.218)	-0.149	(0.344)
Members with health-related mobility problems (ref.cat.: None) Some	0.271	(0.193)	0.266	(0.213)	0.340	(0.306)	0.393	(0.236)	0.237	(0.266)	1.207***	(0.270)
All	0.391*	(0.178)	0.768**	(0.255)	0.966	(0.434)	1.047***	(0.199)	0.421	(0.232)	1.043***	(0.268)
Economic status (ref.cat.: Very low): Low	-0.457	(0.256)	-0.541*	(0.235)	-0.409	(0.396)	-0.464	(0.264)	-0.247	(0.288)	-0.642*	(0.287)
Medium	-1.493***	(0.228)	-1.521	(0.207)	-1.617***	(0.274)	-1.650	(0.181)	-1.581	(0.236)	-1.327***	(0.293)
High	-1.775	(0.219)	-2.119***	(0.250)	-2.669***	(0.320)	-2.422***	(0.290)	-2.181***	(0.314)	-2.219***	(0.362)
Very high	-2.495***	(0.267)	-3.235***	(0.377)	-2.627***	(0.581)	-2.579***	(0.442)	-2.696***	(0.566)	-2.751***	(0.741)
(constant)	6.242***	(0.660)	4.540***	(0.692)	5.670***	(1.249)	5.846***	(0.898)	4.179***	(0.693)	3.561***	(1.041)
N	4,165		3,827		1,887		5,143		6,501		4,207	
McFadden's pseudo R^2	0.268		0.309		0.324		0.360		0.387		0.406	

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

Tab. 6.12 - Logistic regression models for the probability of not owning a household car, by municipality size (logit coefficients and robust standard errors). Unit of analysis: households. Source: own elaboration on MiD 2008 data.

6.1.3. Reasons for not owning cars: a typology of carless households

In the previous section, I have focused on the changing socio-demographic composition of the carless households group across different types of area, thus addressing hypothesis H1.1 (see §3.3.2). In this section, I focus on the reasons for not owning cars, thus addressing hypothesis H1.2. The hypothesis states that people who deliberately choose to live without cars are more likely to be found in compact cities, while in sparse areas I expect the carless to mention mainly constraints (e.g. age, disability, low income) when asked about the reasons for not owning a car.

In this section, I apply latent class analysis to a battery of items about the reasons for not owning cars. The goal here is to build a typology of households without cars. By describing the distribution of the different clusters across different types of areas, I am able to test hypothesis H1.2. Subsequently, I describe the typology with regard to variables in the following key areas: socio-demographics, mobility capital, travel behaviour and accessibility to services and opportunities. This allows to better grasp the nature of the clusters, as well as to approach hypothesis H1.1 from another angle. Finally, it also allows me to provide first empirical evidence on H1.3 and H1.4. The last two hypotheses are then explored more in depth in the next section (§6.1.4).

In order to build the typology, I have used a battery of six dichotomous items about the reasons underlying the lack of a car, drawn from the MiD 2008 household questionnaire. The question "For which of the following reasons does your household not own a car?" had a multiple choice answer format with six options: *not necessary, deliberate abstinence, too expensive, health reasons, age reasons, other reasons*. Tab. 6.13 presents the frequency distribution of the answers.

	Not necessary	***Deliberate abstinence***	***Too expensive***	***Health reasons***	***Age reasons***	***Other reasons***	**Total**
Multiple choice items	45	43	50	20	21	25	-
'Priority' variable	16	5	50	19		9	100

Tab. 6.13 – Reasons for not owning a car (percentage values). Unit of analysis: households. Source: own elaboration on MiD 2008 data.

It is worth noting that, even though *too expensive* was the most chosen option, more than 40% of respondents selected either *not necessary* or *deliberate abstinence.* Health and age-related reasons were chosen only by about one in five respondents, while approximately 25% selected *other reasons*. However, since this was a multiple choice battery, the number of possible patterns of response is 2^6=64. In order to reduce this complexity, the database provides a categorical variable labelled 'reasons for not owning a car (priority)', that was built according to the following criterion (infas, 2010a, p. 4): all households who selected *too expensive* were assigned to this category, regardless of what other response option they may have selected. Of all remaining respondents, all those who had selected either *health reasons* or *age reasons* were then deemed to fit into the *health or age reasons* category, regardless of other selected options. All remaining respondents were assigned to one of the remaining categories following the same criterion, assuming the following priority order: *not necessary, deliberate abstinence, other reasons* (infas, 2010a, p. 4). Unsurprisingly, the resulting variable greatly underestimates reasons other than affordability, as illustrated in Tab. 6.13. Accordingly, researchers using this variable run the risk of finding out that economic reasons are the most important factor behind non-car ownership, just because it was arbitrarily assumed from the start that it had to be so.

I argue here that this method of summarizing the results of the six binary items is unsatisfactory, because the priority order assumed is very arbitrary. In order to reduce the complexity of the 64 possible patterns of response, without making any assumptions about priority order, it is preferable to use latent class analysis (LCA) (§A.4).

Tab. 6.14 shows the results of LCA performed on the subsample of carless households[119]. As input variables, in addition to the six items mentioned above, I have employed a seventh variable, namely a dummy to identify households without licensed drivers, because this is arguably another important reason for the lack of a vehicle. A six-class solution represented the best compromise between fit, parsimony and classification performance, as attested by the low value of the Average Weight of Evidence (AWE) statistic[120] (Vermunt & Magidson, 2005b, p. 112).

Cluster number	**1**	**2**	**3**	**4**	**5**	**6**	
Cluster name	**Car abstinence**	**Too old to drive**	**Economically car deprived**	**No driving licence**	**Car free**	**Health impaired**	**Total (households without cars)**
Cluster size households	35	19	17	14	10	5	100
Cluster size individuals	35	17	21	12	10	4	100
Not necessary	67	29	27	12	100	0	45
Deliberate abstinence	100	39	0	4	0	0	43
Too expensive	56	39	100	20	27	17	50
Health reasons	13	49	6	0	8	100	20
Age reasons	5	100	0	5	0	0	21
Other reasons	17	17	0	100	9	14	25
No driving licence	38	65	19	84	60	69	50

Tab. 6.14 – Latent class analysis results, cluster profile, percentage values[121] for the clusters obtained with modal assignment[122]. Unit of analysis: households (and individuals). Source: own elaboration on MiD 2008 data.

In Tab. 6.14, the clusters are ordered by decreasing cluster size (in the household database). In the following section, I provide interpretation of the clusters.

Cluster 1 accounts for approximately 35% of the carless (both in terms of households and individuals), and is thus by far the largest group. All households in this group chose *deliberate abstinence*, two thirds selected also *not necessary* and 55% (slightly more than the sample average) *too expensive*. Reasons of health, age or *other reasons* were selected only by a small minority of this group, considerably less than in the sample as a whole. Finally, only 38% of households in this cluster do not include any licensed members, well below the average for carless households (50%). For these households, the reasons for not owning cars are a combination of absence of need, affordability problems and deliberate abstinence (always selected).

[119] The analysis was conducted with Latent GOLD® version 4.5.

[120] The process of model selection is discussed at length in §B.3.2.

[121] The reader must note that the values in the lower half of Tab. 6.14 indicate the percentage of members of each cluster that 'ticked' on each of the seven items. Given that the "reason for not owning a car" question allowed multiple choices, these percentages do not add up to 100%. The values reported in the 'total' column indicate the percentage of households on the sample of carless households as a whole that selected each of the seven items.

[122] On modal assignment see §A.4.5.

Reasons associated with health or old age are here only marginal. For this reason, I name the cluster *car abstinence* (CA).

By contrast all respondents in cluster 2 (accounting for approximately 19% of carless households), selected *age reasons*, and almost one in two (well above the sample average) also *health reasons*. A significant minority of respondents selected also *not necessary*, *deliberate abstinence* or *too expensive*, even though less than the sample average. Similarly, 17% of households in cluster 2 mentioned *other reasons*. Overall, people in this group selected several items, taking full advantage of the multiple answer format, but they always chose age and often health, something that sets them apart from other clusters. Moreover, only 35% of households in this group include a licensed member, consistently with the lower share of licensed drivers among old cohorts. Therefore, I name this group *too old to drive* (TOTD).

The third group accounts for approximately 17% of households, but for a significantly larger share of individuals (21%). In fact, it is the second largest group in terms of individuals, a fact suggesting that the mean household size here must be significantly larger. The profile of the group is simple to interpret: all respondents selected *too expensive*, none mentioned *deliberate abstinence*, *age reasons* or *other reasons* and only a minority chose either *not necessary* (27%) or *health reasons* (6%). 81% of households here have (at least) a driving licence, a figure that is much higher than in all remaining clusters. Given the predominant role of economic reasons for this group, I name it *economically car deprived*[123] (ECD).

The fourth group (accounting for only 14% of carless households) is interesting in that all households here mentioned *other reasons*, while only a minority selected also other options. At the same time, this is also the group with the lowest share of licensed drivers (16%). Therefore, I assume that most respondents intended to select the lack of a licensed driver as the main reason but, since this response option was not provided, chose *other reasons* instead. Accordingly, I name this group *no driving licence* (NDL).

The last two groups include only a low proportion of households, and are defined by the prevalence of one response option. The fifth (*car free*, CF, 10%) consists of households who always selected *not necessary* and only in a minority of cases other kinds of reasons. The sixth (*health impaired*, HI, 5%) includes households who always chose *health reasons* and only in a minority of cases other reasons. For both groups, the share of households with at least one licensed driver is well below the sample average.

Overall, the results of LCA show that a simple six-cluster typology is capable of accounting for the variety of households without cars, in a way that is more meaningful and statistically sound than the ‘reasons for not owning a car (priority)’ variable included in the MiD 2008 dataset. The six clusters illustrated in Tab. 6.14 can each be associated with a main reason, but their size is often radically different than their counterparts derived from the ‘reasons for not owning a car (priority)’ variable. For example, while economic reasons have been selected by 55% of respondents in the multiple answer format, the car deprived group accounts for only around 17% of households. This can be interpreted as follows: the financial burden of owning a car is a reason that applies to many carless households (consistently with the results illustrated in §6.1.1, showing the importance of economic status for car ownership), but is the predominant reason only for a minority of them. Conversely, clusters associated mainly with the options *deliberate abstinence* (CA) or *not necessary* (CF) account for almost 45% of households without cars in the sample – more than double than in the priority variable. Therefore, a first merit of the typology put forward here is to unveil the arbitrary and normative nature of the summarizing variable provided by MiD 2008 which, in assuming that affordability *had* to be the main reason for lack of car ownership, inevitably ends up overestimating the number of households who do not own a car because they cannot afford one. Another interesting result of the typology obtained here is to highlight that the absence of a licensed driver is the main reason for not owning a car for approximately 15% of carless households: this fact tends to be obscured by the lack of the relative answer option in the MiD 2008 questionnaire

[123] Since in chapter 2 I have defined ‘car deprivation’ as a form of car-related transport disadvantage (§2.2.1), this cluster label might be the cause of confusion. Therefore, it is important to point out that, ‘economically car deprived’ here refers to households who do not own cars for reasons that are mostly economic. This does not necessarily imply that they experience ‘car deprivation’ or any form transport disadvantage.

Once groups have been described in relation to input variables, the following step is to examine their descriptive statistics for other key variables. In this context, a crucial research question concerns the territorial distribution of the typology of carless households: this is illustrated graphically in Fig. 6.17, according to municipality size[124].

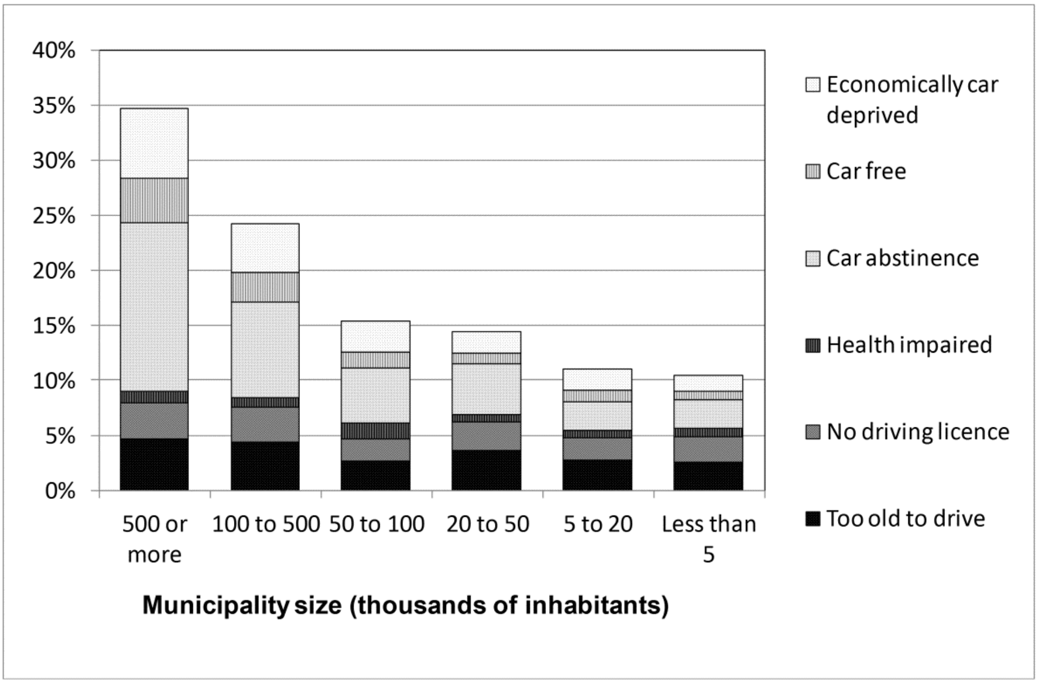

Fig. 6.17 – Carless household typology by municipality size. Unit of analysis: households. Source: own elaboration on MiD 2008 data.

	Municipality size					
	500 or more	**100 to 500**	**50 to 100**	**20 to 50**	**5 to 20**	**less than 5**
CA	44	36	32	32	24	25
TOTD	13	18	17	24	24	24
ECD	18	18	19	14	18	14
NDL	10	13	13	18	18	22
CF	11	11	10	7	9	7
HI	3	4	9	5	6	5
Total	*100*	*100*	*100*	*100*	*100*	*100*
CA + ECD + CF	74	65	61	53	51	47
TOTD + NDL + HI	26	35	39	47	49	53
Total	*100*	*100*	*100*	*100*	*100*	*100*

Tab. 6.15 – Carless households typology by municipality size (percentage values). Unit of analysis: households. Source: own elaboration on MiD 2008 data.

The graph shows clearly that the size of virtually all clusters increases in moving from small municipalities to large German cities. However, even simple visual inspection shows that the size of clusters TOTD, NDL and HI (depicted with black background patterns) does not increase as much as that of clusters CA, ECD and CF (depicted with white background patterns): indeed, chi-square tests of significance (not reported here for the sake of brevity) even show that it cannot be ruled out that the size of NDL and HI groups is the same in

[124] Using alternative geographical variables (type of district, population density at the municipal level and in the 1x1km proximity area) does not lead to different conclusions. The relative graphs are not reported here for the sake of brevity.

every kind of municipality[125]. By contrast, the size of clusters CA, ECD and CF increases dramatically in larger municipalities, notably over 100,000 inhabitants. For example, only 2.6% of households living in very small municipalities (under 5,000 inhabitants) fit into the CA group, making its size comparable to that of the TOTD cluster (2.5%). By contrast, in cities over 500,000 inhabitants, 15.4% of the sample belongs to CA (approximately six times more than in the smallest municipalities), while TOTD accounts for only 4.6% (not even double the size it has at the other extreme of the spectrum). As a result, as illustrated in Tab. 6.15, while the 10% of carless households in very small municipalities is almost equally split between TOTD, NDL and HI, on one hand, and CA, ECD and CF on the other, the latter account for more than two thirds of carless households in large German cities.

Overall, these results suggest that the typology might be further simplified in two macro-groups of clusters: the first (including TOTD, NDL and HI) represents a sort of 'hard core' of carless households, accounting for the approximately the same share of the population in every type of area. The size of the second (clusters CA, ECD, CF), by contrast, is extremely variable according to the degree of urbanity.

Further evidence in support of this second-order clustering is provided by Fig. 6.18, showing how the composition of the carless group (according to the typology) changes with age: it is apparent that, while household members classified into the CA, EDC and CF clusters (depicted with white background patterns) are found in all age groups, the TOTD, NDL and HI clusters (depicted with black background patterns) account for a relevant share of the carless group only among seniors.

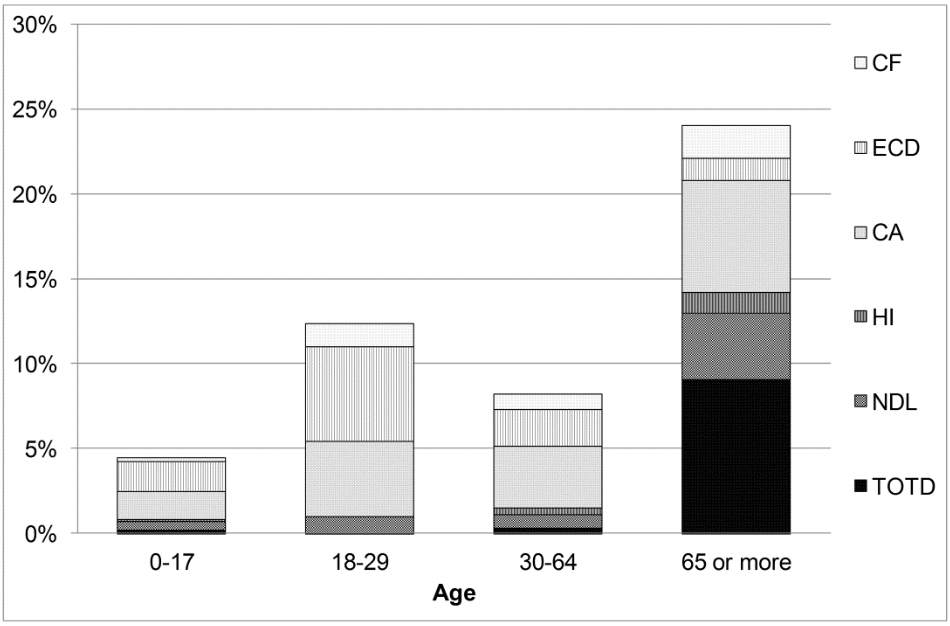

Fig. 6.18 – Individuals living in households without cars, by age and carless households typology. Unit of analysis: individuals. Source: own elaboration on MiD 2008 data.

This conclusion is confirmed by Fig. 6.19, showing the smoothed age distribution for individuals in each cluster: it is apparent that the age distribution for TOTD, NDL and HI is strongly skewed to the right, meaning that these clusters consist essentially of older people. By contrast, clusters CA and CF present the bimodal distribution that is characteristic of the carless household subset as a whole (see Fig. 6.1 above), while ECD

[125] By contrast, the hypothesis of constant size across municipality sizes can be ruled out for all other clusters. The relative chi-squared tests are not reported here for the sake of brevity.

even shows a distribution that is skewed to the left, meaning that it consists essentially of young people[126]. Interestingly, the ECD cluster is also the largest in the age group 18-29 (Fig. 6.18).

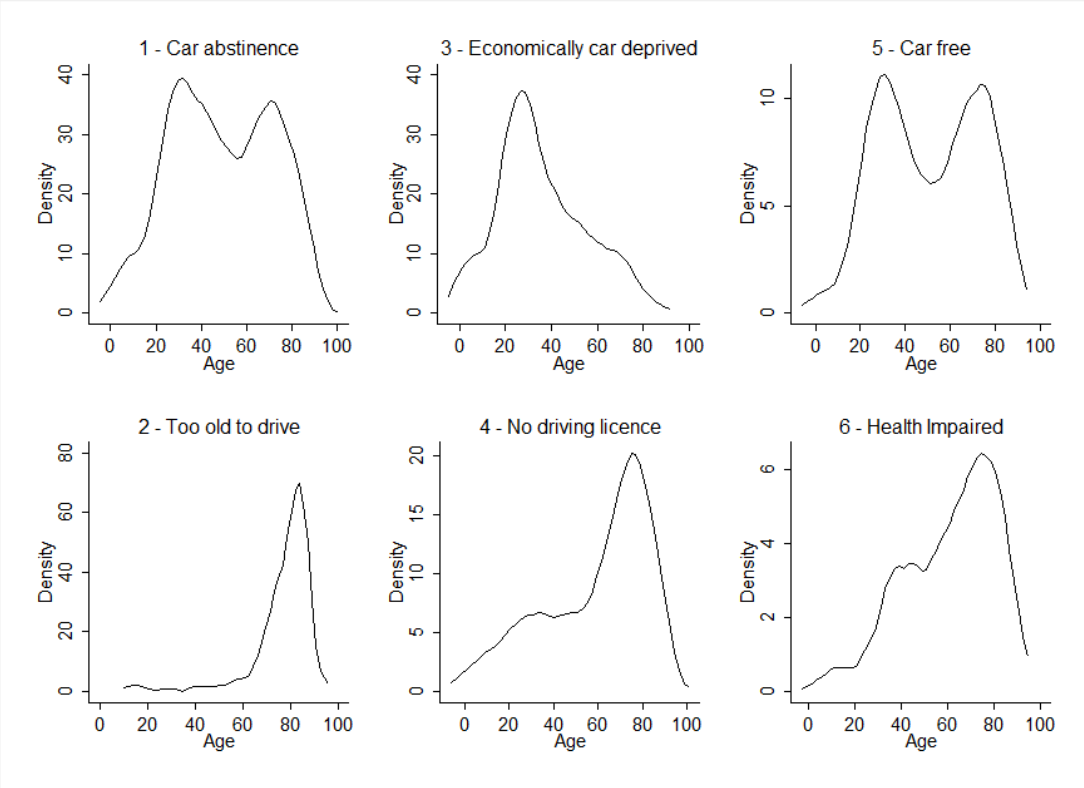

Fig. 6.19 – Smoothed age distribution of household members for clusters of the carless households typology. Unit of analysis: individuals. Source: own elaboration on MiD 2008 data.

Overall, these preliminary results suggest that the six-clusters typology can be further simplified into two macro-classes: clusters TOTD, NDL and HI show an age distribution strongly skewed towards upper ages, and are defined by reasons for not owning a car that are either directly or indirectly (lack of driving licence, health problems) related to old age. Moreover, the size of these clusters does not vary so much across different types of area. Therefore, I argue that they can be labelled as 'age-related' clusters (AR). By contrast, clusters CA, ECD and CF are not defined so much by a particular age profile (with the partial exception of ECD, that is concentrated among young adults), but rather from their relative concentration in larger cities and high-density areas. Accordingly, in the following these clusters are referred to collectively as the 'non-age-related' macro-class (NAR).

In the remainder of this section, the six clusters are described with respect to variables in four key areas (the same used in §6.1.1 to illustrate the systematic differences between households with and without cars): socio-demographics, mobility capital, travel behaviour and accessibility to services and opportunities. The question here is: do differences in the stated reasons for not owning cars correspond to 'real' differences in such key areas? Throughout this discussion, differences between clusters in terms of age distribution and distribution across different types of area should be kept in mind, because they are likely to explain many of the differences observed in other areas. In the remainder of this section, the second-ordering clustering proposed above (that is based on theoretical considerations, rather than on the use of a data reduction analysis technique) is also discussed in light of this new evidence.

[126] Further analysis disaggregated by gender shows that for all clusters except ECD and TOTD the age distribution is more skewed to the right for women. The relative graphs are not reported here for the sake of brevity.

Tab. 6.16 shows the composition of the six clusters, with respect to ten key socio-demographic variables (the same illustrated in Tab. 6.2). In the two rightmost columns, the values for the carless households group and for the MiD 2008 sample as a whole are reported to allow comparison.

		1 - CA	2 - TOTD	3 - ECD	4 - NDL	5 - CF	6 - HI	Households without cars	Total (MiD 2008 sample)
Mean age of adults	**18-29**	8	0	24	5	11	1	9	5
	30-64	47	7	56	28	45	43	38	64
	65+	45	92	20	67	44	56	53	31
	Total	*100*	*100*	*100*	*100*	*100*	*100*	*100*	*100*
Household type	**retired single**	40	71	23	64	41	58	47	18
	retired HH	6	14	3	5	8	18	8	15
	Single	40	12	53	25	41	18	34	21
	Other	14	3	22	7	10	6	11	46
	Total	*100*	*100*	*100*	*100*	*100*	*100*	*100*	*100*
No. of adult men	**0**	55	74	59	78	59	52	62	25
	1 or more	45	36	61	22	41	48	38	75
	Total	*100*	*100*	*100*	*100*	*100*	*100*	*100*	*100*
No. of employed members	**0**	62	97	60	82	71	87	73	40
	1 or more	38	3	40	18	19	13	27	60
	Total	*100*	*100*	*100*	*100*	*100*	*100*	*100*	*100*
All adults unemployed	**Yes**	4	1	11	4	5	6	5	2
	No	96	99	89	96	95	94	95	98
	Total	*100*	*100*	*100*	*100*	*100*	*100*	*100*	*100*
Student household	**Yes**	5	0	16	1	9	0	6	2
	No	95	100	84	99	91	100	94	98
	Total	*100*	*100*	*100*	*100*	*100*	*100*	*100*	*100*
No. of minor children	**0**	95	99	90	97	98	96	96	81
	1 or more	5	1	10	3	2	4	4	19
	Total	*100*	*100*	*100*	*100*	*100*	*100*	*100*	*100*
Economic status	**very low**	10	13	27	12	16	16	15	8
	low	23	26	37	32	24	24	28	12
	medium	38	40	28	44	36	37	37	41
	high	24	18	7	12	21	15	17	29
	very high	4	2	0	1	3	8	3	10
	Total	*100*	*100*	*100*	*100*	*100*	*100*	*100*	*100*
No. of members with a university degree	**0**	72	89	82	91	81	90	81	71
	1 or more	28	11	18	9	19	10	19	29
	Total	*100*	*100*	*100*	*100*	*100*	*100*	*100*	*100*

Tab. 6.16 – Distribution of key socio-demographic variables for clusters in the carless households typology (percentage values[127]). Unit of analysis: households. Source: own elaboration on MiD 2008 data.

[127] All row and column variables in Tab. 6.16 are significantly associated at the $p<0.05$ level (Chi-square tests). Occasionally, percentage values do not add up to 100% because of rounding errors.

		1 - CA	2 - TOTD	3 - ECD	4 - NDL	5 - CF	6 – HI	Households without cars	Total (MiD 2008 sample)
Car available as driver[128]	**Always/sometimes**	27	10	38	10	23	10	23	83
	Never /not a licensed driver	73	90	62	90	77	90	77	17
	Total	*100*	*100*	*100*	*100*	*100*	*100*	*100*	*100*
Car available on travel diary day[129]	**All the time / to some extent**	20	23	26	28	24	24	23	83
	Not at all	80	77	74	72	76	76	77	17
	Total	*100*	*100*	*100*	*100*	*100*	*100*	*100*	*100*
Bicycle owner	**Yes**	71	33	66	53	62	46	59	78
	No	29	67	34	47	38	54	41	22
	Total	*100*	*100*	*100*	*100*	*100*	*100*	*100*	*100*
Public transport ticket (at least week ticket[130])	**Yes**	43	18	47	24	44	15	36	17
	No	57	82	53	76	56	85	64	13
	Total	*100*	*100*	*100*	*100*	*100*	*100*	*100*	*100*
Driving licence (motorcycles)	**Yes**	22	5	26	8	14	9	17	29
	No	78	95	74	92	86	91	83	71
	Total	*100*	*100*	*100*	*100*	*100*	*100*	*100*	*100*
Distance from closest bus stop[131]	**less than 400m**	68	61	64	62	69	64	65	56
	400m or more	32	39	36	38	31	36	35	44
	Total	*100*	*100*	*100*	*100*	*100*	*100*	*100*	*100*
Distance from closest local train station[132]	**less than 1km**	59	45	57	43	61	43	54	32
	1km or more	41	55	43	57	39	57	46	68
	Total	*100*	*100*	*100*	*100*	*100*	*100*	*100*	*100*
Health-related mobility problems	**Yes**	12	43	9	19	14	60	20	8
	No	88	57	91	81	86	40	80	92
	Total	*100*	*100*	*100*	*100*	*100*	*100*	*100*	*100*
Internet access[133]	**Yes**	53	6	64	26	51	39	43	72
	No	47	94	36	74	49	61	57	28
	Total	100	100	100	100	100	100	100	100

Tab. 6.17 – Mobility capital indicators for clusters in the carless households typology (percentage values[134]). Unit of analysis: individuals. Source: own elaboration on MiD 2008 data.

In terms of household type, while retired singles and retired households are overrepresented in AR clusters (with the exception of retired households in the NDL group), NAR clusters exhibit an overrepresentation of (non-retired) singles and other types of families, accounting for at least 50% of households in each cluster. This result is not surprising, given the age differences between the groups. Similarly, households without adult men and family units where no member is employed are overrepresented in the AR clusters (with the partial exception of HI), something which is consistent with their older mean age. The ECD cluster is characterised by a significant overrepresentation of households where all adults are unemployed, of student households and of households with minor children. These characteristics set this group apart from all other clusters. Concerning economic status, significant differences from the sample average are observed only for the ECD group (where low and very low income households are overrepresented and account for 64%) and

[128] This question was asked only to household members aged 14 or more.

[129] This question was asked only to household members aged 14 or more.

[130] This question was asked only to household members aged 14 or more.

[131] This question was asked only to household members aged 14 or more. In this case, the results of the chi-square test indicate that the association between row and column variables is not statistically significant at the 5% level (p = 0.1831).

[132] This question was asked only to household members aged 14 or more.

[133] This question was asked only to household members aged 14 or more.

[134] All row and column variables in Tab. 6.17 are significantly associated at the p<0.05 level (chi-square tests), except where otherwise noted. Occasionally, percentage values do not add up to 100% because of rounding errors.

for CA (where by contrast high and very high income households account for 28% of the cluster, a figure that is ten percentage point above average). Similarly, CA is also the only group where the share of households where at least one member has achieved a university degree is significantly higher than average.

Tab. 6.17 shows the frequency distributions for some indicators of mobility capital (the same as in Tab. 6.4) for the six-clusters typology. It shows clearly that NAR clusters perform better on virtually all indicators of availability of transport modes (with the partial exception of motorcycle driving licences for the CF group). Individuals in these clusters own more bicycles and public transport tickets and are more likely to have a driving licence (for cars and motorcycles alike) than AR clusters. They also have a car available (as driver) more often[135]. While no significant differences exist for the distance to the closest bus stop, households in NAR clusters live on average closer to the local train station than the rest of the carless. Of course, this might by a by-product of the concentration of NAR clusters in dense urban areas. Finally, TOTD and HI report a much higher incidence of health-related mobility problems, something which is consistent with their profile in terms of age and stated reasons for not owning a car.

Tab. 6.18 shows the performance of the clusters on key travel behaviour variables, derived from the one-day travel diary included in the MiD 2008 questionnaire. The variables are the same used in Tab. 6.5 in §6.1.1 to illustrate the systematic differences between households with and without cars. Overall, the table shows that with some exceptions (mostly related to CF), individuals in NAR clusters are on average more mobile: they are more likely to make at least one trip on the travel diary day, carry out more trips, travel further and longer than the rest of the carless. Accordingly, they are also responsible for a greater share of CO_2 emissions. The typology also offers some interesting insights with regard to travel time: while, as observed for Tab. 6.5, the mean value of the time spent travelling by carless households is not significantly different from the German average, there is a large difference between the average travel time for NAR clusters (ranging from 1 hour and 20 minutes to 1 hour and 28 minutes) and for AR clusters (ranging from 59 minutes to 1 hour and 9 minutes). As a result, the average for the carless household group as a whole is deceiving in that it obscures important differences within the carless population: the coexistence of a more mobile group of carless (who actually spend *more* time on travel than the average German) and a group which spends on average 16 to 20 minutes less on travel than the German average.

In terms of modal split, for all clusters the share of non motorised mods (walking and cycling) on all trips is at least 57%, even if this corresponds to only 10-17% of the covered distance. However, the modal share of cycling is higher for individuals in NAR clusters (with the partial exception of CF), and the same is true for walking for AR clusters. These differences are less pronounced if the modal split in terms of travel distance is considered, since walking trips tend to be shorter than others. Car driving does not account for more than 8% of trips for any cluster – considerably less than the MiD 2008 average (53%). However, it is significantly higher for the ECD cluster, accounting for 8% of trips and almost one third of the travel distance. Paradoxically, the modal share of 'car driver' in terms of distance is also slightly above average for the NDL cluster[136]. The share of trips as car passenger is higher than average only for AR clusters. However, if travel distance is considered, this modal share is above average only for the NDL and CA clusters. This suggests that 'car abstinent' people tend to rely on lifts from others for longer journeys. Motorbikes and taxis account for a residual share of trips and distances for all clusters, with the partial exception of taxis for HI. With regard to public transport, the modal share in terms of trips is higher for NAR than for AR clusters. This is partly contradicted by figures for travel distances, showing that the public transport use is below average only for ECD and NDL.

[135] This is not confirmed by the indicator 'car available on travel diary day', showing lower than average car availability only for the CA cluster. This can be explained by the fact that this indicator measures car availability in general (both as a driver and as a passenger), and NAR clusters rely more on car lifts (see below).

[136] A tentative explanation for this result is the following: the NDL cluster also includes 16% of households who include at least one member with a driving licence. For these households, the 'other reason' for not owning cars is obviously not the absence of a licensed member. This (unknown) reasons might in turn be associated with a great share of car driving, as well as with longer daily travel distances, and this is enough to offset the modal share of car driving among the remaining 84% of the NDL cluster (that should be very close to zero). Further in-depth analysis (not reported here for the sake of brevity) tends to strengthen this hypothesis. However, given the small sample size of the NDL cluster, it is impossible to provide a conclusive answer to this question.

On travel diary day			1 - CA	2 - TOTD	3 - ECD	4 - NDL	5 - CF	6 – HI	HH without cars	Total (MiD 2008 sample)
At least one trip	Yes	%	88	72	88	80	87	79	84	90
	No		12	28	12	20	13	21	16	10
	Total		*100*	*100*	*100*	*100*	*100*	*100*	*100*	*100*
Trips	Generic mean	Mean	3.33	2.15	3.34	2.50	2.76	2.41	2.94	3.42
	Specific mean		3.80	2.97	3.80	3.11	3.17	3.06	3.51	3.81
Travel distance (km)	Generic mean	Mean	27.6	10.8	26.6	19.6	22.0	11.8	22.4	39.1
	Specific mean		31.6	15.2	30.2	24.7	25.3	15.0	26.9	43.6
Travel time (h:min)	Generic mean	Mean	1:28	0:58	1:23	1:09	1:20	1:02	1:18	1:19
	Specific mean		1:40	1:23	1:35	1:26	1:31	1:19	1:33	1:28
Average length of trips (km)		Mean	8.4	5.1	8.0	7.9	8.0	4.9	7.7	11.5
CO_2 emissions (kg)		Mean	1.95	0.77	2.21	1.53	1.92	0.73	1.70	4.50
Modal split (basis: trips)	Walking	%	40	54	40	51	48	53	44	24
	Cycling		23	10	17	11	12	11	17	10
	Car / van driver		2	0	8	4	3	1	4	42
	Car / van passenger		7	12	9	12	8	11	9	15
	Motorbike/ other private		0	0	2	1	0	0	1	1
	Taxi / Minicab		1	2	0	1	0	3	1	0
	Public Transport		27	21	24	19	29	21	25	8
	Total		*100*	*100*	*100*	*100*	*100*	*100*	*100*	*100*
Modal split (basis: distance)	Walking	%	6	9	7	7	8	10	7	3
	Cycling		9	5	8	3	3	7	7	3
	Car / van driver		6	1	31	15	11	3	13	53
	Car / van passenger		26	19	20	28	13	17	23	25
	Motorbike / other private		0	1	1	0	0	0	0	1
	Taxi / Minicab		0	2	0	1	0	4	1	0
	Public transport		52	63	33	45	65	58	49	15
	Total		*100*	*100*	*100*	*100*	*100*	*100*	*100*	*100*

Tab. 6.18 – Travel behaviour indicators for clusters in the carless households typology (percentage values and means[137]). Unit of analysis: individuals, trips. Source: own elaboration on MiD 2008 data.

Overall, figures for modal split confirm only in part the distinction between AR and NAR clusters. There is some evidence to suggest that, on average, AR clusters rely more on walking and car as passengers, while

[137] All differences between means in Tab. 6.18 have been tested with adjusted Wald test and are significant at the 5% level. Occasionally, percentage values do not add up to 100% because of rounding errors. Where percentage values are presented, row and column variables are significantly associated at the p<0.05 level (chi-square tests).

NAR clusters use bicycles and public transport more[138]. However, there are many exceptions to this rule, and conclusions change if travel distance is considered (instead of trips). Notably, the ECD cluster has a profile in terms of modal behaviour that is distinct from all others, showing a higher than average reliance on cycling, but also on car driving, and a lower use of public transport than other AR clusters. In a nutshell then, evidence about modal split is less supportive than other travel behaviour measures of the division of the carless group in two main macro-clusters (NAR vs. AR).

Tab. 6.19 presents the score of the six clusters on several indexes of accessibility to services and opportunities, built on the basis of the indicators listed in Tab. B.4 (§B.2.3). The indexes are the same used in Tab. 6.6 in § 6.1.1 in order to show the systematic differences between households with and without cars

		1 - CA	2 - TOTD	3 - ECD	4 - NDL	5 - CF	6 – HI	HH without cars	Total (MiD 2008 sample)
Accessibility	Walking	4,23	3,43	4,24	3,77	4,24	3,36	3.99	3.60
	Cycling	3,91	2,77	4,01	3,51	3,96	3,36	3.66	3.44
	Public transport	3,31	2,72	3,41	2,81	3,23	2,82	3.13	2.57
	Car	3,62	3,59	3,98	3,59	3,47	3,83	3.68	4.31
All modes	Maximum	4,67	4,40	4,76	4,47	4,65	4,54	4.60	4.67
	Mean	3,73	3,13	3,87	3,41	3,68	3,34	3.59	3.44
Alternative modes (car excluded)	Maximum	4,53	3,96	4,55	4,21	4,56	4,13	4.38	3.95
	Mean	3,75	2,96	3,82	3,31	3,75	3,17	3.55	3.09
Accessibility and mobility capital index		2,51	1,81	2,50	2,11	2,45	1,93	2.30	3.13
Available transport modes	Maximum	4,50	3,89	4,51	4,09	4,51	3,97	4.32	4.62
	Mean	3,81	3,12	3,86	3,36	3,78	3,16	3.45	3.47

Tab. 6.19 – Accessibility indexes for the clusters in the carless households typology: mean values[139]. All indexes range between 0 (min.) and 5 (max.). Unit of analysis: individuals. Source: own elaboration on MiD 2008 data.

The table presents an unequivocal picture: on all indexes, NAR clusters score better than the rest of the carless. This is true for all indicators except for car accessibility, where only ECD and HI show values above average. By contrast, household members in the TOTD, NDL and HI clusters exhibit lower scores, often lower than the MiD sample average even for mean accessibility indicators, where carless household members score on average higher than their motorised counterparts. For example, individuals belonging to the TOTD cluster have a level of access by foot that is worse than the sample average, something that might be related with health-related mobility problems. The average value for carless households on this indicator tends to obscure this fact: this shows the usefulness of the typology put forward here for revealing the heterogeneity of the carless group. Of course, the differences shown in Tab. 6.19 might also be the result of the fact that while AR clusters are scattered across all types of area, NAR clusters are 'clustered' in dense urban areas, where accessibility by modes alternative to the car is considerably better.

To sum up, the results of LCA and the subsequent descriptive analysis of the clusters show that differences in the stated reasons for not owning cars correspond to real differences in key areas such as socio-demographics, type of area of residence, accessibility to services and opportunities, mobility capital and travel behaviour. They also confirm that it makes sense to group the clusters in two 'macro-groups', each including three of the clusters obtained with LCA.

138 Of course, these differences might partially be explained by the concentration of NAR clusters in urban areas, where public transport and cycling infrastructure is more developed.

139 All differences between means in Tab. 6.19 have been tested with adjusted Wald test and are significant at the 5% level.

NAR clusters (CA, ECD and CF) – accounting for approximately 62% of carless households and 11% of the whole sample – are the only clusters that include a relevant share of young household members – which even constitute the majority of individuals in the ECD cluster, while CA and CF are characterized by a bimodal age distribution. Accordingly, clusters in this macro-group are the only ones where non-retired households represent the majority. In terms of territorial distribution, the size of this macro-group increases dramatically moving from less dense and more peripheral areas to large cities (where it accounts for around 20% of the population as a whole). In terms of mobility capital, households in NAR clusters enjoy greater availability of transport means (car and driving licences included), greater proximity to public transport infrastructures (something which might be related to their concentration in urban areas) and report less health-related mobility problems. In terms of travel behaviour, respondents in the CA, ECD and (to a lesser extent) CF group are characterized by higher levels of mobility than the rest of the carless, in virtually every respect (trips, travel distance, travel time), and are thus responsible for a greater amount of transport-related CO_2 emissions. In terms of modal split, differences between AR and NAR clusters are not so clear-cut. However, NAR clusters show a higher than average use of bicycles (CA and ECD), public transport (CA and CF) or automobiles (ECD): overall, this modal profile shows a greater reliance on modes allowing independent or relatively long-distance travel. This could also be a by-product of the overrepresentation of these clusters in urban areas, where public transport is better. Moreover, individuals in this macro group enjoy a greater degree of accessibility to services and opportunities than the rest of the carless, and often score even better than the sample average in terms of mean accessibility (all modes considered). This result could also be explained by the overrepresentation of this macro-group in urban areas, where accessibility by modes alternative to the car is generally better. Overall, NAR clusters can be characterized as younger, more urban and more mobile than the rest of the carless, while at the same time enjoying better access to services. It also represents a more polluting kind of carless living, at least in terms of CO_2 emissions.

AR clusters (TOTD, NDL and HI) account for approximately 38% of households without cars (7% of the whole sample). They are primarily characterized by the old age of household members, and by the predominance of retired households, accounting for no less than 70% of family units in these clusters. Households with employed members are also rare here, and many do not include any adult men. In terms of territorial distribution, the size of these clusters does not vary much in moving from rural to urban areas – indeed, for two clusters (NDL and HI) chi-square tests show that it is impossible to rule out the hypothesis that, in the population, they have the same size in all types of area. People in these clusters have less mobility capital, as they have less access to modes of transport (car included), live further away from local train stations and report more health-related mobility problems. Only a minority of households in this macro group include a licensed driver, something which is also one of its defining features. In terms of travel behaviour, AR clusters are significantly less mobile than the German average and the average of carless households, and this is true in terms of trips, travelled distances and travel time. Accordingly, their travel-related CO_2 emissions are way below those of other carless households (with the partial exception of NDL). In terms of modal split, respondents belonging to AR clusters walk more than half of their trips, and rely more on car lifts (more than 10% of trips) than NAR clusters. This suggests a greater reliance on the slowest mode of transport (walking) as well as greater dependence on others. In terms of accessibility to services and opportunities, individuals in this macro group score worse than the rest of the carless, and often lower than the sample average. Overall, this macro group is older and less mobile, and suffers from a deficit of accessibility. Contrary to the NAR macro group, it is not concentrated in any type of area, representing a ‘scattered’ form of non-car ownership. It also represents a more environmentally benign kind of carless living, something which can be attributed to lower mobility levels.

In short then, I argue that the results illustrated in this section point at the existence of two main groups of carless households, with quite different characteristics. First, a ‘hard core’ of old, less mobile people, who suffer from a lack of accessibility and represent approximately the same share of the population in every territorial contexts. This can be defined as a ‘scattered’ form of non-car ownership, that is ultimately motivated by reasons related to old-age. Second, a group of households who are more mobile and enjoy better accessibility conditions. The reasons put forward for the lack of a household car are a mixture of choice, absence of need and unaffordability. In terms of socio-demographics, the group is composed mostly by households in the phases before or after employment and family formation. However, most carless households who are in the labour force are also found here. Defining characteristics of this group are higher mobility levels, as well as greater reliance on transport modes that allow independent or relatively long-distance travel (public transport, cycling, car as driver). Of course, this is partially explained by the concentration of this group in urban areas, with better public transport and cycling infrastructure. Indeed, the size of NAR clusters is more variable depending on spatial features of the residential area: it can even be argued that it is the variation in the size of this group that explains the higher share of carless households in medium-large cities. In that sense, this is a 'clustered' form of non-car ownership.

As illustrated in Chapter 2, Hine and Grieco put forward the idea that trasnsport disadvantage takes the form of "scatters and clusters" (Grieco et al., 2000; Hine & Grieco, 2003). In this section, I borrow the notion of 'scatters vs. clusters' from Hine and Grieco, but I apply it to non-car ownership. With this, I do not mean to imply that lack of a household car necessarily entails transport disadvantage.

In a nutshell, the findings illustrated in this section lead me to formulate the hypothesis that the group of carless households in Germany can be described as the mixture of two forms of non-car ownership: a 'scattered' form, mainly associated with reasons related to old age, and a 'clustered' form, mainly associated with reasons unrelated to old age (affordability, deliberate abstinence, lack of need). In order to test this hypothesis, I present here the results of a multinomial logistic regression model (Tab. 6.20).

As illustrated in more detail in §A.2, a multinomial logistic regression model consists of n-1 logistic regression models, where n is the number of categories of a variable with two outcomes or more. In this case, the outcome variable is the following household typology:

- 0 = household with cars
- 1 = household without cars, NAR clusters
- 2 = household without cars, AR clusters

The first column in Tab. 6.20 presents the logistic regression model for the probability of belonging to a NAR cluster of carless households, rather than owning cars. The second column does the same for AR clusters. The model fit is high (Mc Fadden's Pseudo R^2=0,37), indicating that the model is a good representation of the data[140]. With regard to the question of interest, the model confirms expectations: virtually all logit parameters associated with territorial variables in the second sub-model (probability of being in AR clusters, rather than owning cars) are not statistically significant[141]. By contrast, they are all statistically significant for NAR clusters. This can be interpreted as follows: when other relevant factors are controlled for, population density and access to public transport have little impact on the probability of being carless for reasons related to old age (TOTD), lack of licensed household members (NDL) or health issues (HI). By contrast, territorial variables have an impact on the probability of being carless for reasons related to deliberate abstinence, affordability and lack of need[142] (CA, ECD, CF).

140 Further methodological details about the model are presented in §B.3.3.

141 The exception here is the 'East Germany' variable. However, as discussed above, this predictor captures the effect of growing up in the GDR, rather than the influence of land-use and built environment characteristics.

142 However, it must be noted that the coefficient associated with the predictor 'car-related accessibility advantage' is negative and statistically significant in both sub-models. Indeed, the results of a similar multinomial logistic regression model that excludes the 'car-related accessibility advantage" index (not reported here for the sake of brevity), show that a greater number of coefficients associated with territorial variables are significant in the second sub-model (even if still less than in the first sub-model). This can be interpreted as follows: the probability of belonging to AR clusters does not increase with population density and public transport access, when the self-rated accessibility to a limited range of basic services and opportunities is controlled for. Therefore, there is virtually no independent effect of the territorial variables on this probability, because the effect is entirely mediated by the 'car-related accessibility advantage' index. The same is not true for the probability of belonging to NAR clusters, meaning that it is more likely to be member of CA, ECD and CF clusters in dense urban areas with good public transport access, even when self-rated accessibility to basic services and opportunities is held constant.

Functional set of variables			1/0 Coef.	1/0 Robust Std. Error	2/0 Coef.	2/0 Robust Std. Error
Socio-demographic variables	**No. of HH members**		-1.962***	(0.106)	-1.741***	(0.204)
	No. of HH members (squared)		0.152***	(0.0149)	0.152***	(0.0215)
	No. of minor children		0.686***	(0.115)	0.631**	(0.202)
	No adult men in HH (dummy)		0.672***	(0.0983)	1.080***	(0.142)
	Mean age of adults		-0.0776***	(0.0170)	-0.151***	(0.0210)
	Mean age of adults (squared)		0.000642***	(0.000164)	0.00176***	(0.000186)
	No. of employed HH members		-0.136	(0.0806)	-0.369**	(0.135)
	At least one member with university degree (dummy)		-0.0713	(0.0991)	-0.776***	(0.157)
	Members with health-related mobility problems (ref.cat.: None):	Some	0.285	(0.149)	0.727***	(0.159)
		All	0.650***	(0.138)	1.266***	(0.164)
	Economic status (ref.cat.: Very low):	Low	-0.418**	(0.134)	-0.483*	(0.190)
		Medium	-1.512***	(0.115)	-1.479***	(0.152)
		High	-2.061***	(0.140)	-1.958***	(0.199)
		Very high	-2.822***	(0.198)	-2.748***	(0.447)
Territorial variables	**East Germany (dummy)**		0.337***	(0.0823)	0.817***	(0.103)
	Population density (municipality) (ref.cat.: >2,000 in/km^2) :	1,500-2,000	-0.272*	(0.111)	-0.0952	(0.190)
		1,000-1,500	-0.459**	(0.149)	0.00101	(0.202)
		500-1,000	-0.784***	(0.158)	-0.360	(0.187)
		200-500	-0.912***	(0.144)	-0.266	(0.187)
		<200	-0.975***	(0.170)	-0.488*	(0.217)
	Population density (1x1km pixel) (ref.cat.: >10,000 in.):	5,000-10,000	-0.403**	(0.146)	-0.208	(0.235)
		2,000-5,000	-0.582***	(0.154)	-0.355	(0.222)
		1,000-2,000	-0.472*	(0.188)	-0.232	(0.242)
		500-1,000	-0.482*	(0.218)	-0.347	(0.277)
		250-500	-0.654**	(0.251)	-0.180	(0.323)
		100-250	-0.871*	(0.364)	-0.807	(0.427)
		1-100	-1.576***	(0.431)	-0.392	(0.502)
		0	-1.497	(0.890)	-1.484**	(0.569)
	Distance residence – closest bus stop (meters)		-0.0000725	(0.0000507)	-0.0000749	(0.0000653)
	Distance residence – closest local train station (meters)		-0.0000546***	(0.0000152)	-0.0000215	(0.0000155)
	Car-related accessibility advantage		-0.499***	(0.0283)	-0.356***	(0.0360)
	(constant)		5.394***	(0.412)	3.406***	(0.656)
	N		24,441			
	McFadden's pseudo R^2		0.373			

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Tab. 6.20 – Multinomial logistic regression model for the probability of being in NAR clusters, rather than owning cars (1/0) and the probability of being in AR clusters, rather than owning cars (2/0) (logit coefficients and robust standard errors). Unit of analysis: households. Source: own elaboration on MiD 2008 data.

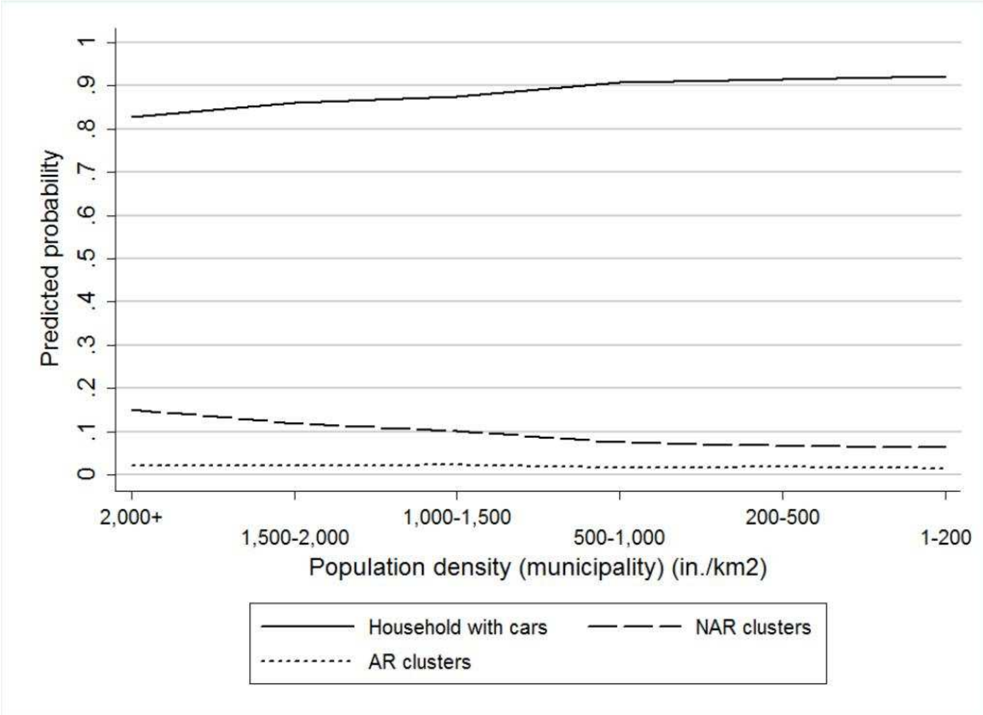

Fig. 6.20 - Predicted probabilities of owning cars, belonging to NAR clusters and belonging to AR clusters, by population density in the municipality. The probabilities are predicted using the multinomial logistic regression model reported in Tab. 6.20. Unit of analysis: households. Source: own elaboration on MiD 2008 data.

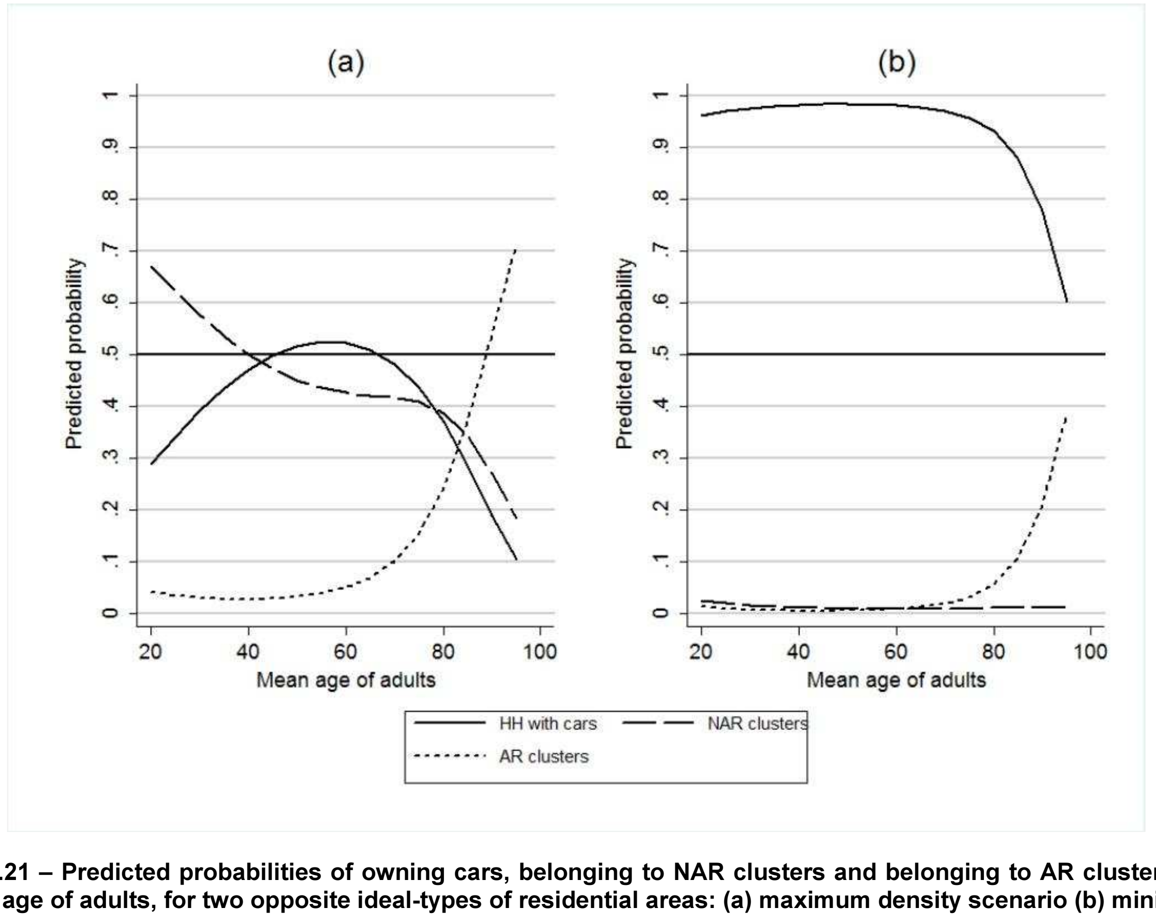

Fig. 6.21 – Predicted probabilities of owning cars, belonging to NAR clusters and belonging to AR clusters, by mean age of adults, for two opposite ideal-types of residential areas: (a) maximum density scenario (b) minimum density scenario. The probabilities are predicted using the multinomial logistic regression model reported in Tab. 6.20. Unit of analysis: households. Source: own elaboration on MiD 2008 data.

The implications of these results are illustrated in Fig. 6.20 and Fig. 6.21, showing the predicted probabilities derived from the model in Tab. 6.20. Fig. 6.20 shows how the predicted probabilities for the three outcomes vary according to population density at the municipality level, for a German household with average characteristics on all other predictors[143]. The graph shows clearly that the probability of belonging to NAR clusters is considerably higher than the probability of belonging to AR clusters in very dense municipalities. As population density decreases, while the probability of belonging to NAR clusters decreases visibly, the probability of belonging to AR clusters is not affected. This shows that, even after controlling for other factors, the size of NAR clusters varies across different types of area (i.e. it is a 'clustered' form of non-car ownership), while the size of AR clusters is rather stable (thus constituting a 'scattered' form of non-car ownership[144]).

Fig. 6.21 shows how the predicted probabilities for the three outcomes vary according to the mean age of adults in two opposite ideal-types of residential area: a maximum (Fig. 6.21a) and a minimum density scenario[145] (Fig. 6.21b). Fig. 6.21a shows that, in a maximum density scenario, the probability of belonging to NAR clusters is highest for young adults, and then decreases gradually (particularly after the age of 80). By contrast, the predicted probability of belonging to AR clusters is very low until the age of 60, then takes off rapidly: starting from approximately the age of 85, belonging to AR clusters is the most probable outcome in a maximum density scenario. Fig. 6.21b shows that, in a minimum density scenario, the predicted probability of not owning cars is very low across most of the age spectrum: it is only around the age of 70 that the probability of belonging to AR clusters starts to increase. The probability of belonging to NAR clusters, by contrast, is very low across the whole age spectrum, although it increases slightly for people in their early twenties. Taken together, the results illustrated in these graph confirm that AR clusters correspond to a 'scattered' form of non-car ownership, while NAR clusters are 'clustered' in certain types of area (large, dense urban areas), thus corroborating the hypothesis.

6.1.4. Travel behaviour and accessibility among the carless across different types of area

In §3.3.2 four specific hypotheses about the changing composition of the carless group across different types of areas have been put forward. The first two have been explored in the previous sections and concerned socio-demographics (§6.1.2) and reasons for not owning cars (§6.1.3). The third concerned travel behaviour, and posited that non-car ownership in low-density areas corresponds mostly to low levels of mobility, while this relationship should be attenuated in dense urban areas. Finally, based on the fourth hypothesis, I expect many carless individuals in low-density areas to suffer from a significant lack of accessibility to services and opportunities, as compared to members of car-owning households, while I expect the carless group in inner cities to be more diverse, including a substantial proportion of individuals who enjoy good access to essential services and opportunities

In the previous section, a typology of carless households, based on the reasons for not owning cars, has been proposed. The results of this analysis show that NAR clusters are more mobile (in terms of trips, travelled distance and journey times), and report better accessibility to basic services and opportunities, as compared to AR clusters. Since the proportion of carless households belonging to NAR clusters is directly correlated with the degree of population density and urbanity, this could be taken as evidence in support of hypotheses H1.3 and H1.4. However, this conclusion has some limitations: in fact, accessibility is correlated with population density and urbanity, and so is mobility (at least for carless households). Therefore, average values for the two macro-clusters might be just the by-product of their different territorial distribution (with NAR clusters 'clustered' in dense cities, and AR clusters 'scattered' across different types of area). If this is

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[143] All other variables have been kept to their mean or mode in the MiD 2008 sample.

[144] In Fig. 6.20, predicted probabilities are very low for both NAR and AR clusters. This is due to the fact that other territorial variables (such as population density in the proximity area, access to public transport and car-related accessibility gain) and all socio-demographic predictors are held constant to their mean or modal value in the population. Figures referred to other socio-demographic profiles (not reported here for the sake of brevity) show higher predicted probabilities for both NAR and AR clusters. However, this does not change the conclusion that the predicted probability of belonging to NAR clusters is correlated with population density, contrary to the probability of belonging to AR clusters.

[145] The specific values for territorial variables held constant in the two scenarios are reported in Tab. 6.9 in §6.1.1. All socio-demographic variables except mean age of adults have been held constant at their mean or modal values in the MiD 2008 sample.

true, it would mean that, inside each type of area there is no difference between AR and NAR clusters, in terms of accessibility and travel behaviour.

On travel diary day			Municipality size (thousands of inhabitants)				Total
			500 or more	100 to 500	20 to 100	less than 20	
At least one trip	**HH with cars**	%	*91.0*	90.4	90.7	90.1	90.5
	HH without cars		*89.3*	84.8	81.3	81.4	83.8
	NAR clusters		91.4	88.9	86.7	*78.7*	87.7
	AR clusters		81.4	75.2	73.2	*75.3*	76.0
Trips	**HH with cars**	**Mean**	3.47	3.55	3.54	3.41	3.48
	HH without cars		3.19	3.17	2.91	2.37	2.94
	NAR clusters		3.37	3.53	3.29	2.58	3.26
	AR clusters		2.50	2.32	2.33	2.15	2.31
Travel distance (km)	**HH with cars**	**Mean**	36.9	41.5	39.6	43.0	41.1
	HH without cars		28.7	21.1	19.8	17.2	22.4
	NAR clusters		31.9	*24.0*	*23.1*	*21.6*	26.5
	AR clusters		16.0	*14.3*	*14.5*	*12.6*	14.1
Travel time (h:min)	**HH with cars**	**Mean**	*1:26*	*1:23*	*1:18*	1:16	*1:19*
	HH without cars		*1:30*	*1:18*	*1:14*	1:05	*1:18*
	NAR clusters		1:37	1:24	*1:19*	*1:08*	1:25
	AR clusters		1:03	1:04	*1:06*	*1:01*	1:04
Average length of trips (km)	**HH with cars**	**Mean**	*10.6*	11.8	11.2	12.6	11.8
	HH without cars		*9.0*	6.7	6.9	7.3	7.7
	NAR clusters		*9.5*	*6.9*	*7.1*	*8.4*	*8.2*
	AR clusters		*6.6*	*6.2*	*6.2*	*5.9*	*6.2*

Tab. 6.21 – Travel behaviour indicators for households with and without cars and for NAR and AR clusters of carless households (percentage values and means[146]). Unit of analysis: individuals, trips. Source: own elaboration on MiD 2008 data.

It is therefore necessary to analyse the differences between NAR and AR clusters inside each type of area. This section focuses on this, starting from travel behaviour. Tab. 6.21 shows how the values for indicators of travel behaviour vary across different types of area, according to municipality size[147]. It shows this for households with and without cars and for NAR and AR clusters of carless households. Given the small sample size of NAR and AR clusters (especially in small municipalities), the six-category variable 'municipality size' has been recoded into a four-category variable, to ensure a healthy number of observations in each type of area.

[146] In Tab. 6.21, Tab. 6.22 and Tab. 6.23, differences in means and percentage values have been tested using chi-square and adjusted Wald tests. However, given the small number of observations in some cells, sampling stratification has not been considered in these tests – while other sampling design characteristics (weights, clustering) have been taken into account (see §B.1.2). Since taking into account stratification generally reduces the standard errors associated with the estimates, this implies an increased risk of false acceptance of the null hypothesis (that there is no difference in the population). This, in addition to to the small number of observations for many cells, might explain the high incidence of non-significant differences in the tables in this section. In this and in the following tables, values for which the difference between households with and without cars (or between NAR and AR clusters) is not significant at the 5% level are written in italic and in a smaller font size.

[147] All trends illustrated in Tab. 6.21 to Tab. 6.23 have been double-checked using three other geographical variables: type of district, population density at the municipal level and for the 1x1km proximity area. The results of these analyses broadly confirm the results illustrated here. The relative tables are not reported here for the sake of brevity.

Four main conclusions can be drawn from Tab. 6.21. Firstly, individuals in households with cars are on average more mobile than their carless counterparts. This was illustrated previously in Tab. 6.5 (§6.1.1): Tab. 6.21 shows that it holds true even after controlling for type of area[148]. The significant exception here is travel time, as in all but the smallest municipalities the difference is so small that it cannot be ruled out that there is no difference among the population.

Secondly, for all indicators of travel behaviour, differences between averages for individuals in households with and without cars increase as municipality size decreases. So for example, the share of individuals who have been out of the house on the day of survey is approximately 90% for both groups in large cities (with more than 500,000 inhabitants). In fact, the results of chi-square test show that it is not possible to exclude that there is actually no difference in this respect. While the share of mobile individuals is substantially stable across all types of area for motorised households, the figure drops eight percentage points for carless individuals in small municipalities (with less than 20,000 inhabitants). The same trend is apparent for the number of daily trips, with the difference between the two groups going from 0.28 to 1.04. Even more strikingly, while the distance travelled by individuals living in motorised households increases as municipality size decreases, the opposite happens for carless individuals: as a result, the difference between the two groups is largest in small municipalities. In terms of travel time, adjusted Wald-tests suggest that there is no difference in all types of area except in the smallest municipalities, where individuals in households with cars travel on average 10 more minutes per day. Finally, also the difference in terms of average length of trips peaks in municipalities with less than 20,000 inhabitants.

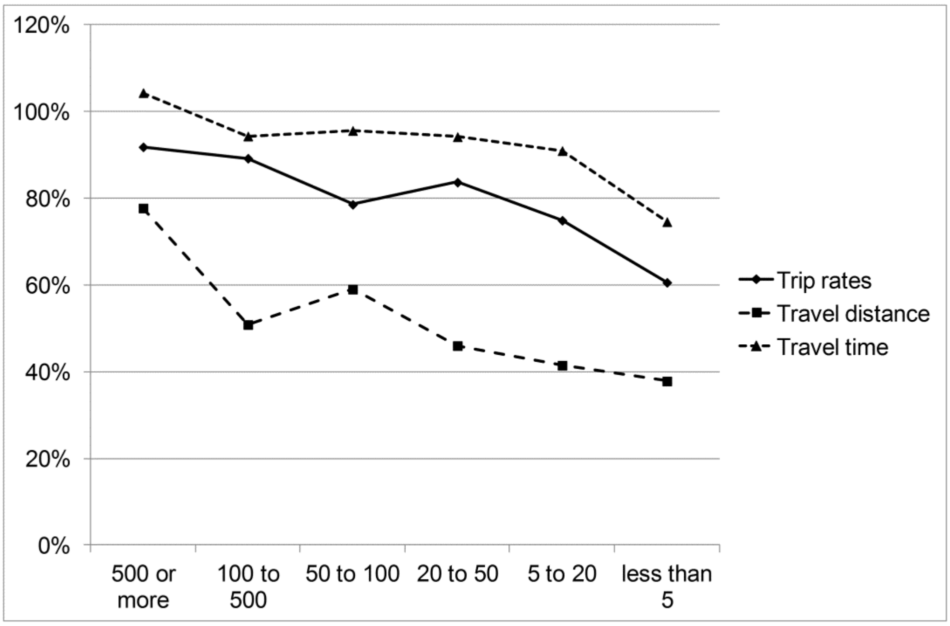

Fig. 6.22 – Travel behaviour indicators for carless individuals, as percentage of the same indicator for individuals in car-owning households, by type of area. Unit of analysis: individuals. Source: own elaboration on MiD 2008 data.

Fig. 6.22 depicts graphically how the 'mobiltiy gap' of individuals in households without cars (as compared to their motorised counterparts) widens as the degree of urbanity decreases. It shows how the values of three travel behaviour indicators (trip rates, travel distance and time) for carless individuals, computed as percentage of the same indicator for individuals in car-owning households, vary across different types of

[148] In fact, differences are even emphasised after controlling for the territorial distribution, because carless households are strongly concentrated in the largest urban areas.

area[149]. The values should be interpreted as follows: in very large cities in Germany, carless individuals make on average approximately 92% of the trips of their motorised counterparts. This figure decreases as the degree of urbanity decreases, reaching 55% in very small municipalities. The same trend is observed for the other two parameters of travel behaviour: travel time and distance.

Thirdly, NAR clusters are on average more mobile than AR clusters. This was illustrated previously in Tab. 6.18: Tab. 6.21 shows that it holds true even after controlling for type of area. Therefore, it can be excluded that the differences observed for these indicators between NAR and AR clusters in the sample as a whole are just the by-product of the different territorial distribution of the two groups. A partial exception here are the indicators of travel distance, where high standard errors do not allow to rule out that there is no difference between the two macro-groups, in most types of area.

Finally, overall, it appears that the differences between NAR and AR clusters tend to decrease as municipality size decreases, even though there are several exceptions to this rule. However, for all variables (except the average length of trips) the difference between NAR and AR clusters is greatest in large cities (where the travel behaviour profile of NAR clusters is very close to that of individuals in car-owning households) and smallest in municipalities with less than 20,000 inhabitants.

		Municipality size (thousands inhabitants)				Total
		500 or more	**100 to 500**	**20 to 100**	**less than 20**	
Accessibility and mobility capital index	**HH with cars**	3.52	3.50	3.36	3.08	3.28
	HH without cars	2.52	2.40	2.19	2.00	2.30
	NAR clusters	2.63	2.57	2.36	2.25	2.50
	AR clusters	2.08	2.02	1.97	1.76	1.93
Available transport modes (Max)	**HH with cars**	4.69	4.70	4.69	4.65	4.67
	HH without cars	4.51	4.45	4.21	4.02	4.32
	NAR clusters	4.60	4.59	4.41	4.30	4.51
	AR clusters	4.17	4.17	3.94	3.76	3.97
Available transport modes (Mean)	**HH with cars**	3.72	3.74	*3.53*	3.23	3.45
	HH without cars	3.88	3.89	*3.46*	3.08	3.61
	NAR clusters	4.00	4.03	3.63	3.35	3.82
	AR clusters	3.43	3.59	3.23	2.84	3.21

Tab. 6.22 – Accessibility indexes for households with and without cars and for NAR and AR clusters of carless households (mean values[150]). All indexes range between 0 (min.) and 5 (max.). Unit of analysis: individuals. Source: own elaboration on MiD 2008 data.

Taken together, these conclusions provide evidence in support of hypothesis H1.3. Indeed, non-car ownership in low-density areas corresponds to average levels of mobility that are significantly lower than those of motorised households (as illustrated in Fig. 6.22). By contrast, this relation is attenuated in dense urban areas. Tab. 6.21 shows that this is not just a result of the fact that carless individuals are, on average, less mobile in peripheral areas. It is also the result of the changing composition of the carless group across different types of area: in small municipalities AR clusters (who, in most types of area, are less mobile than NAR clusters) account for a larger share of the carless. Conversely, in large cities, the composition of the carless group is more diverse also in terms of travel behaviour, including a substantial proportion of people

[149] The trends illustrated in Fig. 6.22 were double-checked using other geographical variables (population density at the municipality level and in the 1*1 km pixel): the results (not reported here for the sake of brevity) are broadly consistent with those reported here.

[150] In Tab. 6.22, values for which the difference between households with and without cars (or between NAR and AR clusters) is not significant at the 5% level (according to the adjusted Wald test) are written in italic and with smaller font size.

(NAR clusters), whose mobility profile is similar to that of individuals in households with cars. In a nutshell, then, Tab. 6.21 suggests that the different socio-demographic composition of the carless group is a key factor to explain differences in the average travel behaviour of individuals without cars across different types of area.

Tab. 6.22 shows the result of the same analysis for three indexes of accessibility to basic services and opportunities. Four main conclusions can be drawn from it. Firstly, in all types of area, accessibility is better for individuals in households with cars. The exception in this context is the index that takes into consideration the mean value of self-rated accessibility for available modes. According to this indicator, individuals in households without cars in municipalities with 100,000 inhabitants or more experience better accessibility levels than their motorised counterparts.

Secondly, for all groups, accessibility decreases as municipality size decreases. The only exception in this context is the index 'available transport modes (max)', that remains quite stable across different types of area for individuals in motorised households

Thirdly, this decrease is more pronounced for the carless: therefore, in smallest municipalities the 'accessibility gap' for individuals in households with cars is at its peak (even for the index 'available transport modes (mean)'). This is shown in Fig. 6.23.

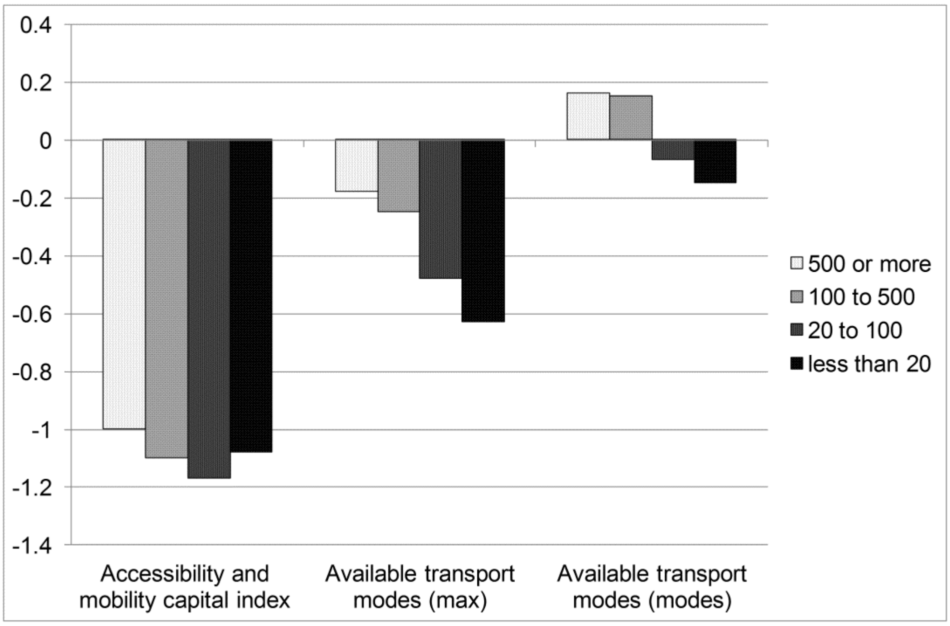

Fig. 6.23 – Score differential between individuals in carless and car owning households for three accessibility indexes (scores reported in Tab. 6.22). Unit of analysis: individuals. Source: own elaboration on MiD 2008 data.

Finally, in all types of areas, regardless of the index used, NAR clusters report higher accessibility levels than AR clusters. This was illustrated previously in Tab. 6.19 (§6.1.3): Tab. 6.22 shows that it holds true even after controlling for type of area. Therefore, it can be excluded that the differences observed for these indicators between NAR and AR clusters in the sample as a whole are just the by-product of the different territorial distribution of the two groups.

Taken together, these conclusions provide evidence in support of hypothesis H1.4. The 'accessibility gap' for carless households is greatest in peripheral, low density areas (see Fig. 6.23), and this is due also to the fact that in these areas the carless group is more concentrated among AR clusters, which in every area report worse accessibility than NAR clusters[151]. Conversely, the carless group in inner cities is more diverse, including a substantial proportion of individuals who report accessibility levels closer to those of car-owning households (NAR clusters). In a nutshell, then, Tab. 6.22 suggests that the composition of the carless group is a key factor to explain how the accessibility levels reported by individuals without cars vary across different types of area.

In order to explore the reasons of the differential in accessibility between NAR and AR clusters, Tab. 6.23 shows the average values of the accessibility indexes for three modes available to carless individuals (walking, cycling and public transport), by municipality size, for the two groups. It shows that, while in every type of area it is more difficult for AR clusters to access services by foot and bike, this is not true for public transport in most areas. This suggests that the differential in accessibility levels between NAR and AR clusters is mainly due to the difficulties that the latter experience with non motorised modes. This in turn is likely to be associated with old age and health-related mobility problems. In a nutshell, then, the same reasons that explain the lack of a household car for AR clusters might explain their 'accessibility gap' that affects them[152].

		Municipality size (thousands of inhabitants)				
		500 or more	100 to 500	20 to 100	less than 20	Total
Walking	**NAR clusters**	4.39	4.33	4.04	3.98	4.23
	AR clusters	3.77	3.65	3.56	3.33	3.55
Cycling	**NAR clusters**	4.10	4.00	3.79	3.72	3.95
	AR clusters	3.24	3.05	3.33	2.88	3.11
Public transport	**NAR clusters**	3.60	*3.64*	*3.15*	*2.48*	3.33
	AR clusters	2.96	*3.49*	*2.80*	*2.18*	2.67

Tab. 6.23 – Accessibility indexes (by travel mode) for NAR and AR clusters of carless households (mean values[153]). Unit of analysis: individuals, Source: own elaboration on MiD 2008 data.

6.1.5. Conclusions

In the previous sections (§6.1.2 to §6.1.4) the four hypotheses related to Question 1 have been explored separately. In this final section, I review the empirical findings, highlighting the interrelationship between findings for the different hypotheses.

With regard to H1.1 (different socio-demographic composition of the carless group across different types of area), the hypothesis is corroborated by the German data. Descriptive analysis shows that the carless households group is significantly more concentrated among marginal groups in peripheral low-density areas. Odds ratios show that the association between non-car ownership and most of its socio-demographic determinants is considerably stronger in these areas too. Finally, the results of logistic regression models

[151] The reader might be surprised at the small differentials between the scores of individuals in car-owning and carless households. However, as I discuss at greater length in §B.2.3, the accessibility indexes discussed in this chapter have several limitations, many of which arguably result in an underestimation of the accessibility disadvantage for the carless. Therefore, all differentials in accessibility levels between individuals with and without cars should be considered as conservative estimates, as the 'true' differential is likely to be higher.

[152] Finally, it must be kept in mind that the accessibility gap between NAR and AR clusters is likely to be underestimated: indeed, the indexes used here are averaged across the destinations that the individual is assumed to need to access (see §B.2.3). This means that, for approximately 90% of individuals in AR clusters, the accessibility indexes reported here refer exclusively to the access to shops for daily shopping. By contrast, for approximately 40% of individuals in NAR clusters the indexes are averaged over two destinations (corresponding to either the workplace or school), because of the higher share of people in employment or education. As accessibility to shops is (on average) rated better than accessibility to workplace and school, one would expect AR clusters to report better accessibility than NAR. Since the opposite is true, it is possible to conclude that, if all carless had to access to same services and opportunities, the accessibility gap for AR clusters would be even greater. Further analysis focused only on access to shops (not reported here for the sake of brevity) confirms this conclusion.

[153] In Tab. 6.23, values for which the difference between NAR and AR clusters is not significant at the 5% level (according to the adjusted Wald test) are written in italic and with smaller font size.

show that it is much easier to predict non-car ownership using socio-demographic variables in small municipalities, as compared with large cities.

However, the analysis also suggests that this is more true for socio-demographic variables in a narrow sense (age, gender, employment, etc.) than for indicators of social status. Indeed, there are only marginal differences in the odds ratios for economic status and education level across different types of area (see Tab. 6.11). This suggests that, at least in Germany, carless households in peripheral, low density areas are actually more concentrated among marginal groups in a *socio-demographic sense* (e.g. retired old women) as compared to dense urban areas, but not from a social status perspective. In other words, they are not significantly more concentrated among the poor and the low-skilled.

Overall, however, the hypothesis of varying socio-demographic composition of the carless group across different types of area is corroborated by German data. The results of the regression analysis illustrated in §6.1.1 suggest a tentative explanation of *why* this happens. The analysis of the predicted probabilities illustrated in Fig. 6.3 and Fig. 6.4 shows that there exist two main conditions that make it very unlikely 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. Secondly, there are also socio-demographic situations which make it very unlikely not to own cars: 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. My argument here is that *it is the interweaving of these two impeding conditions, one related to geography, the other to social practices* (see §1.4.1)*, 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 ‘female’ 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 old age, non-employment, small household size etc.. Similarly, for working households with children, simply living in a densely populated area is not a condition sufficient to induce non-car ownership; 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 process potentially explains the greater diversity of household without cars that is observed in dense German urban areas.

With regard to H1.2 (different composition of the carless group across different types of area in terms of reasons for not owning cars), expectations are only partially confirmed. Notably, I put forward the hypothesis that non-car ownership in peripheral, low density areas would be defined more by *constraining factors* and less by *choice*, as compared to dense urban areas. On one hand, the empirical results show that in small municipalities the carless group is more concentrated among AR clusters, for whom the main reasons for non-car ownership are constraints related to old age. Conversely, clusters defined mainly by deliberate abstinence or lack of need (CA and CF) are significantly overrepresented in large cities. These findings corroborate the hypothesis.

On the other hand however, the empirical results suggest that there is no clear opposition between households who have chosen to live without a car and those who are forced to do so. Notably the role of affordability problems defies expectations, in at least two respects: firstly, the profile of the largest cluster (CA) shows that choice, absence of need and unaffordability are often associated. This can be explained in different ways: households who cannot afford cars might reduce cognitive dissonance (Festinger, 1957) by presenting the situation as one of ‘deliberate abstinence’ or ‘lack of need’. An alternative explanation is that, when the benefits associated with car ownership are low (such as for example for singles living in dense urban areas with good public transport networks), the related costs, even when affordable, tend to appear ‘too high’. Secondly, the cluster of households who unequivocally indicated affordability problems as the main reason (ECD) has a profile (in terms of socio-demographics, travel behaviour, territorial distribution, mobility capital and accessibility) more similar to clusters mainly defined by choice or absence of need (CA and CF) than to other clusters. It is for this reason that, in many analysis, I have discussed the opposition between AR and NAR clusters, thus contradicting the initial hypothesis of an opposition between carless for *choice* and *forced* carless. Notably, unlike clusters defined by age-related constraints, the size of ECD is larger in dense urban areas, and its relative weight in the carless group does not increase as the degree of urbanity and population density decrease.

This can be interpreted as follows: while age-related constraints such as health-related mobility problems of lack of a driving licence are *absolute* constraints to car ownership, low income is probably looser constraint. This would also help explain why, as discussed for hypothesis H1.1, non-car ownership is not significantly more concentrated among poor households in peripheral, low density areas. In a nutshell, this suggests that poor German households who are in absolute need of a car, are in many cases able to get one, even if this means having to cut in other essential areas of the household budget. Therefore, the smaller size of the ECD cluster in small municipalities can be interpreted as a tell-tale sign of a greater incidence of car-related economic stress in these areas, as suggested by existing research (see §2.2.2). Conversely, the larger size of the ECD cluster in large cities might suggest that in these areas the need for car ownership is not strong enough to motivate people to invest a large part of their limited budget in the purchase and running of a vehicle. In that sense, in dense urban areas there is a relatively large group of people who, albeit stating that affordability is the sole reason preventing them from owning cars, are in fact exercising agency – since in other, more car dependent areas, they would be able to find ways to purchase a vehicle.

To adopt the terminology put forward in Chapter 2, households with limited economic resources (who are present in all types of area) face a trade-off between two forms of car-related transport disadvantage: car deprivation and car-related economic stress. In more car dependent areas, they are more likely to choose the latter, and this explains the greater incidence of 'forced car ownership' (as demonstrated by previous research, see §2.2.2). In dense urban areas, where car dependence is lower, they are more likely to suffer the transport disadvantage associated with lack of car ownership, rather than cutting on other areas of the household budget: this in turn explains why the ECD cluster size is larger in dense urban areas[154].

With regard to H1.3 (different composition of the carless group across different types of area in terms of travel behaviour) and H1.4 (in terms of accessibility to services and opportunities) the empirical results corroborate the hypothesis. In peripheral, low density areas, carless households are considerably more concentrated among AR clusters, that are less mobile and more likely to experience low levels of accessibility to essential services and opportunities, mostly because of reasons related to old age. Conversely, the large majority of the carless group in dense urban areas consists of NAR clusters, characterised not only by a different socio-demographic composition, but also by levels of mobility and accessibility that are closer to those of individuals in car-owning households. Importantly, the analysis shows that the differences between AR and NAR hold true even after controlling for the type of area.

Considering the empirical results for hypothesis H1.3 and H1.4 in light of the findings for the other two hypothesis, it is possible to put forward a simple theoretical scheme to explain why travel behaviour and accessibility for carless households vary across different types of area (Fig. 6.24). As illustrated in the graph, higher levels of car dependence in peripheral, low density areas have both *direct* and *indirect* effects on the levels of mobility and accessibility for carless households. The direct effect is that, since it is more difficult to access services and opportunities without a car, carless households experience lower levels of accessibility, even when all other factors are equal. Accordingly, they also limit their own mobility (in terms of trips and travel distance), opting for closer destinations and/or giving up trips that would take too much time to be made[155].

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[154] Of course, these observations go beyond the empirical evidence provided here. They should be considered as hypotheses for further empirical research.

[155] It is worth reiterating that the differences between individuals living in households with and without cars in terms of travel time are minor and generally statistically non-significant (see Tab. 6.21).

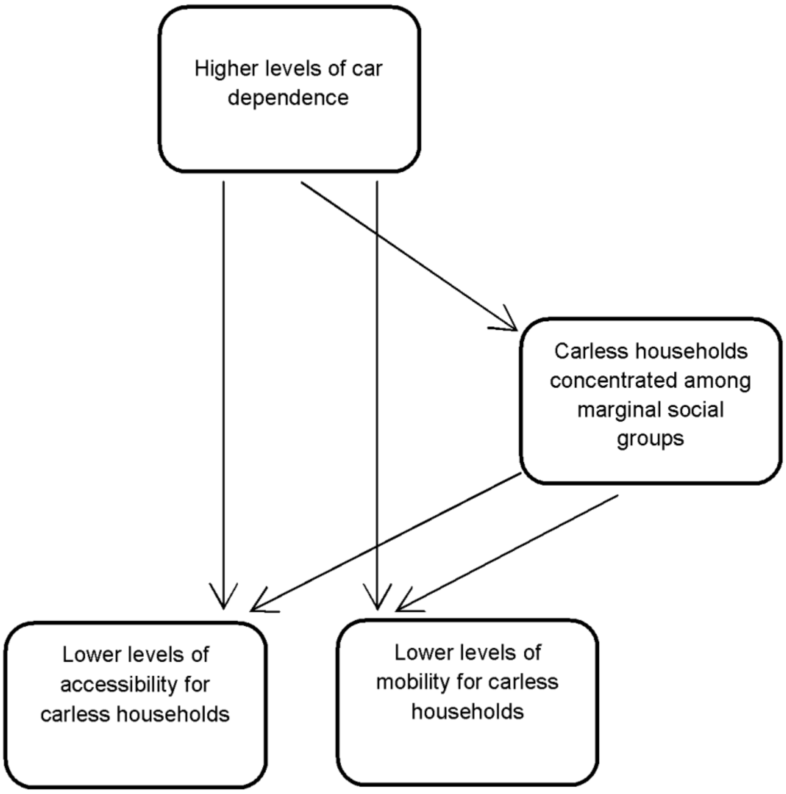

Fig. 6.24 – Diagrammatical representation of the relationships between car dependence, socio-demographic composition of the carless households group and mobility and accessibility levels. Source: own elaboration.

However, the empirical results illustrated in §6.1.4 show that there is also an indirect effect: non-car ownership in car dependent areas is disproportionately concentrated among marginal social groups for whom the lack of a car is motivated first and foremost by constraints related to old age (AR clusters). For the same reasons, individuals in these clusters are, in every type of area, less mobile and more likely to experience lower levels of accessibility. Therefore, the low levels of mobility and accessibility observed for carless households in peripheral, low density areas are the result of higher levels of car dependence *and* of a different composition of the carless household group which, in turn, is also the result of higher levels of car dependence.

Overall, the empirical evidence for the four hypotheses suggests that the composition of the carless group in dense urban areas is more diverse in terms of socio-demographics, reasons for owning cars, travel behaviour and accessibility, as compared to peripheral, low density areas. This can be explained as follows: as in inner cities it is much easier to be mobile without a car, carless living is here not confined to the elderly, but it is an option also for households who, in other types of area, are quite unlikely to be carless. In that sense, it can be argued that the composition of the carless group is a good indicator for the level of car dependence of a local area.

6.2. Question 2

This section illustrates the empirical results for Question 2: the focus is therefore on how the composition of the group of households without cars has changed in Germany in the period between the last two waves of the MiD survey (2002 and 2008). The section is structured as follows: section §6.2.1 focuses on the empirical results, and the theoretical conclusions are presented in §6.2.2.

6.2.1 Empirical results

As illustrated in §3.3.3, Question 2 focuses on trends in the composition of the carless group over time, and notably how they vary across different types of area. Notably, I have put forward two alternative hypotheses: according to H2.1, over time the carless households group becomes more concentrated among marginal social groups, notably in peripheral, low density areas. According to H2.2, in recent years the composition of the carless households group has changed, with an increasing proportion of younger adults offsetting a decrease in the proportion of older households.

Tab. 6.24 shows the distribution of the MiD 2002 and 2008 samples in terms of household car ownership. It shows that the percentage of carless households has decreased, in terms of households and individuals. While in 2002 19.5% of households, accounting for 12.6% of individuals, did not own cars, the corresponding figures were 17.7% and 11.2% in 2008[156]. Although the decrease is small (around 1-2 percentage points), it is statistically significant according to chi-square tests ($p<0.05$).

	2002				*2008*			
No. of household cars	***Households***		***Individuals***		***Households***		***Individuals***	
	%	***N***	***%***	***N***	***%***	***N***	***%***	***N***
0	19.50	3,386	12.61	5,147	17.73	2,953	11.25	4,302
1	53.06	12,949	49.01	28,566	53.02	13.095	47.26	27.565
2	23.31	7,720	31.52	21,944	24.19	8,083	33.80	22.778
More than 2	4.14	1,793	6.86	6,072	5.06	1,781	7.69	6,051
Total	100.00	25,848	100.00	61,729	100.00	25,912	100.00	60,696

Tab. 6.24 – Number of household cars (percentage values and number of observations). Unit of analysis: households, individuals. Source, own elaboration on MiD 2002 & 2008 data.

		2002	**2008**	***Percent variation***
Municipality size (thousands of inhabitants)	**500 or more**	36.5	34.7	
	100 to 500	25.7	24.2	
	50 to 100	17.8	15.5	*-13%*
	20 to 50	16.0	14.5	*-10%*
	5 to 20	13.2	11.0	*-17%*
	less than 5	12.3	10.4	*-15%*
Type of district	**core city**	30.9	29.1	*-6%*
	dense district	13.4	12.3	*-8%*
	rural district	16.1	13.7	*-15%*

Tab. 6.25 – Households without cars across different types of area in 2002 and 2008 (percentage values and percent variation[157]). Unit of analysis: households. Source: own elaboration on MiD 2008 data.

These figures are consistent with the historical trend towards increasing motorisation in Germany during the last decades, as illustrated in §4.2.1. Tab. 6.25 shows that the trend towards decreasing non-car ownership over the period 2002-2008 varies according to the type of area[158]. Indeed, in large municipalities (over 100,000 inhabitants) the results of chi-square tests suggest that it cannot be ruled out that, in the population, the percentage of carless households is stable between 2002 and 2008. By contrast, in smaller municipalities the difference is significant and is equivalent to a percent variation of up to -17% over six years. Similar results are obtained if the type of district is considered. Overall, it appears that the decrease in

[156] In Tab. 6.26, the percentage values do not correspond exactly to the number of observations, as weighting has been applied (see §B.1.2).

[157] All differences between waves in Tab. 6.25 are significantly associated at the $p<0.05$ level (chi-square tests), except where the value of the percent variation is not reported.

[158] As variables measuring population density are not available for MiD 2002, they are not reported in Tab. 6.25.

non-car ownership is more pronounced in peripheral areas, as compared to large cities. This is consistent with the historical trend towards a 'widening gap' between areas in terms of motorisation, as illustrated in §4.2.1.

Having ascertained that the size of the carless group has decreased over the period of interest, I focus now on the composition of the group. Tab. 6.26 shows the composition of the carless in 2002 and 2008, according to key socio-demographic variables associated with non-car ownership (roughly the same used in Tab. 6.2 in §6.1.1). The percent variation over the period is also reported. In the rightmost columns, values for the sample as a whole are reported, in order to provide contextualization.

		Households without cars			MiD sample		
		2002	**2008**	***Percent variation***	**2002**	**2008**	***Percent variation***
Household size	**1**	76.0	80.8	*+6%*	35.8	38.9	*+9%*
	2 or more	24.0	19.2	*-20%*	64.2	61.1	*-5%*
	Total	*100.0*	*100.0*		*100.0*	*100.0*	
Household type	**retired single**	46.5	47.1	*+1%*	14.7	17.6	*+20%*
	retired HH	9.8	7.7	*-21%*	14.1	15.5	*+10%*
	single	29.5	33.7	*+14%*	21.1	21.2	-
	other	14.2	11.5	*-19%*	50.1	45.7	*-9%*
	Total	*100.0*	*100.0*		*100.0*	*100.0*	
Mean age of adults	**18-29**	11.0	8.8	*-20%*	8.9	5.2	*-42%*
	30-64	41.9	38.0	*-9%*	70.1	64.4	*-8%*
	65+	47.1	53.2	*+13%*	20.9	30.5	*+46%*
	Total	*100.0*	*100.0*		*100.0*	*100.0*	
No. of adult men	**0**	58.1	62.0	*+7%*	24.0	25.3	*+5%*
	1 or more	41.9	38.0	*-9%*	76.0	74.7	*-2%*
	Total	*100.0*	*100.0*		*100.0*	*100.0*	
No. of employed members[159]	**0**	72.9	73,3		36.5	40.1	*+10%*
	1 or more	27.1	26.7		63.5	59.9	*-6%*
	Total	*100.0*	*100.0*		*100.0*	*100.0*	
All adults unemployed	**Yes**	5.2	4.7		2.2	1,5	*-33%*
	No	94.8	95.3		97.8	98.5	*+1%*
	Total	*100.0*	*100.0*		*100.0*	*100.0*	
Student household	**Yes**	4.4	5.7	*+30%*	1.7	1.6	
	No	95.6	94.3	*-1%*	98.3	98.4	
	Total	*100.0*	*100.0*		*100.0*	*100.0*	
No. of minor children	**0**	91.9	95.5	*+4%*	73.8	81.2	*+10%*
	1 or more	8.1	4.5	*-44%*	26.2	18.8	*-28%*
	Total	*100.0*	*100.0*		*100.0*	*100.0*	
Economic Status	**very low + low**	47.3	42.4	*-10%*	28.5	20.2	*-29%*
	medium + high + very high	52.7	57.6	*+9%*	71.5	78.8	*+10%*
	Total	*100.0*	*100.0*		*100.0*	*100.0*	
Members with health-related mobility problem	**None**	81.2	75.5	*-7%*	87.9	86.9	*-1%*
	Some	4.2	4.0	*-5%*	7.0	6.6	*-6%*
	All	15.6	20.5	*+31%*	5.1	6.5	*+27%*
	Total	*100.0*	*100.0*		*100.0*	*100.0*	

Tab. 6.26 – Distribution of key socio-demographic variables for households without cars and for the whole sample in 2002 and 2008 (percentage values and percent variation[160]). Unit of analysis: households. Source: own elaboration on MiD 2008 & MiD 2002 data.

159 The results of the comparison between waves for this variable should be considered with care, since the variable has been modified from that originally available in the MiD 2002 database (see, §B.2.6).

Overall, the table suggests that the composition of the carless group has changed significantly between 2002 and 2008. In most cases, however, this is due to broader trends in the composition of the German population as a whole (as shown by the right columns). For example, the share of households with minor children has shrunk dramatically among the carless in the period 2002-2008, going from 8 to 4% in just six years. This is consistent with the trend in the population as a whole, caused by low fertility rates and the general ageing of German society. Similarly, in terms of economic status, the relative weight of households in a 'low' or 'very low' economic condition decreases in the population over the period of interest; the same trend (although less pronounced) is observed for carless households[161]. The percentage of households who do not include any adult men has increased both among carless households and in the population. The share of singles is higher in 2008 both among the carless and in the whole sample. However, the distribution of the variable 'household type' shows that this increase is due to an increasing number of non-retired singles among the carless, while in the German population it is essentially due to a greater number of retired singles. Similarly, while the share of retired households (with at least two members) increases among the population, it decreases among the carless. Other types of households account for a decreasing share of both the population and the carless group. Finally, the share of carless households where all members have health-related mobility problems is higher in the latest wave, reaching approximately 20%. This is consistent with the same trend observed for the population as a whole, and it is probably related to the ageing of German society.

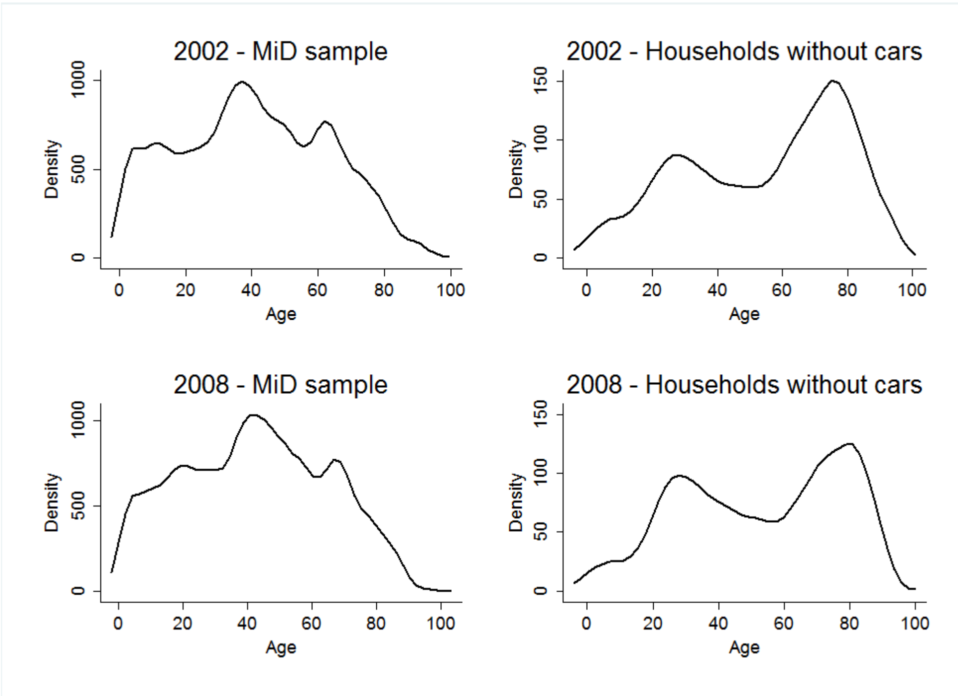

Fig. 6.25 – Smoothed age distribution for carless households and for the sample as a whole in 2002 and 2008. Unit of analysis: individuals. Source: own elaboration on MiD 2002 & MiD 2008 data.

The table also suggests that the carless group is older in 2008 than it was in 2002: indeed, in the last survey wave older households account for more than half of households without cars, while the relative weight of younger households is shrinking. This would be consistent with a more general ageing trend in the German population (as shown in the right column), even though, if the percent variation is taken into consideration, it

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160 Chi-square tests show that the association between row and column variables in Tab. 6.26 is statistically significant at the $p<0.05$ level for most socio-demographic variables. For cases where the association is not significant at the $p<0.05$ level, values in the 'percent variation' column are not reported.

161 Given that an 'economic status' variable is not available in the original MiD 2002 database, and has been constructed (see §B.2.2), the results of this comparison should be considered with caution.

appears the carless group is actually ageing at a slower pace than the MiD sample as whole. However, further analysis that take the individual (instead of the household) as the unit of analysis show that the smoothed age distribution for individuals living in households without cars is more bimodal in 2008 than in 2008 (Fig. 6.25). Indeed, contingency tables based on the individual database show that, over the period of interest, the percentage of carless over the age of 65 decreases slightly (from 45% to 42%), while the proportion of young adults (18-29) increases from 13 to approximately 16%. Overall, analyses based on the individuals database suggest that the carless group has become younger over the period of interest.

For other variables, Tab. 6.26 shows a trend divergence between the total sample and the carless group. This is the case for example for the percentage of households without employed members, increasing among the population, for which no statistically significant change is observed for the carless. The same pattern applies to households where all adults are unemployed (decreasing in the population, stable among carless households). Student households, by contrast, increase significantly among households without cars, but are stable among the population.

Overall, the results illustrated in Tab. 6.26 show that the composition of the carless group has changed significantly over the period of interest. While in most cases these changes are consistent with broader socio-demographic trends in German society, at other times different trends are observed for the carless group. However, it is impossible to disentangle these effects by looking just at the composition of the carless group. It is thus necessary to see how the *propensity* to be carless has changed over time, for the socio-demographic groups of interest (Tab. 6.27).

		2002	2008	*Percent variation*
Household size	**1**	41	37	*-11%*
	2 or more	7	6	*-24%*
Household type	**retired single**	62	47	-23%
	retired HH	14	9	-35%
	single	27	28	
	other	6	5	-20%
Mean age of adults	**18-29**	24	30	+26%
	30-64	12	10	*-10%*
	65+	44	31	*-29%*
No. adult men	**0**	47	43	*-8%*
	1 or more	11	9	*-16%*
No. of employed members[162]	**0**	39	32	*-17%*
	1 or more	8	8	
All adults unemployed	**Yes**	46	55	*+21%*
	No	19	17	*-9%*
Student household	**Yes**	51	62	+21%
	No	19	17	*-10%*
No. of minor children	**0**	24	21	*-14%*
	1 or more	6	4	-31%
Economic Status	**very low + low**	33	37	+12%
	medium + high + very high	15	13	-14%
Members with health-related mobility problems	**None**	18	15	*-13%*
	Some	12	11	
	All	60	56	*-6%*

Tab. 6.27 – Proportion of households without cars for selected socio-demographic groups in 2002 and 2008 (percentage values and percent variation[163]). Unit of analysis: households. Source: own elaboration on MiD 2002 & MiD 2008 data.

[162] The results of the comparison between waves for this variable should be considered with care, since the variable has been modified from that originally available in the MiD 2002 database (see §B.2.6).

Among most socio-demographic groups identified in the table, the percentage of carless households has decreased between 2002 and 2008, consistently with the trend observed in the population as a whole (see above). However, the table also suggests that in many cases the reduction has been slower (in terms of percent variation) for groups where non-car ownership is higher, such as (non-retired) singles, households without adult men, households without minor children and households where all members have health-related mobility problems. For other social groups where the carless are traditionally overrepresented, such as young adults (18-29), student households, households where all members are unemployed and people in a low economic status, the propensity to live without cars is even increasing, contrary to the trend observed among the general population.

The big exception here are older people, as in this group, where carless households are still significantly overrepresented, the decrease is very fast: for example, while virtually two-thirds of retired singles were carless in 2002, this figure has decreased to 47% in 2008. A similar trend is observed with regard to the presence of employed members in the household: while among households including at least an employed member the proportion of carless is low and stable at 8%, a strong decrease is observed for other households, even though the percentage value is still over 30%. As most people over the age of 65 are not in the labour force, the trends are probably related.

Variable	Odds ratio	Year	Municipality size (thousands inhabitants)						Total
			500 or more	100-500	50-100	20-50	5-20	Less than 5	
Household size	1 (vs. 2 or more)	2002	6.05	8.11	8.27	8.48	10.97	10.51	8.96
		2008	7.29	7.71	7.13	13.30	14.45	11.43	9.96
No. of minor children	0 (vs. 1 or more)	2002	3.35	4.82	4.05	4.03	5.79	7.79	5.00
		2008	4.23	4.08	4.20	6.07	9.58	12.56	6.05
No. of adult men	0 (vs. 1 or more)	2002	5.77	6.51	7.02	5.96	8.93	10.45	7.39
		2008	4.75	7.02	6.14	9.48	10.93	12.19	7.73
Mean age of adults	65 or more (vs. 18-64)	2002	2.61	3.77	4.88	5.28	9.62	16.26	5.18
		2008	1.96	2.37	3.00	3.69	5.07	9.31	3.30
No. of employed members	0 (vs. 1 or more)	2002	3.77	5.85	6.29	7.02	12.61	28.08	7.04
		2008	3.55	4.23	5.46	5.84	9.14	15.04	5.59
Members with health-related mobility problems[164]	All (vs. None or Some)	2002	-	-	-	-	-	-	7.10
		2008	-	-	-	-	-	-	7.19
Economic status	very low + low (vs. middle + high + very high)	2002	3.26	3.72	3.66	3.31	2.71	3.24	2.87
		2008	4.83	4.52	4.44	4.26	5.69	3.77	4.03
Additive index[165]	4 to 7 characteristics (vs. less than 4)	2002	7.69	10.79	11.16	13.63	18.09	27.39	12.21
		2008	6.79	7.93	10.41	13.50	18.15	19.64	10.37

Tab. 6.28 – Odds ratios for the odds of not owning cars, rather than owning it. Unit of analysis: households. Source: own elaboration on MiD 2008 data.

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[163] Chi-square tests show that the differences in the percentage values between 2002 and 2008 in Tab. 6.27 are statistically significant at the $p<0.05$ level for most socio-demographic categories. For cases where the association is not significant at the $p<0.05$ level, values in the 'percent variation' column are missing.

[164] Tab. 6.28 does not report the odds ratios for health-related mobility problems in the different types of area. The reason for this is that, in many areas, the number of observations for households without cars where all members experience problems is too low to allow to compute odds ratios. However, the additive index reported in Tab. 6.28, is computed using all seven socio-demographic variables listed in the table, including the presence of members with health-related mobility problems.

[165] The additive index in Tab. 6.28 is referred to the seven variables listed in the table. Unlike the one reported in Tab. 6.11, it does not include the education level.

Overall then, with the exception of age and employment, the data reported in Tab. 6.27 suggest that we are witnessing an increasing concentration of non-car ownership among specific social groups. Indeed, if motorisation increases for social groups who already have a higher motorisation rate, but less so (or even decreases) for others, the gap between the two will necessarily deepen. If this is true, we should observe an increasing association between the socio-demographic variables of interest and non-car ownership.

To test this hypothesis, in Tab. 6.28 I show the odds ratios for selected socio-demographic characteristics that are associated with non-car ownership, by type of area and survey year[166]. For each category, the value of the odds ratio is equivalent to the value of the odds of not owning a car (rather than owning it) for the category of interest, divided by the same odds for the rest of the sample.

In the rightmost column, the values of the odds ratio for the whole sample are reported. They show that five variables out of seven are more associated with non-car ownership in 2008, as compared to 2002. While for some of them the increase is relatively small (absence of adult men, health-related mobility problems), for others it is more significant (singles, households without minor children and poor households). In terms of differences across types of area, the results for these variables suggest that the association increases more rapidly in small municipalities (where it was already more intense), as compared to large cities. Indeed, in municipalities over 50,000 inhabitants, for some variables, the odds ratios decrease rather than increasing, indicating a lower degree of association between the variables. In smaller municipalities, by contrast, all values increase over the period of interest, and the increase is often greater than in larger cities.

However, none of this applies to odds ratios for old age and absence of employed members in the household: here a rather strong decrease is observed in the whole sample as well as in all types of area[167]. Moreover, the decrease is stronger in small municipalities. This suggests that the association between these socio-demographic characteristics and non-car ownership is significantly weaker in 2008 than in 2002, notably in peripheral areas.

The odds ratios for the additive index in the last row of Tab. 6.28 show the association between accumulating several of the socio-demographic characteristics listed above (at least four out of seven) and non-car ownership is higher in 2002 than 2008, in all types of area. This can be interpreted as follows: while there is a strong association between belonging to marginal social groups and non car ownership for both years, this has decreased over the period of interest. This is probably the result of increasing motorisation among older, retired households, as illustrated above.

Another way to explore whether the concentration of the carless households group among marginal social groups has increased over the period of interest is to consider the goodness of fit of logistic regression models (outcome: non car-ownership) including only socio-demographic variables, as done previously in §6.1.2. Fig. 6.26 shows the values of McFadden's pseudo-R^2 for logistic regression models fitted separately for the different types of area and for the two survey waves (in total 12 different models). All models include the same socio-demographic predictors, and are thus comparable[168]. Detailed results for the models are not reported here for the sake of brevity.

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[166] The table includes the same variables and odds ratios as Tab. 6.11 in §6.1.2, except for the level of education. The reason for this is that a variable measuring the achievement of a university degree is not available in MiD 2002.

[167] The results of the comparison between waves for this variable should be considered with care, since the original variable has been modified (see §B.2.6).

[168] In detail, the predictors included are the same of the models reported in Tab. 6.12 in §6.1.2, with the exception of the dummy 'At least one member with university degree'. The reason for this exclusion is the lack of a variable measuring the achievement of a university degree in MiD 2002. The second difference with the models reported in Tab. 6.12 is that the variable 'economic status' is recoded in two categories (low or very low; medium, high or very high), in order to allow comparison between the two waves (see §B.2.2).

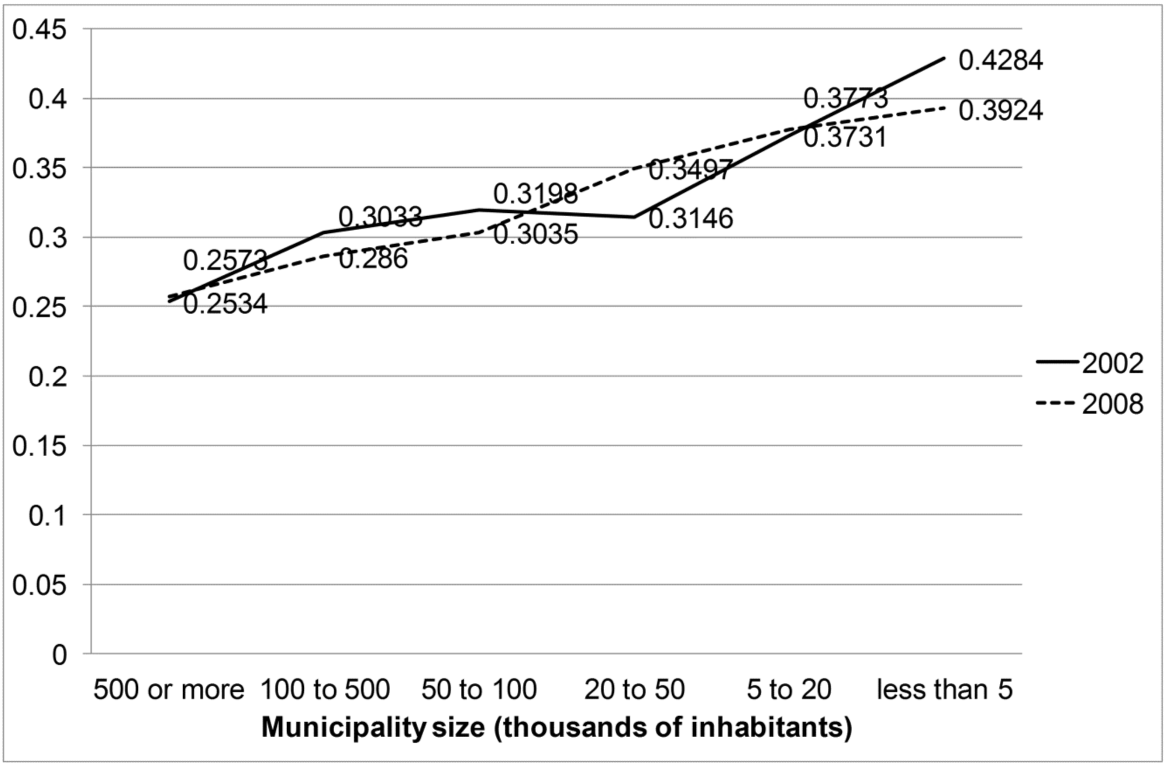

Fig. 6.26 – Values of McFadden's pseudo-R^2 for logistic regression models including only socio-demographic predictors, fitted separately for the different types of area and for the different survey waves. Unit of analysis: households. Source: own elaboration on MiD 2002 & 2008 data.

The graph shows that there is no striking difference between the goodness of fit of the models in 2002 and 2008: the curves tend to overlap, and there is no clear trend across different types of area. Also the comparison between the pseudo-R^2 for a model for 2002, all areas confounded (0.3133) and the same model for 2008 (0.3090) confirms this conclusion[169]. This result can be interpreted as follows: predicting non-car ownership on the basis of socio-demographic variables is as easy in 2008 as it was in 2002. This suggests that, when all relevant socio-demographic characteristics are considered, the carless households is not becoming more concentrated among marginal social groups over the period of interest. The values of the odds ratios reported in Tab. 6.28 above suggest that this is the combined outcome of the decreasing importance of age and employment as determinant of non-car ownership and the increasing association between other socio-demographic variables and the lack of a car: these contrasting trends explain the substantial stability of the predictive power of logistic regression models including both groups of variables. More in-depth analyses involving hierarchical logistic regression models for the two waves (not reported years for the sake of brevity) confirm this conclusion.

6.2.2 Conclusions

In §3.3.3, two alternative hypothesis were put forward. According to the first (H.2.1), the ongoing process of car dependence would determine a greater concentration of the carless households group among marginal social groups. According to the second (H2.2), the sheer force of demographic change (increasing motorisation among older people, opposite trend for young adults) would change the composition of the carless households group accordingly. The result of the analysis illustrated in the previous section (§6.2.1) suggest that the two hypotheses, rather than being alternative, should be integrated.

Indeed, evidence shows that the size of the carless group has decreased over the years 2002-2008, and that for most socio-demographic determinants of non-car ownership the association has increased over the

[169] The models include the same predictors as those of Tab. 6.12. The detailed results for the models are not reported here for the sake of brevity.

period. This confirms what expected (according to H2.1): as motorisation and car dependence increase, the lack of a car is increasingly associated with socio-demographic characteristics identifying marginal social groups (such as, for example, the poor and the disabled). There are also hints that this double process is happening faster in small municipalities, thus deepening the gap with large cities.

On the other hand, however, MiD data also show that demographic change impacts on the carless households group. The higher propensity to own cars of new cohorts of older people (past the age of retirement) combines with the decreasing propensity of new cohorts of young households in their twenties. At a descriptive level, this results in a slight increase in the relative weight of young people among the carless, even if this effect is obscured (and even reversed) if the mean age of adults is considered. However, changes in the propensity to own cars result only partially in changes in the composition of the carless group, because of the general ageing of the population (whereby the increasing propensity of older households to own cars is balanced by the increasing weight of old cohorts in the population, while the opposite happens for young adults). A better way to explore questions about the concentration of carless households among certain groups is to look at associations between variables: this analysis shows that the association between old age and non-car ownership is decreasing rapidly over the period of interest. The same is true for the absence of employed household members, probably because of the dwindling relationship between retirement and lack of a car.

Therefore, I argue that, while some analyses (such as the goodness of fit of logistic regression models) show stability between 2002 and 2008, this is not due to stability in the determinants of non-car ownership, but rather to the simultaneity of two opposite trends: decreasing association between non-car ownership, old age and retirement, offset by its increasing association with other socio-demographic variables. This shows that the social consequences of car dependence intersect in a complex manner with broader socio-demographic trends.

7. Carless households in Great Britain: empirical results

In this chapter, I present the empirical results of the secondary analysis for the British case study. The chapter is structured as follows: §6.1 illustrates the findings for Question 1 (§3.3.2), and §6.2 for the second question (§3.3.3).

7.1. Question 1

This section illustrates the empirical results for Question 1 (§3.3.2): the focus is therefore on how the composition of group of households without cars changes across different types of area. The section is structured as follows: section §7.1.1 illustrates the systematic differences between households with and without cars. This preliminary step has two goals: first, it allows to interpret correctly the differences between clusters of carless households, that constitute the focus of subsequent steps. Second, it allows me to explore whether and how the determinants of non-car ownership vary across different types of area, thus addressing Question 1 from a different angle. In section §7.1.2, I use a variety of data analysis techniques (descriptive analysis, odds ratios, logistic regression models) to illustrate evidence about how the socio-demographic composition of the carless group varies systematically across different types of area, thus addressing hypothesis H1.1 (see §3.3.2). In section §7.1.3, I focus on the travel behaviour of individuals living in carless households, thus addressing hypothesis H1.3. In doing that, I put forward a typology of households without cars, and discuss it at length. In §7.1.4, I focus on hypothesis H1.4, showing how the composition of the carless group in terms of accessibility to services and opportunities changes across different types of area. Finally, in section §7.1.5, I discuss the results at a substantive level, in light of the research questions set out in §3.3.2[170].

For most analyses in this section, I have use pooled data from the NTS 2002-2010 database (DfT, 2012). Since population density variables are not available for the years 2009-2010, some analysis is limited to the years 2002-2008. Pooling the data 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 26% of households and 19% of individuals (20,416 households, 36,064 individuals and 316,325 trips, see Tab. 7.1 below). Therefore, larger sample size allows for more disaggregate analysis and more robust estimates than would be possible for individual years – notably when the sample is further divided across types of areas. 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. The changing size and composition of the carless households group over the period of interest are explored in a dedicated section (§7.2): for this reason, in this section I will not comment on differences between years.

7.1.1. Systematic differences between households with and without cars

Tab. 7.1 shows that 25% of households in the pooled sample (corresponding to 19% of individuals) do not own cars. These figures are quite high for an industrialized country, consistently with data on motorisation rates showing that in 2009 the UK had a lower number of passenger cars per 1,000 inhabitants (470) lower than the EU-15 (503) and the EU-27 average (473) (European Commission, 2011, p. 79).

The difference between the percentage of individuals and households without cars suggests that the size of non-car owning households is significantly smaller than that of the average British household. The opposite

[170] Given the lack of information about the reasons for not owning cars in NTS, H1.2 is not addressed for the British case study, as noted in §3.4.3.

is true for multi-car households, accounting for approximately 31% of households, but for virtually 41% of individuals. Finally, the relative majority of British households owns a single vehicle.

Number of household cars	*Households*		*Individuals*	
	%	*N*	*%*	*N*
0	25.54	20,416	18.83	36,064
1	43.05	35,732	40.56	80,108
2	25.79	21,321	32.14	63,260
More than 2	5.61	4,383	8.47	15,572
Total	100.00	81,852	100.00	195,004

Tab. 7.1 – Number of household cars (percentage values and number of observations[171]). Unit of analysis: households, individuals. Source: own elaboration on NTS 2002-2010 data (interview sample).

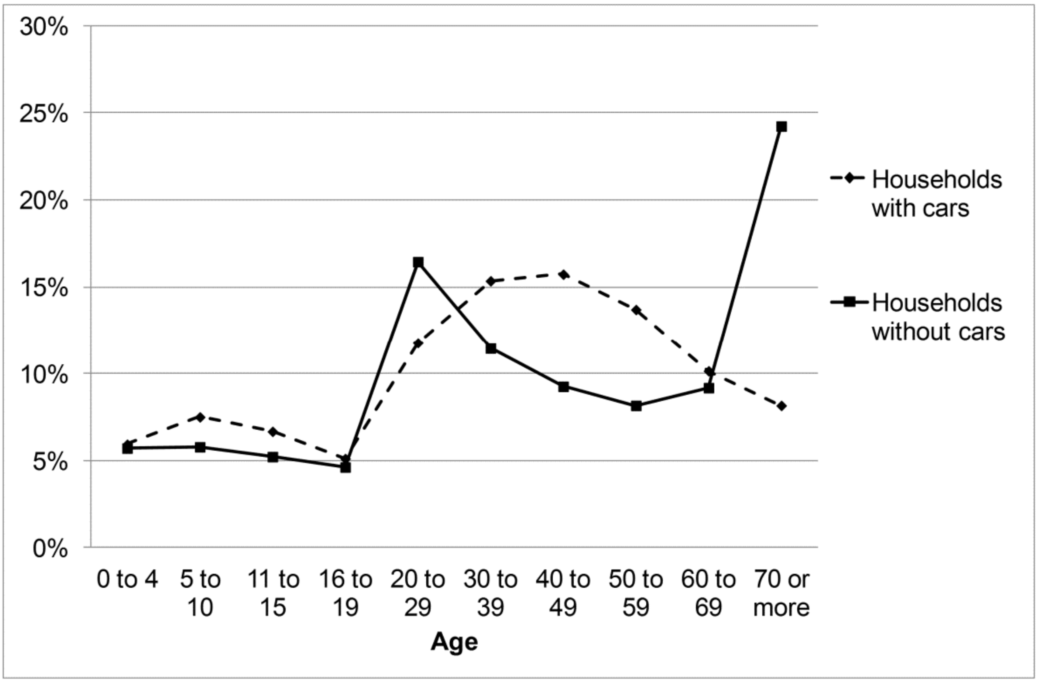

Fig. 7.1 – Age distribution for households with and without cars. Unit of analysis: individuals. Source: own elaboration on NTS 2002-2010 data (interview sample).

Household size is not the only socio-demographic difference between the carless and the rest of the population. Another major difference is the age of household members. Fig. 7.1 compares the age distribution for individuals living in households with and without cars: it shows that the curve for the carless has a bimodal shape, which contrasts with the more normal distribution of motorised households. The two modes also correspond to the only two age groups that are overrepresented among the carless: 20-29 and over 70. Similarly to what shown for the German case, this suggests that households without cars are overrepresented among people in the phases preceding and following employment and family formation.

Disaggregated analysis by gender (Fig. 7.2) shows that the bimodal age distribution of the carless group is observed both for males and for females. However, the highest peak for the male curve corresponds to the ’20-29’ age group, while for women to the ’70 or more’ age group. This confirms that the bimodal distribution

[171] In Tab. 7.1, the percentage values do not correspond exactly to the number of observations, because weighting has been applied (see §C.1.3).

observed for the carless group as a whole is the combined result of two slightly different age distributions: skewed towards young adults for men, but skewed towards older people for women.

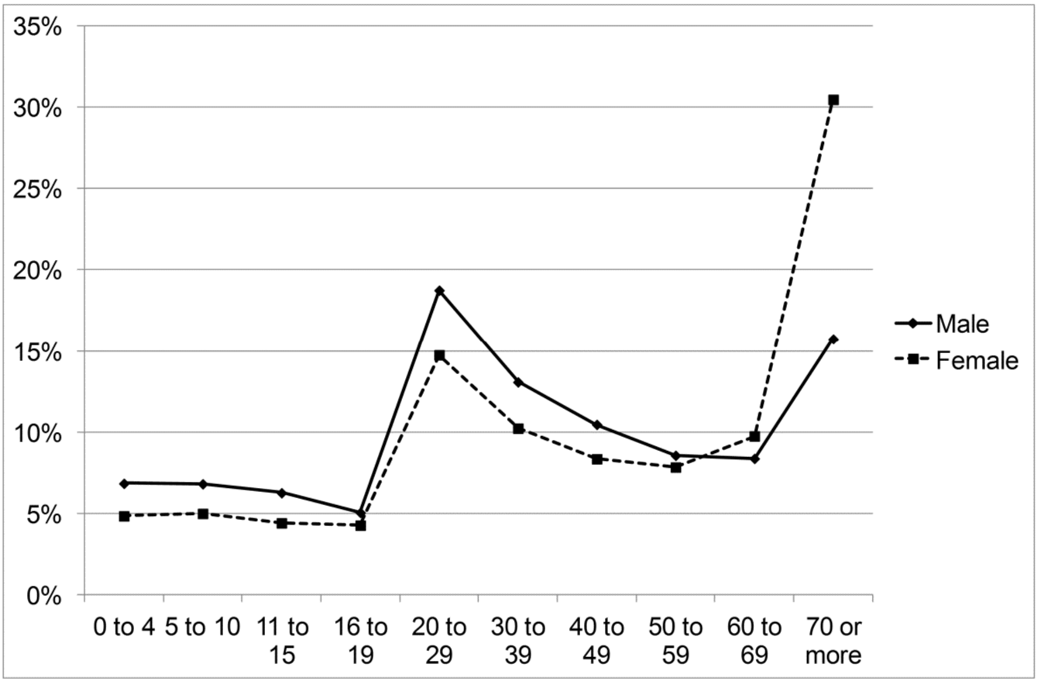

Fig. 7.2 – Age distribution for male and female living in households without cars. Unit of analysis: individuals. Source: own elaboration on NTS 2002-2010 data (interview sample).

In terms of socio-demographic profile, descriptive statistics (Tab. 7.2) show that singles, households without children and poor households are overrepresented among the carless. Notably, approximately 70% of carless households are in the two lowest quintiles of the real equivalent income distribution. The same is true for family units with a household reference person (HRP) that is female, not in employment or non-white. Pensioner households and households with a retired HRP are also overrepresented, consistently with the high share of HRPs over 60 (49%)[172]. Overall, these results are not surprising and confirm theoretical expectations, as 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).

The incidence of non-car ownership is obviously very uneven across different types of areas (Tab. 7.3): while 41% of family units in London Boroughs do not own cars, this figure is as low as 10% in rural areas. The same trend appears if population density in the Local Authority and in the primary sampling unit is considered. The table also shows that in all types of area the proportion of carless individuals is regularly lower than the proportion of households, indicating smaller than average household size for the carless. However, this difference is greater in peripheral, low-density areas: this suggests that households without cars are larger in size in compact core cities. Overall, these results confirm theoretical expectations of a positive relationship between the degree of urbanity, centrality and density of the residential area and the percentage of non-motorised household (cfr. §1.5.4).

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172 The HRP is defined as "the householder with the highest income, or their spouse or partner" who answered the household questionnaire (Rofique et al., 2011, p. 16).

			Households without cars	Households with cars	Total
Household	Size	1	57.0	18.0	28.0
		2	24.9	40.0	36.1
		3	9.6	17.8	15.7
		4 or more	8.5	24.2	20.2
		Total	*100.0*	*100.0*	*100.0*
	Structure	1 or 2 adults youngest child 0-15	17.2	30.3	27.0
		Family adult child(ren)	6.4	13.9	12.0
		Pensioner household	44.3	19.3	25.6
		Other household	32.1	36.5	35.4
		Total	*100.0*	*100.0*	*100.0*
	Income quintile[173]	Lowest	41.3	12.7	20.0
		Second	28.9	17.0	20.0
		Third	13.8	22.1	20.0
		Fourth	8.6	23.9	20.0
		Highest	7.4	24.3	20.0
		Total	*100.0*	*100.0*	*100.0*
HRP	Age	16-29	14.9	8.2	9.9
		30-59	36.1	63.5	56.5
		60+	49.0	28.3	33.6
		Total	*100.0*	*100.0*	*100.0*
	Gender	Female	59.7	28.9	63.3
		Male	40.3	71.1	36.7
		Total	*100.0*	*100.0*	*100.0*
	Working status	Working	29.6	71.5	60.8
		Retired / permanently sick	53.3	24.1	31.5
		Other non working	17.2	4.4	7.7
		Total	*100.0*	*100.0*	*100.0*
	Ethnic group	Non-white	10.8	6.4	7.5
		White	89.2	93.6	92.5
		Total	*100.0*	*100.0*	*100.0*

Tab. 7.2 – Distribution of key socio-demographic variables for households with and without cars (percentage values[174]). Unit of analysis: households. Source: own elaboration on NTS 2002-2010 data (interview sample).

[173] For details about the income quintile variable see §C.2.1.

[174] All row and column variables in Tab. 7.2 are significantly associated at the 5% level (chi-square tests).

		Households	Individuals
Type of area (thousands of inhabitants)	**London Boroughs**	41.1	33.3
	Metropolitan built-up areas	32.7	24.9
	Other urban over 250	24.9	18.2
	Urban over 25 to 250	24.6	17.9
	Urban over 10 to 25	23.3	15.9
	Urban over 3 to 10	19.1	12.6
	Rural	10.3	6.4
Population density – Local authority[175] (persons/hectare)	**45 and over**	51.1	43.1
	35 to 44.99	31.5	24.1
	25 to 34.99	31.9	24.3
	20 to 24.99	29.6	22.3
	15 to 19.99	24.2	17.0
	10 to 14.99	25.6	18.8
	5 to 9.99	23.2	16.4
	3.50 to 4.99	19.0	12.8
	2 to 3.49	17.2	11.4
	1 to 1.99	18.0	12.0
	under 1	19.6	13.6
Population density -primary sampling unit[176] (persons/hectare)	**75 and over**	53.5	45.7
	60 to 74.99	41.0	32.7
	50 to 59.99	36.3	27.7
	45 to 49.99	33.0	25.5
	40 to 44.99	31.1	22.9
	35 to 39.99	27.6	20.7
	30 to 34.99	26.4	19.0
	25 to 29.99	27.8	20.3
	20 to 24.99	24.7	18.1
	15 to 19.99	23.2	16.6
	10 to 14.99	23.9	16.9
	5 to 9.99	20.6	13.8
	1 to 4.99	16.0	10.5
	under 1	13.3	8.7

Tab. 7.3 – Households and individuals without cars across different types of area (percentage values[177]). Unit of analysis: households and individuals. Source: own elaboration on NTS 2002-2010 and NTS 2002-2008 data (interview sample).

As illustrated for the German case (§7.1.1), non-car ownership is not only associated with socio-demographic characteristics and spatial features of the residential area, but also with access to other transport modes and the physical capability to be mobile. Tab. 7.4 and Tab. 7.5 describe this relationship by showing differences between households with and without cars on 12 variables, gathered under the label of 'mobility capital' indicators (see §2.1.3, Kaufmann et al., 2004). The goal is to show how the presence or absence of a household car is related to extent to which household members have the *potential* for mobility[178].

A first conclusion that can be drawn from Tab. 7.4 is that living in a non-car owning household is associated with lack of car access as a driver: only 18% of individuals living in households without cars has access to a car as driver, as compared to roughly 65% in motorised households. This demonstrates that, as argued in §3.2.3, even though *in theory* lack of household car ownership is not equivalent to lack of individual car

[175] As this variable is not available for the years 2009-2010, percentage values refer to the years 2002-2008.

[176] As this variable is not available for the years 2009-2010, percentage values refer to the years 2002-2008.

[177] The percentage differences across areas reported in Tab. 7.3 are significant at the p<0.05 level (chi-square tests).

[178] Obviously, I do not claim that the variables reported here enable me to tap the concept of 'mobility capital' as a whole; however, they allow me to highlight differences in the potential for mobility (as opposed to actual travel behaviour) between carless households and the rest of the British population. For a similar use of the notion of 'mobility capital' in the analysis of quantitative data see Castrignanò and Melzi (2012).

availability, *in practice* there is a considerable degree of overlap. In terms of driving licence ownership, unsurprisingly a much lower share of individuals living in carless households are licensed drivers (29%) as compared to their motorised counterparts (70%).

			Households without cars	Households with cars	Total
Access to car as driver[179]		**Yes**	18.0	65.5	56.6
		No	82.0	34.5	43.4
		Total	*100.0*	*100.0*	*100.0*
Driving licence[180]		**Yes**	28.8	70.1	62.3
		No	71.2	29.9	37.7
		Total	*100.0*	*100.0*	*100.0*
Own or use a bicycle[181]		**Yes**	24.0	47.5	43.0
		No	76.0	52.5	57.0
		Total	*100.0*	*100.0*	*100.0*
Ticket holding (public transport)		**OAP pass / season ticket[182]**	35.2	14.4	18.3
		Other / no pass	64.8	85.6	81.7
		Total	*100.0*	*100.0*	*100.0*
Mobility difficulties[183]	**Car**	**Yes**	11.8	4.0	5.5
		No	88.2	96.0	94.5
		Total	*100.0*	*100.0*	*100.0*
	Foot and/or Bus	**Yes**	24.0	9.2	12.0
		No	76.0	90.8	88.0
		Total	*100.0*	*100.0*	*100.0*
Special transport services available[184]		**0**	22.2	22.4	22.3
		1	34.9	30.8	32.5
		2 or more	42.9	46.7	45.2
		Total	*100.0*	*100.0*	*100.0*

Tab. 7.4 – Mobility capital indicators for households with and without cars (percentage values[185]). Unit of analysis: individuals. Source: own elaboration on NTS 2002-2010 data (interview sample).

With regard to access to alternative modes of transport, the results are mixed: on one hand, carless individuals are significantly less likely to own or use a bicycle. As observed for the German case, this is probably related to the substantial proportion of older people among the carless, as well as to their concentration in large cities (where bicycle ownership is lower). In terms of access to public transport, however, carless households members are more likely to own public transport passes and season tickets.

179 The percentages refer to the whole sample (including individuals under 16 who by definition cannot be drivers).

180 The variable refers to full driving licences "valid in Great Britain to drive either a car, or a motorcycle, scooter or moped" (Rofique et al., 2011, p. 82). The percentages refer to the whole sample (including individuals under 16 who by definition are not licensed).

181 This question was asked of each person aged 5 or over (Rofique et al., 2011, p. 81).

182 In the UK, eligible older people are entitled to free off-peak travel on local buses ('Old Age Pensioner' passes) (see https://www.gov.uk/apply-for-elderly-person-bus-pass). As older people are overrepresented among the carless, this might explain the higher rate of ticket ownership.

183 This question was asked of each person aged 16 or over (Rofique et al., 2011, p. 79). This variable is available only for 2007 and subsequent waves. Accordingly, the percentages here refer to the period 2007-2010. For the period 2002-2006 another variable ('travel difficulties') is available. Since the results are consistent, it is not reported here. Further details on how the variable 'mobility difficulties' was constructed are found in §C.2.2.

184 The question was asked only of respondents with "disability or long standing health problem that makes it difficult to go out on foot, use a local bus or get in or out of a car" (Rofique et al., 2011, p. 79). The variable considers the following specialist transport services: dial-a-ride service, supermarket bus, hospital car or service, day centre car or service, shared taxi scheme, taxi voucher scheme, postbus, community owned minibus and 'other special services'. As the variable is missing for the year 2009, the percentages here refer to the years 2002-2008 and 2010.

185 All row and column variables in Tab. 7.4 are significantly associated at the 5% level (Chi-square tests).

As in NTS the quality of public transport services is assessed at the household level, the relative variables are reported separately in Tab. 7.5. It shows that carless households are significantly more likely to live closer to public transport stops and to have access to a more frequent service. The exception in this context is the walk time to the bus stop where the advantage for the carless, albeit statistically significant, is substantially very small. Since 2002, the NTS questionnaire includes questions about the availability of special transport services, asked of respondents with health-related mobility problems (Tab. 7.4, for details see footnote): however, there is no clear difference between individuals living in households with and without cars in this respect[186]. Overall, carless households seem to have better access to public transport: this is also likely to be the result of the fact that households without cars are disproportionately concentrated in dense urban areas (see Tab. 7.3). In a nutshell, lack of a household car is associated with greater access to public transport, thus potentially compensating the reduction of 'mobility capital'. The same is not true, however, for other 'alternative' modes of transport such as bicycles. Finally, carless individuals are more likely to report mobility difficulties, with consequences both on car use and on the use of alternative modes (foot, bicycles). This is probably related to the high number of older people among the carless.

Overall, Tab. 7.4 and Tab. 7.5 suggest that the 'potential for mobility' of carless households is lower in several respects, as compared to car-owning households. The significant exception here is better access to public transport. However, it is clear that the confounding effect of other variables (type of area, age) is relevant.

			Households without cars	**Households with cars**	**Total**
Bus	**Walk time to stop[187]**	**6 minutes or less**	87.0	85.8	86.1
		7 minutes or more	13.0	14.2	13.9
		Total	*100.0*	*100.0*	*100.0*
	Frequency	**At least 1 every half hour**	85.7	71.5	75.1
		Less than 1 every half hour	14.3	28.5	24.9
		Total	*100.0*	*100.0*	*100.0*
Railway	**Time to station (by foot or bus)[188]**	**13 minutes or less**	42.3	34.6	36.5
		14 minutes or more	57.7	65.4	63.5
		Total	*100.0*	*100.0*	*100.0*
	Frequency	**Frequent service all day**	90.8	88.5	89.1
		Frequent service rush hour only / less	9.2	11.5	10.9
		Total	*100.0*	*100.0*	*100.0*
	Rail/metro/tram stop closer than railway	**Yes**	14.4	6.8	8.7
		No	85.6	93.2	91.3
		Total	*100.0*	*100.0*	*100.0*

Tab. 7.5 – Public transport service indicators for households with and without cars (percentage values[189]). Unit of analysis: households. Source: own elaboration on NTS 2002—2010 data (interview sample).

[186] The results reported in Tab. 7.4 show that individuals in carless households are as likely as their motorised counterparts to report that there have no special service available, more likely to report just one service but less likely to report two or more. A chi-square test indicates that the row and column variables are significantly associated at the 5% level. However, this could be due to large sample size: further analysis disaggregated by survey wave shows that the differences are not statistically significant for several single years. Other analyses show that the mean number of special transport services available is slightly higher for individuals in car-owning households, and the difference is statistically significant (adjusted Wald test). Also In this case, however, for several single years the difference is not statistically significant.

[187] A chi-square test indicates that the row and column variables are significantly associated at the 5% level. However, this could be due to large sample size: further analysis disaggregated by survey wave shows that the differences are not statistically significant for many single years.

[188] For details on how the variable measuring the time necessary to reach the railway station is constructed, see §C.2.3.

		Value	Households without cars	Households with cars	Total
At least one trip[190]	**Yes**	%	92.5	97.2	96.3
	No		7.5	2.8	3.7
	Total		*100.0*	*100.0*	*100.0*
Trips	**Generic mean**[191]	**Mean**	14.4	20.5	19.4
	Specific mean		15.5	21.1	20.1
Travel distance (miles)	**Generic mean**	**Mean**	58.6	152.5	134.9
	Specific mean		63.4	157.0	140.1
Journey time[192] **(h:min)**	**Generic mean**	**Mean**	6:05	7:31	7:15
	Specific mean		6:35	7:24	7:22
Travelling time[193] **(h:min)**	**Generic mean**	**Mean**	5:42	7:17	6:59
	Specific mean		6:10	7:29	7:15
Average length of trips (miles)		**Mean**	5.6	8.4	8.1
Modal split[194] **(basis: trips)**	**Walking**	%	45.9	19.5	23.2
	Cycling		2.6	1.3	1.5
	Car / van driver		1.4	47.9	41.4
	Car / van passenger		14.0	23.8	22.4
	Motorbike/ other private		1.7	1.1	1.2
	Taxi / Minicab		3.6	0.7	1.1
	Public Transport		30.9	5.7	9.2
	Total		*100.0*	*100.0*	*100.0*
Modal split (basis: distance)	**Walking**	%	7.9	1.9	2.4
	Cycling		1.5	0.5	0.6
	Car / van driver		3.8	55.0	50.8
	Car / van passenger		27.1	28.6	28.5
	Motorbike / other private		4.4	2.3	2.5
	Taxi / Minicab		2.7	0.5	0.7
	Public transport		52.6	11.2	14.6
	Total		*100*	*100*	*100.0*

Tab. 7.6 – Travel behaviour on travel diary week for households with and without cars (percentage values and means[195]). Unit of analysis: individuals, trips. Source: own elaboration on NTS 2002-2010 data (diary sample[196]).

Tab. 7.6 shows differences between individuals in households with and without cars with regard to actual travel behaviour. With no exceptions, all indicators show that individuals in carless households are less mobile than their motorised counterparts: they are less likely to travel on the travel diary week, make less trips, cover distances that are considerably shorter and spend less time travelling, even though here differences are less pronounced. Unsurprisingly, modal split figures show that they use 'alternative' modes more and the car less. On average, carless individuals walk almost half of their trips, even though this accounts for just 8% of travel distance. Conversely, the modal share of car driving is considerably lower, accounting for just 1% of trips and 4% of travel distance (the corresponding figures for individuals in car-owning households are 48 and 55%). Incidentally, it can be noted that this confirms what argued in §3.2.3,

189 All row and column variables in Tab. 7.5 are significantly associated at the 5% level (chi-square tests).

190 The row and column variables are significantly associated at the p<0.05 level (chi-square tests).

191 Here and in the following, adopting the terminology used in time-use studies, I define as 'generic mean', the mean computed for the whole sample. The 'specific mean' is referred instead only to those who have made at least one trip on the travel diary day.

192 In NTS, 'journey time' refers to the time between the start and the end of the trip, including waiting time and short walks (Hayllar et al., 2005, p.121).

193 In NTS, 'travelling time' refers to the time actually spent travelling, excluding waiting time and most short walks (Hayllar et al., 2005, p.120).

194 Details about the recoded variable 'main mode of transport' are provided in §C.2.5.

195 All differences between means in Tab. 7.6 have been tested with adjusted Wald test and are significant at the 5% level.

196 As explained in §C.1.3, NTS consists of two samples: the interview sample (including all respondents) and the diary sample (including only respondents who completed the travel diary). For all analysis focused on travel behaviour in this chapter, I refer to the diary sample. For others, I usually refer to the interview sample, unless otherwise noted.

namely that, even though *in theory* household car ownership is not equivalent to individual car use, *in practice* there is a considerable degree of overlap. However, the table also shows that, while carless individuals use the car as passenger for a lower share of their trips (14%), as compared to car-owning household members (24%), this difference is greatly reduced if distances are taken into consideration (27% and 29% respectively). This confirms what observed for the German case, and suggests that carless individuals rely on car lifts more rarely, but when they do it they cover longer distances[197]. Overall, Tab. 7.6 suggests greater reliance on active travel and public transport on the part of carless households[198]. This explains why the differences between the two groups are much more pronounced in terms of distance than in terms of trips and travel time: as carless individuals use slower modes, they end up spending on average (almost) the same amount of time to travel shorter distances, as compared to their motorised counterparts.

"How long would it take (me) to get to the nearest (X) (even if it is not the one you use) on foot or by public transport using whichever is the quickest?"[199]		**Households without cars**	**Households with cars**	**Total**
General Practitioner	**15 min or less**	83.5	77.1	78.7
	Over 15 min	16.5	22.9	21.3
	Total	*100.0*	*100.0*	*100.0*
Chemist	**15 min or less**	89.3	81.2	83.2
	Over 15 min	10.7	18.8	16.8
	Total	*100.0*	*100.0*	*100.0*
Hospital	**20 min or less**	41.9	34.2	36.2
	Over 20 min	58.1	65.8	63.8
	Total	*100.0*	*100.0*	*100.0*
Shopping centre	**15 min or less**	63.9	51.5	54.7
	Over 15 min	36.1	48.5	45.3
	Total	*100.0*	*100.0*	*100.0*
Grocer	**15 min or less**	95.8	91.7	92.7
	Over 15 min	4.2	8.3	7.3
	Total	*100.0*	*100.0*	*100.0*
Post office	**15 min or less**	89.2	83.9	85.2
	Over 15 min	10.8	16.1	14.8
	Total	*100.0*	*100.0*	*100.0*
Primary school[200]	**15 min or less**	93.6	90.0	90.5
	Over 15 min	6.4	10.0	9.5
	Total	*100.0*	*100.0*	*100.0*
Secondary school[201]	**15 min or less**	69.6	62.6	63.7
	Over 15 min	30.4	37.3	36.3
	Total	*100.0*	*100.0*	*100.0*
College[202]	**15 min or less**	57.8	48.6	50.2
	Over 15 min	42.2	51.4	49.8
	Total	*100.0*	*100.0*	*100.0*

Tab. 7.7 – Journey time to essential services and opportunities for households with and without cars (percentage values[203]). Unit of analysis: households. Source: own elaboration on NTS 2002—2010 data (interview sample).

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197 Indeed, the average length of car passenger trips is longer for carless individuals (10.7 miles) than for others (8.5). The difference between means is statistically significant at the 0.05 level (adjusted Wald test).

198 It is worth noting that, while the carless own on average less bicycles (Tab. 7.4), they tend to use them more.

199 All 'journey time' variables in Tab. 7.7 were asked in this form only from 2005 onwards. However, some of them were asked on alternate years, or to subsamples. Therefore, the reference sample varies between variables. For details see §C.2.4. The analysis of similar variables for previous waves (2002-2004) shows similar results (not reported here for the sake of brevity).

200 This question was asked if the household had a child aged 5-10.

201 This question was asked if the household had a child aged 11-15.

202 This question was asked if the household had a person aged 16-19.

203 All row and column variables in Tab. 7.7 are significantly associated at least at the 5% level (chi-square tests).

In the context of this thesis, it is interesting to observe how households with and without cars evaluate the accessibility to services and opportunities. The NTS 2002-2010 database includes several variables assessing accessibility by foot and public transport, even if questions and answer format vary considerably between single waves, and this complicates the analysis[204]. Tab. 7.7 shows the values for households with and without cars for some of these variables. It shows that, for all destinations, journey times by foot or public transport are on average shorter for households without cars. This result, however, should be interpreted with care, for at least two reasons. First, households without cars are disproportionately concentrated in large urban areas (see above), where distances to services are shorter and public transport service is better, and this confounding effect can explain the results observed in Tab. 7.7. Second, even if carless households experience better accessibility by alternative travel modes, this does not mean that they enjoy higher levels of accessibility overall. In fact, even though no NTS variable measures journey times by car, it is reasonable to assume that, if this was taken into consideration, households with cars would report higher accessibility levels[205].

		Households without cars	Households with cars	Total
Travel difficulties[206]	**Travelling to doctor / hospital**	14.2	6.3	7.8
	Visiting friends / relatives at their home	13.0	5.4	6.9
	Travelling to other social activities, including taking children	8.3	3.5	4.4
	Taking the children to school[207]	4.0	4.6	4.1
	Travelling to school/college/university[208]	5.5	9.6	8.5
	Travelling for any other reason	1.9	1.2	1.4
	No difficulties with any of these	76.1	86.3	84.3

Tab. 7.8 – Travel difficulties for households with and without cars (percentage values[209]). Unit of analysis: individuals. Source: own elaboration on NTS 2002—2008 data (interview sample).

This hypothesis is strengthened by Tab. 7.8, showing the values for individuals living in households with and without cars on indicators of travel difficulties to access selected services and opportunities. It shows that, for both groups, most respondents report no difficulties. However, for most opportunities, individuals in carless households are more likely to report travel difficulties: this is particularly apparent for health services (14%) and 'visiting friends and relatives at their home' (13%), as well as for 'other social activities' (8%). The opposite is true for travelling to schools and universities, where individuals in households with cars are actually more likely to report difficulties: this could be explained by the low number of observations for students in carless households. Overall, the proportion of individuals who do not report travel difficulties for any destination is significantly lower for carless households (76%) than for their motorised counterparts (86%). This suggests that the better accessibility by foot and public transport (Tab. 7.7) is not always sufficient to make up for the accessibility disadvantage associated with the lack of a car. However, given limitations in the available data, this conclusion should be considered with care.

204 For more details on accessibility variables in NTS 2002-2010 see §C.2.4.

205 Moreover, it should be noted that the percentage values for journey times to primary and secondary school are computed on a small number of observations for carless households. This is explained by the fact that households with children under 16 are considerably underrepresented among the carless (see above). Therefore, they are likely to be highly self-selected and the accessibility levels to schools that they report are likely to biased upwards.

206 All questions in Tab. 7.8 were asked only to individuals over 15.

207 For this answer category, the percentages refer to the subsample of individuals living in households including at least one child under 16. In this case, the chi-square test shows that row and column variables are not significantly associated at least at the 5% level (P = 0.0664).

208 For this answer category, the percentages refer to the subsample of students.

209 All row and column variables in Tab. 7.8 are significantly associated at the 5% level (chi-square tests) unless where otherwise noted. As this was a multiple choice battery, and the percentages reported in the table refer to different subsamples, the values do not add up to 100%.

Functional set of variables			Coef.	Robust Std. Error
Socio-demographic variables	**No. of HH members**		-1.386***	(0.0379)
	No. of HH members (squared)		0.136***	(0.00594)
	No. of members under 16		0.0953**	(0.0307)
	HRP female (dummy)		0.811***	(0.0249)
	Age group of HRP (ref. cat. 16 – 29 years)	30 – 39	-0.757***	(0.0479)
		40 – 49	-0.955***	(0.0498)
		50 – 59	-1.196***	(0.0519)
		60 – 69	-1.440***	(0.0537)
		70 +	-0.689***	(0.0510)
	No. of employed members		-0.363***	(0.0251)
	Presence of member(s) with mobility difficulties (foot and/or bus) (dummy)[210]		0.457***	(0.0275)
	HRP non-white (dummy)		0.251***	(0.0546)
	Real household income equivalent quintile (ref.cat.: Lowest):	Second	-0.430***	(0.0316)
		Third	-1.129***	(0.0373)
		Fourth	-1.681***	(0.0454)
		Highest	-2.126***	(0.0511)
Territorial variables	**Region** (ref. cat.: England)	Wales	0.254***	(0.0595)
		Scotland	0.512***	(0.0441)
	Type of area (thousands of inhabitants) (ref. cat.: London Boroughs)	Metropolitan built-up areas	0.255***	(0.0632)
		Other urban over 250	0.0427	(0.0663)
		Urban over 25 to 250	0.198**	(0.0689)
		Urban over 10 to 25	0.320***	(0.0805)
		Urban over 3 to 10	0.232**	(0.0854)
		Rural	-0.265**	(0.0864)
	Population density – Local Authority (persons / hectare)		0.00890***	(0.000847)
	Population density - primary sampling unit (persons / hectare)		0.0142***	(0.00131)
	Walk time to bus stop: 7 minutes or more (dummy)		-0.0960**	(0.0351)
	Frequency of bus service: less than 1 every half hour (dummy)		-0.329***	(0.0341)
	Time to railway station (by quickest mode) (ref. cat.: 13 minutes or less):	14-26 minutes	-0.102***	(0.0295)
		27 minutes or longer	-0.214***	(0.0349)
	Type of railway station: frequent service rush hour only or less (dummy)		-0.119**	(0.0434)
	Rail/metro/tram stop not closer than railway (dummy)		-0.309***	(0.0531)
Survey Year	**Survey year**		-0.0187**	(0.00677)
	(constant)		2.571***	(0.145)
	N		62,503	
	McFadden's pseudo R^2		0.338	

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Tab. 7.9 – Logistic regression model for the probability of not owning a household car (logit coefficients and robust standard errors). Unit of analysis: households. Source: own elaboration on NTS 2002-2008 data (interview sample).

Up to this point in this section I have shown how non-car ownership is associated with other variables in key areas, without making explicit reference to the order of causal priority. However, there is clearly a difference between variables, such as socio-demographics, that are antecedents of household car ownership, and

210 Details on how this variable was constructed are found in §C.2.2.

others, such as travel behaviour, that are consequences of car ownership . In the remainder of this section, I focus more specifically on the determinants of car ownership.

Overall, the results of the data analysis illustrated in Tab. 7.2 to Tab. 7.8 show that non-car ownership is strongly associated with certain socio-demographic characteristics, with residential location, as well as with access to public transport infrastructure. This is consistent with existing research, reviewed in §1.3.4 and §1.5.4. To illustrate how these factors interplay in a more systematic way, I present a logistic regression model (Tab. 7.9) whose dependent variable is the ownership of at least one household car (0=no, 1=yes). The list of predictors includes, as it is often the case for models of car ownership (see §1.3), a set of socio-demographic variables and one of territorial variables. The fundamental difference between the two is that socio-demographic variables are household attributes, while territorial variables are attributes of its residential location. The model is based on pooled data for the years 2002-2008, since population density variables are not available for the years 2009-2010 (see §C.1.5). In order to control for differences between individual years, it includes a 'survey year' predictor.

The list of socio-demographic variables includes: household size, number of children under 16, the sex, age and ethnic group of the HRP, the number of household members in employment, a dummy variable identifying the presence of members with mobility difficulties (by foot and/or bus) and the household income quintile. A squared term has been used (in addition to the simple one) for the number of household members, to take into account the non-linear relationship of this variable with the outcome (see §A.1.1).

The list of territorial variables includes a three-category variable identifying the region (England, Wales and Scotland), and others concerning the type of area, population density at the local authority level and in the proximity area (primary sampling unit). The quality of public transport service (in terms of distance to stops and frequency) is measured by five distinct categorical variables

As shown in Tab. 7.9, model fit is good (McFadden's pseudo-R^2=0.338): therefore, the model is a good representation of the data. All but one logit parameter associated with the predictors are significant at (at least) the 0.01 level. With regard to the set of socio-demographic variables, the sign of most the logit coefficients confirms theoretical expectations. However, a few coefficients deserve to be commented. As observed for the German case study (see §6.1.1), the number of young children has a net positive impact on the probability of being carless. This is due to the fact that household size is here controlled for, and should be interpreted as follows: other things, such as household size, being equal, having a household member under the age of 16 (who by definition cannot be licensed driver) makes it more likely not to own a car. The net effect of age largely confirms the results of the descriptive analysis, with the likelihood of being carless first decreasing (past the age of 30), then increasing among the elderly; however, all other factors equal, households in the age band 60-69 are the least likely to be without a car. This might explained as follows: the lower motorisation of households in their sixties is essentially due to their lower participation in employment, smaller household size and lower income. Once these factors are controlled for, this is actually the age group with the greatest likelihood of owning a car. Another interesting result is that, once all other factors are controlled for, the age group with the highest likelihood of being carless is the youngest (16-29) and not the oldest (70+). However, this could be a by-product of the predictor used: the NTS database does not include a continuous variable measuring the age of household members, but only a categorical one; as a result, the oldest age group does not differentiate between 'younger' and 'older' elderly households. The analysis conducted for the German case shows that the likelihood of not owning cars increases very rapidly after the age of 70: in the model for NTS, however, the categorical predictor obscures these trends.

Finally, it is worth noting that having a non-white HRP increases the probability of not owning a car, other factors being equal. The predictor identifying the presence of member(s) with mobility difficulties (by foot and bus) also has a net effect that is positive and statistically significant. This means that people with mobility difficulties are, all other factors equal, more likely to be carless. This result is counter-intuitive, as mobility difficulties with alternative travel modes should instead result in greater reliance on the car. There are two possible explanations for this result: first, if most people who report difficulties to travel by foot and bus also encounter difficulties in travelling by car, the predictor might capture the latter effect, thus acting as a proxy variable. However, further in-depth analysis (not reported here for the sake of brevity) including a predictor identifying the presence of members with mobility difficulties by car (available only from the 2007 wave onwards) shows that the independent variable 'Presence of member(s) with mobility difficulties (foot and/or bus)' has a net effect that is positive and statistically significant even after controlling for difficulties by car (which in turn also have a positive effect on non-car ownership). A second possible explanation is the following: the categorical age variable does not distinguish between 'younger' elderly and 'older' households (over 80) who, on one hand, for generational reasons, are less likely to own cars and, on the other, are more likely to have mobility difficulties (by all modes). Therefore, the predictor 'mobility difficulties (foot or bus)' might act as a proxy for 'very old age'.

With regard to territorial variables, as expected worse access to public transport networks has a negative effect on non-car ownership, Population density (at both levels) obviously increases the probability of not owning a car: once this is controlled for, however, the net effect of the type of area contradicts expectations, as in most areas it is more likely to be carless than in London Boroughs. This can be explained as follows: the higher share of households without cars in large urban areas is essentially due to greater population density and better access to public transport networks; once this is controlled for, the net effect of city size is unclear, and it even might be negative in the case of a 8 million inhabitants city like London, where distances between residences and activities can be very large. The 'region' predictor shows that family units in Wales and Scotland are more likely to be carless, even after controlling for other variables. The reason for this is unclear, it might be posited that also this variable acts as a proxy for 'very old age', if the proportion of households over 80 is higher in Wales and Scotland, as compared to England.

Finally, it is worth noting that, all other factors being equal, households in later years are less likely to be carless than those interviewed in 2002. Moreover, the logit associated with the survey year variable increases once socio-demographic and territorial variables are partialled out. Therefore, it can be argued that the relative stability observed in descriptive statistics is the consequence of changes in the socio-demographic composition of the population, in its territorial distribution or in levels of access to public transport. Once these factors are held constant, however, British households are actually *more* likely to own a car in 2008 than they were in 2002, even though the difference is not very large.

As done for the German case study, I use hierarchical regression (Cohen et al., 2003, p. 158-163, 508) to answer the question about the relative importance of socio-demographic variables and territorial variables in accounting for non-car ownership. In this framework, the increase in the pseudo-R^2 that follows the entering of an additional set in Tab. 7.10 can be interpreted as the gain in prediction associated with this group of variables (2003, p. 508).

Step	**Sets of variables**	**Pseudo R^2**	**Increase in Pseudo R^2**
1	*Socio-demographic variables*	0.2909	+0.2909
2	*Socio-demographic variables + territorial variables*	0.3361	+0.0452
3	*Socio-demographic variables + territorial variables + survey year*	0..3385	+0.0024

Tab. 7.10 - Hierarchical regression for the logistic regression model reported in Tab. 7.9 (McFadden's pseudo-R^2 and relative increases). Source: own elaboration on NTS 2002-2008 data (interview sample).

The results of hierarchical regression show clearly that socio-demographic factors (pseudo-R^2=0.29) are a much more important determinant of non-car ownership than the functional set of territorial variables (accounting for less than 0.05[211]). On a substantive level, these findings show that not having an household car is mainly a question of socio-demographics and income, while the spatial features of the residential area

[211] 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.

(such as population density, access to public transport) play only a secondary role. However, this very broad conclusion needs to be integrated with a more in-depth look at the model results.

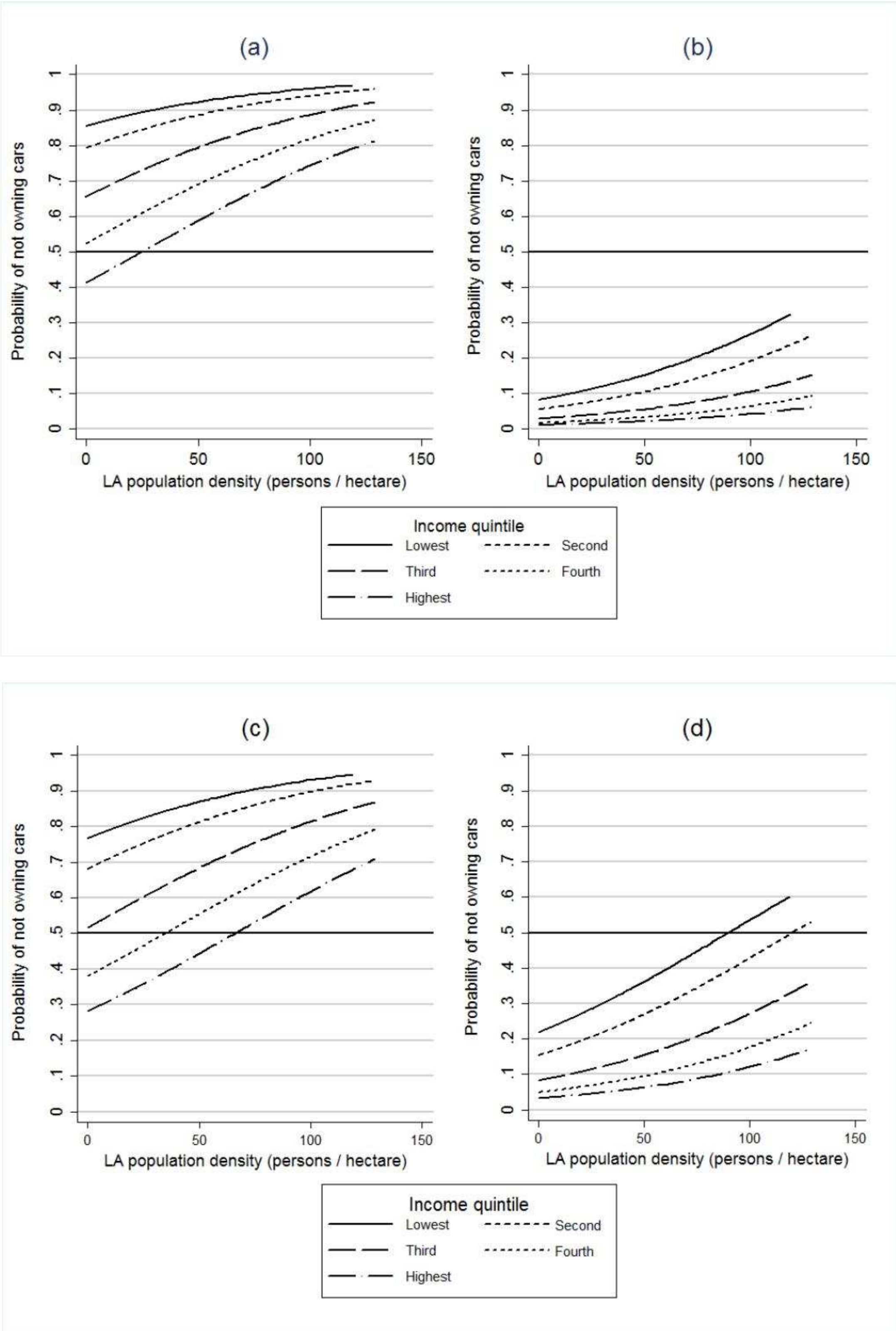


Fig. 7.3 – Predicted probabilities of not owning a car by income quintile and LA population density, for four ideal-typical households: (a) single woman, over 70, not employed (b) four members household including two working adults (age group of HRP: 40-49) and two children under 16 (c) single male 16-29, not employed (d) working couple, 30-39. The probabilities are predicted using the logistic regression model reported in Tab. 7.9. Unit of analysis: households. Source: own elaboration on NTS 2002-2008 data (interview sample).

As illustrated in §A.1.3, the detailed interpretation of a logistic regression model can be challenging, and interpretations based on logits and odds ratios run often the risk of being misleading and deceptive. Therefore, in the following I will discuss predicted probabilities generated by the model reported in Tab. 7.9, showing their values for a series of ideal-typical cases, as done in chapter 6 for the German case study. The goal is to convey in a direct way the substantive results that the model offers[212] .

Fig. 7.3 shows how the predicted probability of non-owning a car (on the y axis) varies according to the population density in the Local Authority (axis x) and to income quintile (different lines) for four 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). The reference horizontal line corresponds to a probability of 0.5 of not having a car, which is the threshold that the model uses as a criterion to assign the case to the motorised or non-motorised group when asked to predict the outcome.

Fig. 7.3a refers to a first ideal-type of household: a single old woman over 70 years old who is obviously not employed, as she is over the age of retirement (all other variables have been kept to their mean or mode[213]). The graph shows that for this ideal-type of household the predicted probability of not owning cars is generally quite high (always higher than 0.4). As expected, households living in more dense areas are more likely to be carless; moreover, the curves corresponding to lower income are higher, confirming that income has a negative effect on the probability of owning a car. Overall, Fig. 7.3a shows that the two predictors represented in the graph have a certain impact on the probability of not owning cars: indeed, the predicted probability to be carless for a single old woman in the middle income quintile goes from 0.65 to 0.90 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 0.40 to about 0.85, depending on the level of income. Overall, however, the probability of not owning cars is in most cases higher than 0.5.

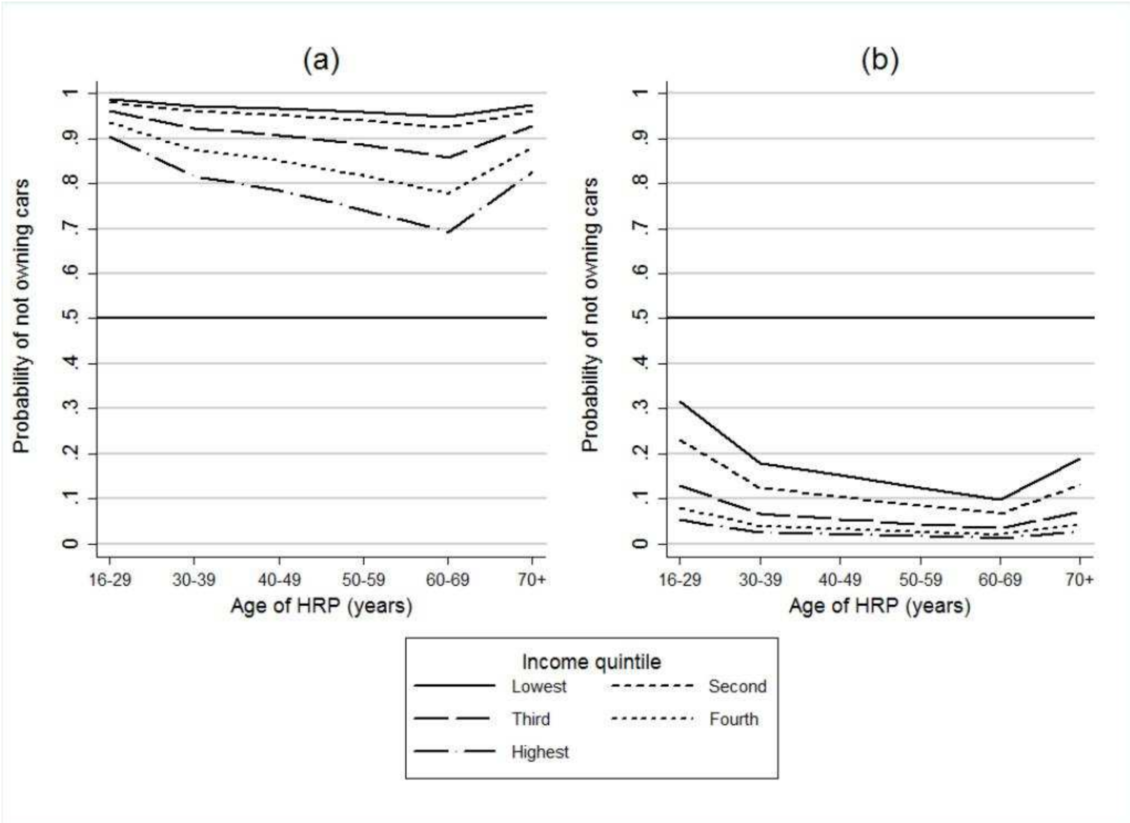
Fig. 7.3b shows the same predicted probabilities for a household including two working adults in the age group 40-49 and two children under 16 (all other variables are kept to their mean or mode[214]). As expected, the likelihood of not owning cars is here much lower; moreover, the probability curves are closer to each other, with the values ranging from virtually zero to just above 0.3. Overall, the area between the curves in Fig. 7.3b is quite smaller than that in Fig. 7.3a, and this can be interpreted as follows: the probability of being carless for the second socio-demographic profile is not only lower, but also less sensitive to changes in population density and/or income. In short then, it appears that for working couples with children not owning a car is very unlikely – no matter where they live or how poor they are.

Taken together, Fig. 7.3a and Fig. 7.3b show that there exist socio-demographic conditions that are almost sufficient by themselves to make it very likely (being a retired single woman) or very unlikely (being a working couple with children) to be carless. When these conditions apply, other factors such as population density and income have little impact on the probability of not owning cars. This is especially true for working couples with young children, as illustrated in Fig. 7.3b.

[212] All predicted probabilities in this chapter were computed in Stata using the 'spostado' package by J. Scott Long and Jeremy Freese (Long & Freese, 2001).

[213] In detail, all territorial variables have been kept to their mean or mode in the NTS 2002-2008 sample. The two remaining socio-demographic variables (presence of members with mobility difficulties, ethnic group of HRP) have been kept to their mode among the subset of cases identified by the socio-demographic profile examined here (single woman, over 70, etc.).

[214] In detail, all territorial variables are kept to their mean or mode in the NTS 2002-2008 sample. The two remaining socio-demographic variables (presence of members with mobility difficulties, ethnic group of HRP) are kept to their mode among the subset of cases identified by the socio-demographic profile examined here (four members household including two minor children, etc.).



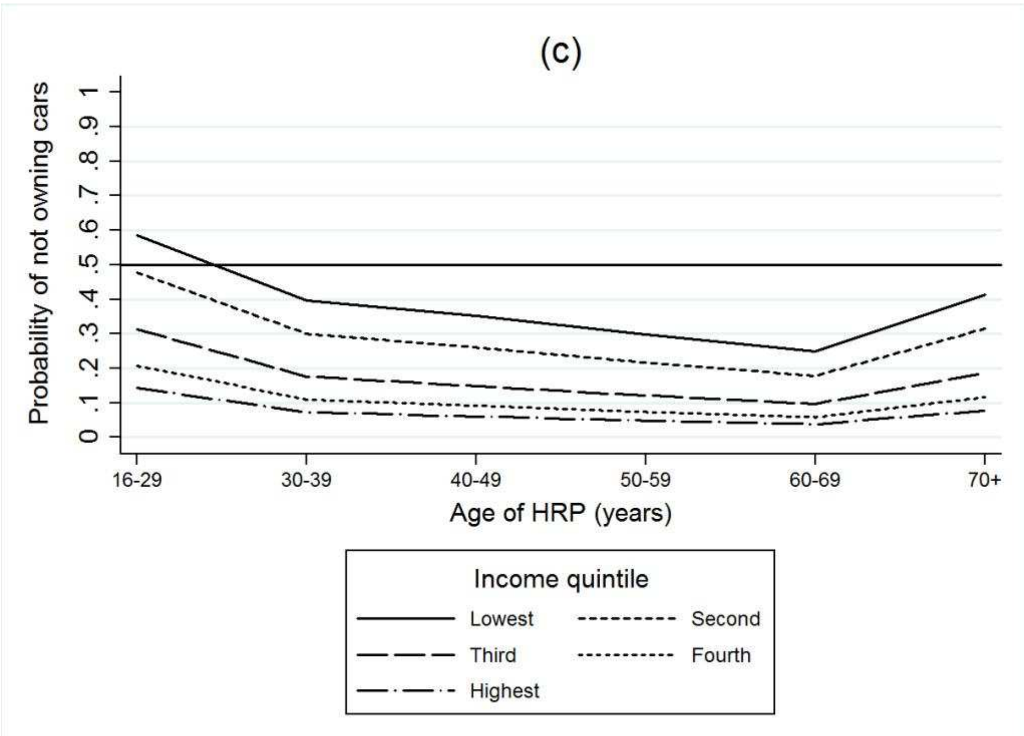


Fig. 7.4 - Predicted probabilities of not owning a car by income quintile and age of HRP, for two opposite ideal-types of residential area: (a) maximum density and public transport service scenario (b) minimum density and public transport service scenario (a) average density and public transport service scenario (for details see Tab. 6.9). The probabilities are predicted using the logistic regression model reported in Tab. 7.9. Unit of analysis: households. Source: own elaboration on NTS 2002-2008 data (interview sample).

Fig. 7.3c and Fig. 7.3d show two additional ideal-typical households, that can be conceived as 'intermediate' between the two extremes illustrated above (in terms of probability to be carless). Fig. 7.3c refers to a single man in the age group 16-29 who is not employed (e.g. a student). The area covered by the curves is here largest, suggesting that for this type of household, income and population density make a considerable difference: depending on their value on these two variables, the probability varies between approximately 0.3 and 0.9. By contrast, the variables have less impact for the ideal-typical household shown in Fig. 7.3d (working couples in the age group 30-39): in this case, the area covered by the probability curves resembles to a 'mirror-image' of Fig. 7.3a, with most cases assigned by the model to the 'car owning' outcome.

Fig. 7.4 is similar to the previous, showing how the predicted probability of not owning cars varies according to the age of HRP and household income, in two opposite ideal-types of residential area, and a third scenario representing the mid-point between the two. Fig. 7.4a refers to a scenario of maximum density and public transport service: here both population density variables included in the model are fixed to their maximum value in the sample, and 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 (see Tab. 7.11[215]). The graph clearly shows that predicted probabilities never go under 0.7, and age and income have only a rather small impact on the likelihood of not owning cars, although differences are greater for households in the middle range of the age distribution. In substantive terms, this means that in a (deliberately unrealistic) scenario combining very high densities and ideal public transport service, age and income make only little difference for car ownership, as the probability to be carless is quite high for all possible combinations of the two variables, even though it is even higher (close to 1.0) for poor households and family units at the extremes of the age distribution.

	Population density and public transport service		
	Maximum (Fig. 7.4a)	**Average (Fig. 7.4c)**	**Minimum (Fig. 7.4b)**
Population density (LA) (persons / hectare)	128.74	25.29	0.08
Population density (PSU) (persons / hectare)	253.66	16.31	0.01
Walk time to bus stop	less than 7 minutes	less than 7 minutes	7 minutes or more
Frequency of bus service	at least 1 every half hour	at least 1 every half hour	less than 1 every half hour
Time to railway station (by quickest mode)	13 minutes or less	14-26 minutes	27 minutes or longer
Type of railway station	frequent service all day	frequent service all day	frequent service rush hour only or less
Rail/metro/tram stop	closer than railway	no closer than railway	no closer than railway

Tab. 7.11 – Values of variables held to specific values for Fig. 7.4. Source: own elaboration on NTS 2002-2008 data (interview sample).

By contrast, Fig. 7.4b refers to a minimum density and public transport service scenario, where density variables are held constant at their minimum values and public transport accessibility indicators at their worst value (with all remaining predictors again fixed at their mean or modal value). In this graph, we observe that the probability curves are considerably lower, and also slightly closer to one another, with values ranging

215 In detail, for all scenarios all socio-demographic variables, survey year and the two remaining territorial variables (region and type of area) are kept to their mean or mode in the NTS 2002-2008 sample.

from 0.0 to 0.2. This suggests that for the average Briton, when population density is very low and access to public transport very difficult, not owning a car is very unlikely – regardless of age and income level.

Fig. 7.4c shows an ‘average’ scenario, where all variables (including those concerning population density and public transport service) are held constant to their modal or mean value (see Tab. 7.11). In this scenario, age and income make more of a difference, with the probability of not owning cars varying from virtually 0.0 (for most high-income households) to 0.6 (for young adults in the lowest income quintile).

The results illustrated in Fig. 7.3 and Fig. 7.4 suggest that when certain independent variables assume values determining a very low (or very high) proability of non-car ownership, the effects of other variables are small to non-existent. Importantly, this phenomenon arises from assumptions that are in-built in logistic regression models, as explained in §A.1.2. On a substantive level, this suggests that there are two main conditions under which being carless is very unlikely, regardless of other circumstances. Firstly, territorial conditions: for households living in low-density areas, the probability of not owning a car is virtually always very low (Fig. 7.4). Secondly, there exist also socio-demographic conditions under which non-car ownership is very rare: working families with children are such an example[216] (Fig. 7.3). As it will be argued later in this chapter (§7.1.5), this conclusion is useful to interpret the findings illustrated in the next section, namely the fact that, in low-density peripheral areas, carless households tend to be concentrated among marginal social groups.

7.1.2. The changing socio-demographic composition of the carless households group across different types of area

In the previous section, systematic differences between households with and without cars have been described. In this section, I turn my attention to how the socio-demographic composition of the carless group changes across different types of area, thus addressing Question 1 more directly. To that end, I use different data analysis techniques, starting with simple descriptive statistics, then discussing odds ratios and finally logistic regression models. The goal here is to test the hypothesis that the carless households group is more concentrated among marginal social groups in peripheral, low density areas, as compared to compact inner cities.

In the previous section, the results of a logistic regression model for non-car ownership have been illustrated (Tab. 7.9). This has shown that several socio-demographic variables are predictors for the lack of a household car, namely:

- household size, with single-person households more likely than others to be carless
- the presence of children, with households including at least one member under 16 more likely to be carless[217]
- the number of employed members, with households without employed members considerably more likely to be carless
- the sex of the HRP, with female-headed households considerably more likely to be carless
- the age of the HRP, with both older people and young adults more likely to be carless. However, given the correlation of old age with other determinants of non-car ownership (smaller household size, retirement, mobility difficulties, etc.), descriptive analysis shows that the percentage of households without cars is higher among older people than among young adults in the age group 16-29 (at least in the pooled sample)
- the ethnic group of the HRP, with households with a non-white HRP more likely to be carless
- income, with low-income households considerably more likely to be carless

[216] Of course, Fig. 7.3 and Fig. 7.4 show that there are also *economic* conditions under which being carless is most unlikely (whatever the other circumstances), namely a very high economic status.

[217] As discussed in §7.1.1, the number of children under 16 in the household is associated with a decrease in the probability of not owning cars, *provided that the number of household members is not controlled for*.

- mobility difficulties by foot and bus, with households where at least one member experiences such problems considerably more likely to be carless

As argued for the German case (§6.1.2), many of these socio-demographic characteristics are also known to be associated with social exclusion and transport disadvantage, and these risks are compounded when several of them are simultaneously present (such as, for example, for an old woman with low income and mobility difficulties). For the British case study, one additional socio-demographic characteristics is considered: the ethnic group of the HRP. This is also arguably associated with increased risk of social exclusion (Loury, 2000), and of transport disadvantage (see §2.1.5).

Overall then, in the British population as a whole, carless households are indeed concentrated among marginal social groups. In this section, I aim to show how this concentration changes across different types of areas. To that end, I focus the attention on the eight variables listed above. Notably, in the following I focus on households who accumulate several of the characteristics mentioned above.

Fig. 7.5 to Fig. 7.12 show the changing composition of the carless households group across different types of area, defined according to type of area. However, every trend has been double-checked using two population density variables (with reference to the period 2002-2008). The results broadly confirm the findings illustrated here with reference to type of area. The corresponding figures and tables are not reported here for the sake of brevity.

Fig. 7.5 shows the composition of the carless group by household size, across different types of area. It shows that in small cities and rural areas, where there are less carless households, a large majority of them consists of single-person units (68% in rural areas, see Tab. 7.12 below). This percentage decreases as the degree of urbanity increases: in London, less than half of carless households (49%) is composed of a single member. Clearly, non-car ownership in peripheral areas is considerably more concentrated among single-person households than in large metropolitan areas.

The same pattern is observed for several socio-demographic determinants of non-car ownership. Fig. 7.7 shows that households without cars are more concentrated among female-headed households in small cities and rural areas. The trend is particularly pronounced for the age of the HRP (Fig. 7.8): only 33% of carless households in London is over 60, while this applies to approximately 72% of them in rural areas (Tab. 7.12). Fig. 7.9 shows that carless households not including any employed member are the majority everywhere except in London, and notably so in small cities and rural areas, where they are more than 80% (Tab. 7.12). By contrast, households including at least one member with mobility difficulties are the minority everywhere (Fig. 7.10): however, they represent virtually 50% in rural areas, as opposed to approximately 25% in London (Tab. 7.12).

However, there are three variables that make exception. The percentage of households without children under 16 is high (between 80 and 90%) everywhere, and there is no clear trend across types of area (Fig. 7.6, Tab. 7.12). The proportion of households with a non-white HRP (Fig. 7.11) is very high in London (30%) but decreases rapidly to just 1% as the degree of urbanity decreases[218] (Tab. 7.12): as a result, this variable shows a pattern opposite to that of all other variables, with carless households more concentrated among ethnic minorities in large urban areas. This is probably related to the distribution of non-whites across different types of area (see below). With regard to income, Fig. 7.12 shows that carless households are concentrated among low-income households virtually everywhere (70-80% in the bottom 40% of the income distribution, see Tab. 7.12): the exception here is London, where they account for ‘just’ 55% of carless households[219]. This is probably related to the concentration of wealthy households in the London area (see below).

[218] Further analysis (not reported here) suggests that the percentage of carless households with a non-white HRP declines much more gradually if population density in the proximity area (PSU) is considered.

[219] However, further analysis (not reported here) suggests that the percentage of carless households in the two lowest income quintiles declines much more gradually if population density (both at the LA and PSU level) is considered instead of the type of area.

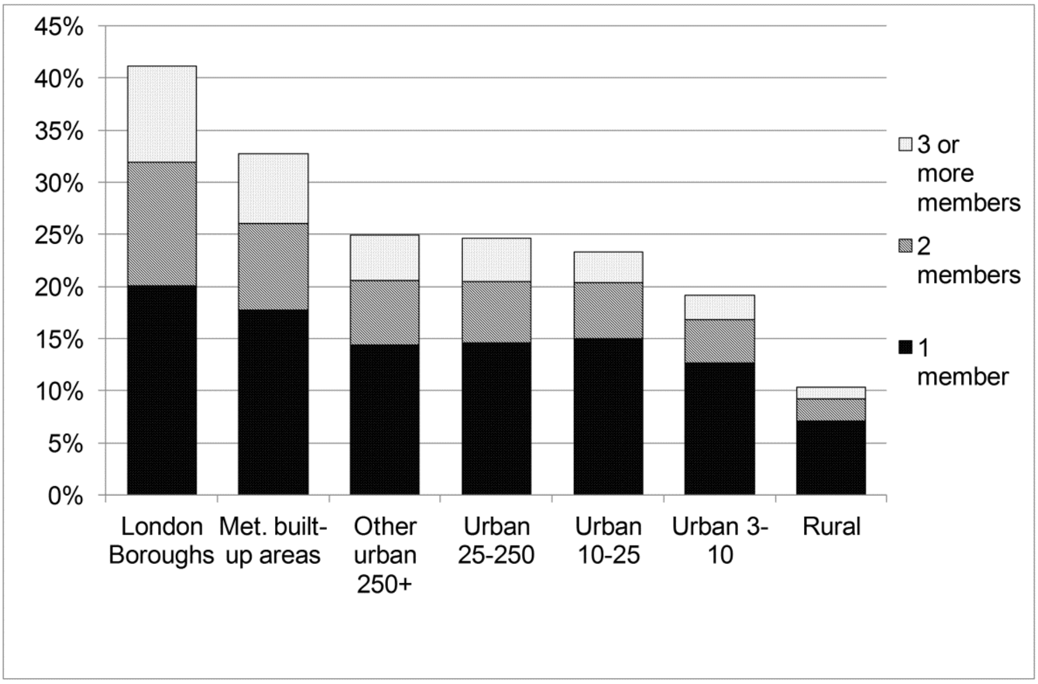


Fig. 7.5 – Composition of the carless households group by household size, across different types of area (thousands of inhabitants). Unit of analysis: households. Source: own elaboration on NTS 2002-2010 data (interview sample).

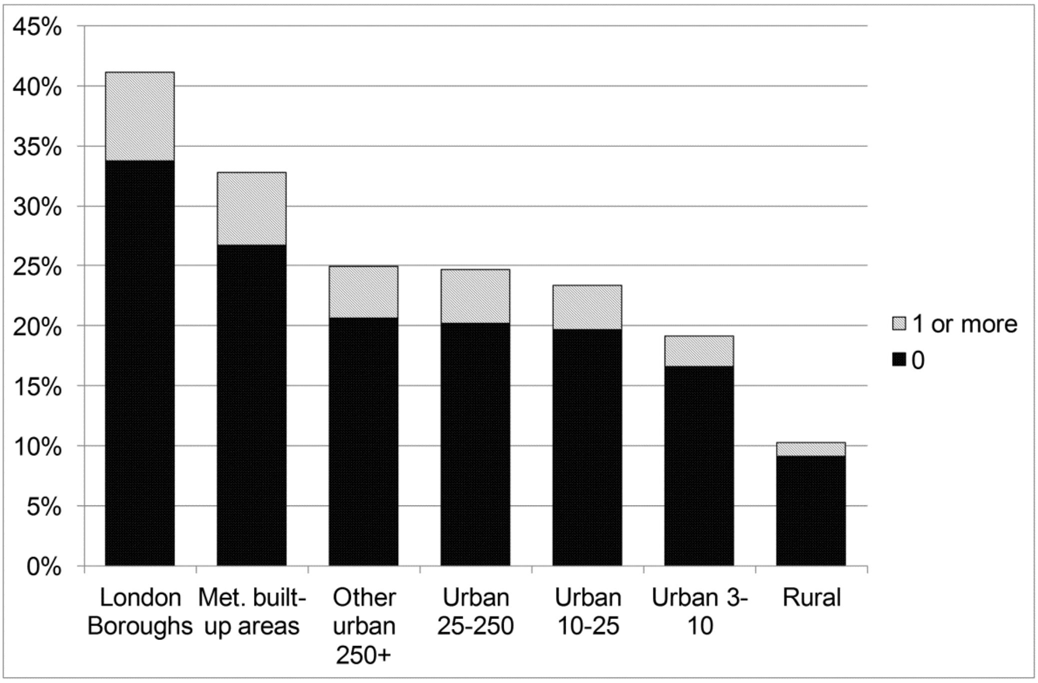


Fig. 7.6 – Composition of the carless households group by number of members under 16, across different types of area (thousands of inhabitants). Unit of analysis: households. Source: own elaboration on NTS 2002-2010 data (interview sample).

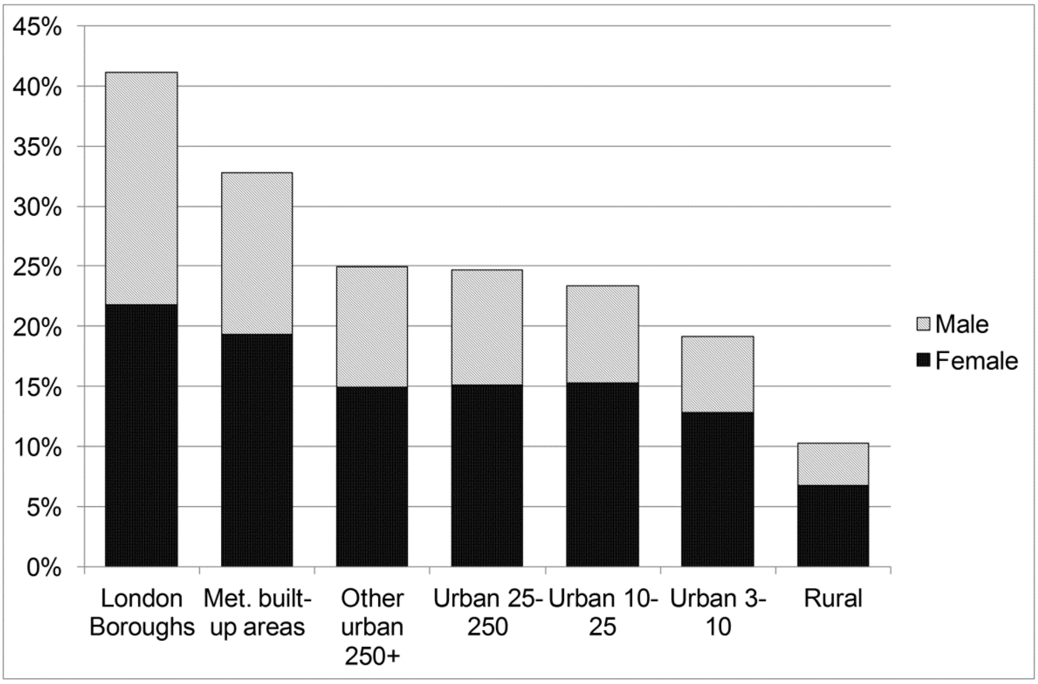


Fig. 7.7 – Composition of the carless households group by sex of HRP, across different types of area (thousands of inhabitants). Unit of analysis: households. Source: own elaboration on NTS 2002-2010 data (interview sample).

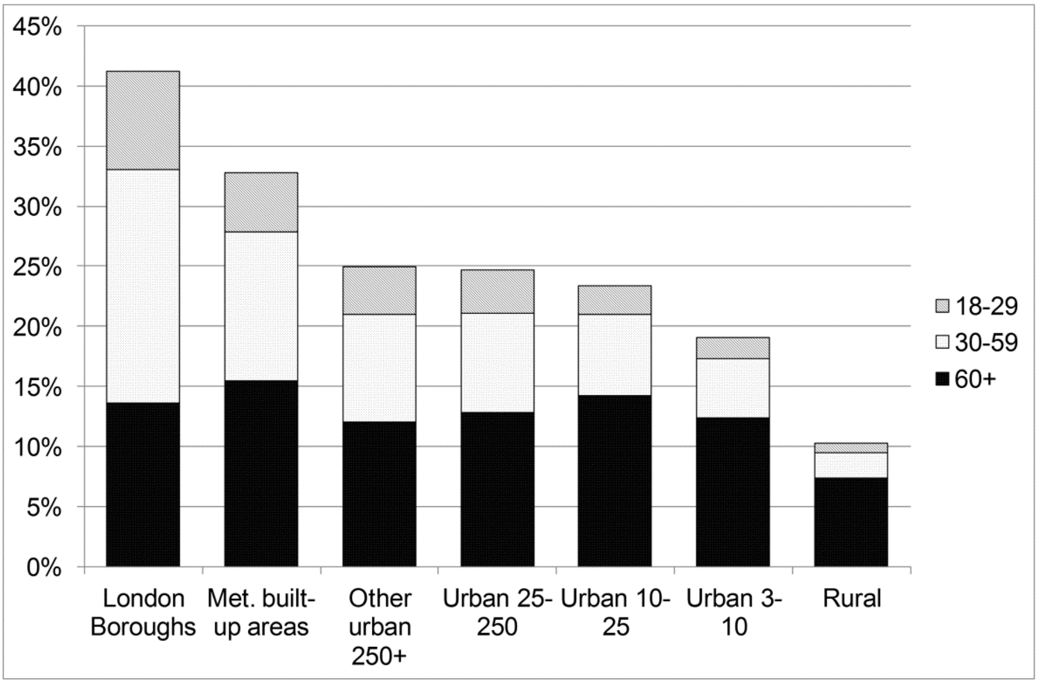


Fig. 7.8 – Composition of the carless households group by age of HRP, across different types of area (thousands of inhabitants). Unit of analysis: households. Source: own elaboration on NTS 2002-2010 data (interview sample).

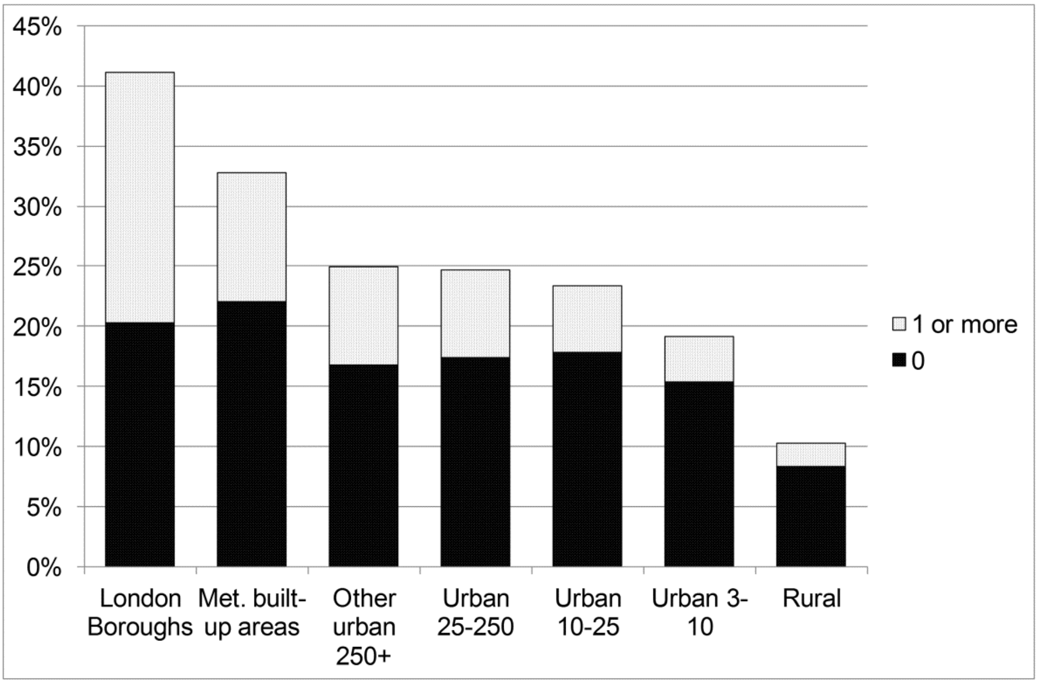


Fig. 7.9 – Composition of the carless households group by number of employed members, across different types of area (thousands of inhabitants). Unit of analysis: households. Source: own elaboration on NTS 2002-2010 data (interview sample).

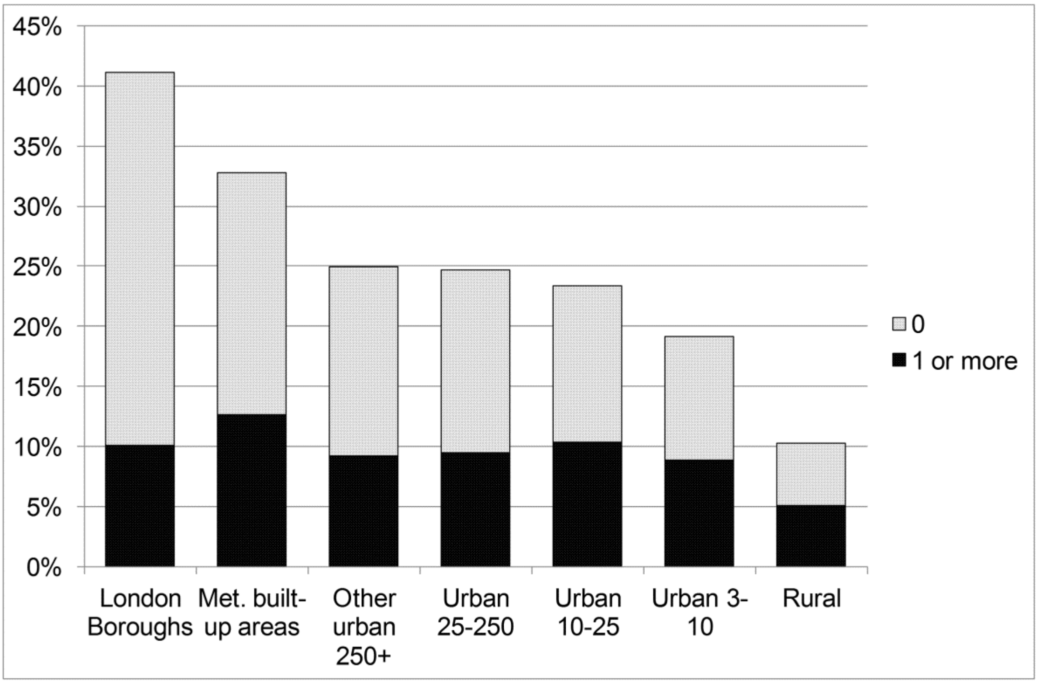


Fig. 7.10 – Composition of the carless households group by number of members with mobility difficulties (foot / bus), across different types of area (thousands of inhabitants). Unit of analysis: households. Source: own elaboration on NTS 2002-2010 data (interview sample).

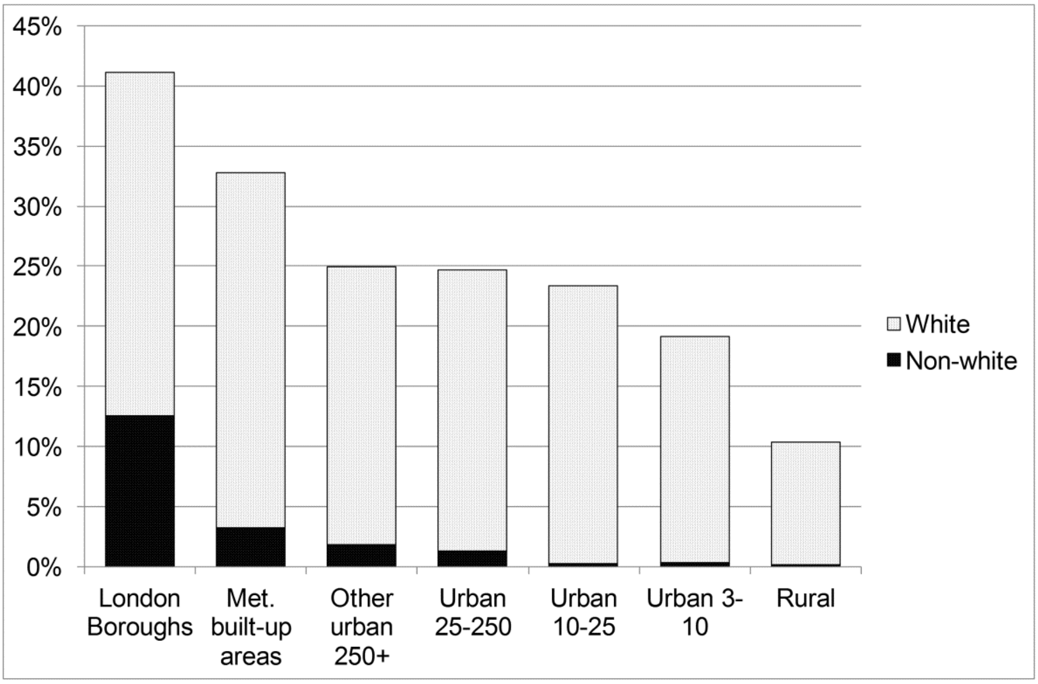


Fig. 7.11 – Composition of the carless households group by ethnic group of HRP, across different types of area (thousands of inhabitants). Unit of analysis: households. Source: own elaboration on NTS 2002-2010 data (interview sample).

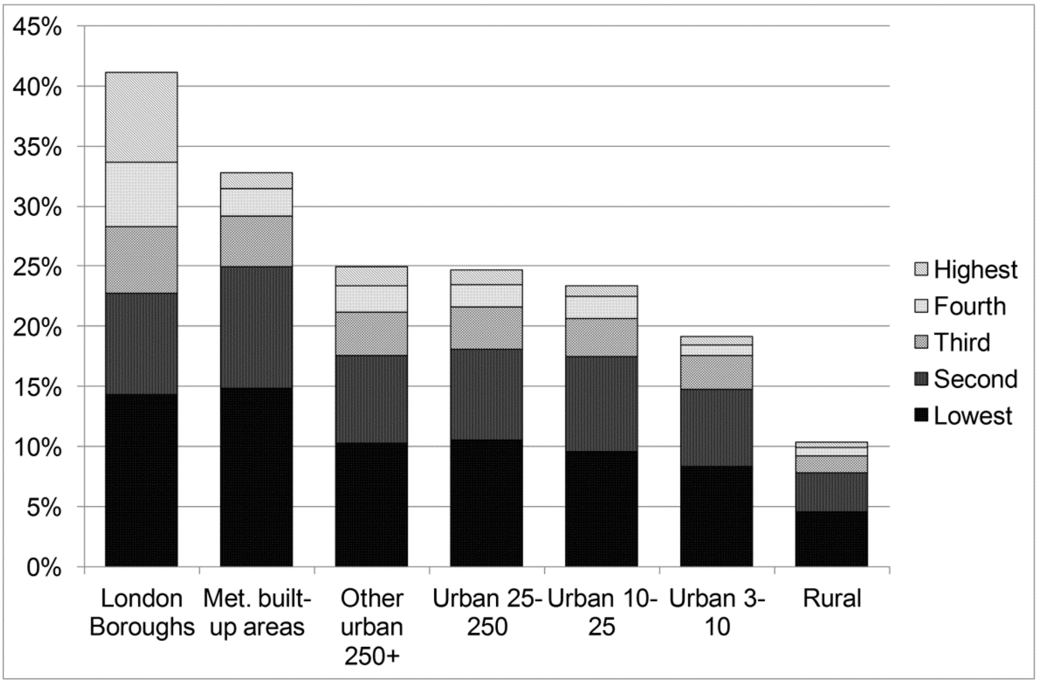


Fig. 7.12 – Composition of the carless households group by income quintile, across different types of area (thousands of inhabitants). Unit of analysis: households. Source: own elaboration on NTS 2002-2010 data (interview sample).

		Type of area (thousands of inhabitants)							
		London Boroughs	Met built-up areas	Other urban over 250	Urban over 25 to 250	Urban over 10 to 25	Urban over 3 to 10	Rural	Total
Household size	**1**	48.7	54.1	57.6	59.1	64.2	66.2	68.2	57.0
	2 or more	51.3	45.9	42.4	40.9	35.8	33.8	31.8	43.0
	Total	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*
No. of members under 16	**0**	82.0	81.5	82.6	82.0	84.4	86.8	88.4	82.8
	1 or more	18.0	18.5	17.3	18.0	15.6	13.2	11.6	17.2
	Total	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*
HRP: sex	**Female**	52.8	59.0	59.7	61.1	65.3	66.8	65.4	59.7
	Male	47.2	41.0	40.3	38.9	34.7	33.2	34.6	40.1
	Total	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*
HRP: age	**60 or more**	33.0	47.0	48.3	52.0	60.9	64.6	71.6	51.0
	16-59	67.0	53.0	51.7	48.0	39.1	35.4	28.4	49.0
	Total	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*
No. of employed members	**0**	49.2	67.3	67.2	70.3	76.2	80.5	80.6	66.5
	1 or more	50.8	32.7	32.8	29.7	23.8	19.5	19.4	33.5
	Total	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*
Members with mobility difficulties	**1 or more**	24.5	38.5	36.9	38.3	44.4	46.5	48.8	36.8
	0	75.5	61.5	63.1	61.7	55.6	53.5	51.2	63.2
	Total	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*
HRP: ethnic group	**Non-white**	30.4	9.7	7.3	5.0	1.0	1.3	1.3	10.8
	White	69.6	90.3	92.7	95.0	99.0	98.7	98.7	89.2
	Total	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*
Income quintile	**Lowest + second**	55.3	76.1	70.3	73.5	74.9	77.0	75.9	70.1
	Third or higher	44.7	23.9	29.7	26.5	25.1	23.0	24.1	29.9
	Total	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*
Additive index	**5 to 8 characteristics**	36.2	49.1	49.3	51.8	58.9	64.1	68.0	49.8
	Less than 5	63.8	50.9	50.7	48.2	41.1	35.9	32.0	50.2
	Total	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*

Tab. 7.12 – Composition of the carless households group across different types of area (thousands of inhabitants) (percentage values[220]). Unit of analysis: households. Source: own elaboration on MiD 2008 data.

Overall, the descriptive analysis illustrated in Fig. 7.5 to Fig. 7.12 and Tab. 7.12 (along with those produced using alternative geographical variables, not reported here) tend to confirm hypothesis H1.1: the carless group is more concentrated among marginal social groups in peripheral, low density areas, as compared to central dense cities. This is true for all socio-demographic variables considered above, with the exception of the presence of minor children, ethnic group and income quintile. However, this could be the by-product of uncontrolled differences in the socio-demographic composition of the population across types of area. Overall, these results suggest that in large cities the group of carless households includes also a non-negligible share of younger, larger households that include working members– these types of household are, by contrast, almost non-existent among carless households in very small municipalities.

An interesting question in this context is whether carless households in peripheral, low density areas also accumulate several of the characteristics listed above. As a device to address this question, I use a simple additive index, indicating how many of the following characteristics apply to the household: single-person household; no children under 16; female HRP; HRP over 60; no employed members; at least one member reporting mobility difficulties; HRP non-white; income in the two lowest quintiles. The last row of Tab. 7.12

220 All row and column variables in Tab. 7.12 are significantly associated at the p<0.01 level (chi-square tests).

shows how many of the carless households, in each type of area, accumulate at least five of these eight characteristics. The pattern observed here is consistent with that observed for most of the variables above: while in rural areas virtually 68% of households without cars accumulate five or more characteristics, this applies to only 36% in large cities. Fig. 7.13 shows graphically how this impacts on the changing composition of the carless households group across different types of area: it shows that most of the increment in non-car ownership observed in larger urban areas is due to households who do not cumulate several of the eight characteristics listed above. This can be considered as another piece of evidence in support of the hypothesis H1.1: moving across the continuum of type of areas, the share of carless households is not the only thing that changes – their socio-demographic profile is also changing considerably.

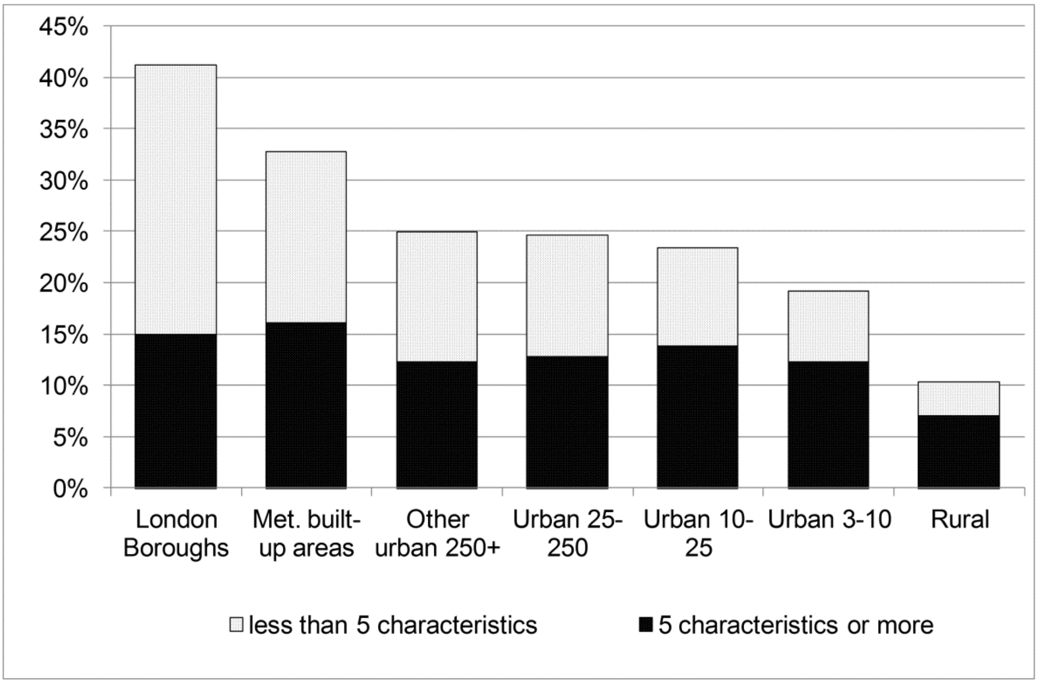


Fig. 7.13 – Composition of the carless households group by score on the additive index of socio-demographic characteristics associated with non-car ownership, across different types of area (thousands of inhabitants). Unit of analysis: households. Source: own elaboration on NTS 2002-2010 data (interview sample).

Up to this point, I have illustrated descriptive statistics: this implies that differences between types of area might be the by-product of socio-demographic differences between them. For example, the carless households group in smaller municipalities includes a greater percentage of households with the HRP over 60, as compared to London. However, also in the population as a whole, the percentage of older people is higher in peripheral areas than in large cities.

A simple way to control for this confounding effect is to compute odds ratios. Tab. 7.13 shows odds ratios for the same eight variables as Tab. 7.12, across different types of area[221]. 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 in Tab. 7.13 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 10.5 in rural areas.

The same trend is apparent for all other variables, with two exceptions: for 'presence of children under 16', the odds ratio is stable at around 2.0 for all urban areas over 25,000 inhabitants, and increases moderately

[221] The same odds ratios have been computed using an alternative geographical variables: population density at the PSU level. The results of this analysis broadly confirm the results illustrated here. The relative table is not reported here for the sake of brevity.

only in smaller cities and rural areas, where it reaches 2.9. This suggests that the association between the absence of members under 16 and non-car ownership is only slightly stronger in peripheral areas, as compared to core cities. This confirms the conclusion drawn from the descriptive analysis reported in Tab. 7.12. With regard to households with a non-white HRP, there are no great differences in the odds ratio, that is approximately 1 in all types of area, suggesting that there is virtually no association between ethnic group and non-car ownership, once the type of area is controlled for. The stronger association that is observed in the sample as a whole (odds ratio=1.8) is thus likely to be explained by the concentration of non-whites in large urban areas in Great Britain.

Variable	Odds ratio	Type of area (thousands of inhabitants)							Total
		London Boroughs	Met built-up areas	Other urban over 250	Urban over 25 to 250	Urban over 10 to 25	Urban over 3 to 10	Rural	
Household size	**1 (vs. 2 or more)**	3.9	5.6	5.8	6.6	8.3	9.1	10.5	6.0
No. of members under 16	**0 (vs. 1 or more)**	2.1	2.2	2.1	2.0	2.4	2.7	2.9	2.1
HRP: sex	**female (vs. male)**	2.4	3.4	3.6	3.8	4.8	5.2	5.4	3.6
HRP: age	**60+ (vs. 16-59)**	1.6	2.5	2.6	2.9	3.6	3.6	4.9	2.4
No. of employed members	**0 (vs. 1 or more)**	4.4	7.1	7.4	8.2	9.2	11.6	12.1	6.7
Members with mobility difficulties	**1 or more (vs. 0)**	1.9	2.6	2.7	2.8	3.4	3.7	4.4	2.6
HRP: ethnic group	**non-white (vs. white)**	1.3	1.0	1.1	1.1	0.8	1.1	1.3	1.8
Income quintile	**Lowest + second (vs. third or higher)**	3.6	6.3	5.8	6.4	6.7	8.3	8.0	5.6
Additive index	**5 to 8 characteristics (vs. less than 5)**	5.0	7.3	7.6	8.7	9.8	12.2	15.7	7.6

Tab. 7.13 – Odds ratios for the odds of not owning cars, rather than owning it. Unit of analysis: households. Source: own elaboration on NTS 2002-2010 data (interview sample).

Moreover, Tab. 7.13 shows that the association between belonging to the bottom 40% of the income distribution and not owning cars increases significantly as the degree of urbanity decreases. This is interesting in that descriptive analysis (Tab. 7.12) showed only minor differences in this respect between areas (with the exception of London). In this case, the difference between simple percentages and odds ratios suggests that differences in income distribution between different types of area tend to obscure differences in the composition of the carless households group. Indeed, there are more low-income households in large urban areas: as a result, we should expect to find more poor carless households in these areas. The fact that, by contrast, the percentage of low-income households in the carless group is similar everywhere suggests that the association between low income and non-car ownership increases as urbanity decreases, as indicated by the odds ratios in Tab. 7.13.

The last row in Tab. 7.13 reports odds ratios for the same additive index reported in Tab. 7.12. The increasing values of the odds ratios suggest that the association between the simultaneous presence of several (at least five) of the eight socio-demographic characteristics and non-car ownership increases greatly as the degree of urbanity decreases.

Overall, the increasing values of the odds ratios indicate that the positive association between the socio-demographic variables and non-car ownership is substantially greater in peripheral and rural areas. This in turn confirms that the carless are significantly more concentrated among marginal social groups where the degree of urbanity is lower.

This conclusion is further supported by more formal analyses: Fig. 7.14 shows the values of McFadden's pseudo R^2 for a series of logistic regression models predictors that have been fitted separately for the different types of area. The independent variables included are the same reported in the regression model illustrated previously (Tab. 7.9), with the exception of territorial variables: therefore, the model includes only socio-demographic predictors as well as the year of survey (in order to control for possible differences between individual years). The detailed results for the models are reported in Tab. 7.14, at the end of this section.

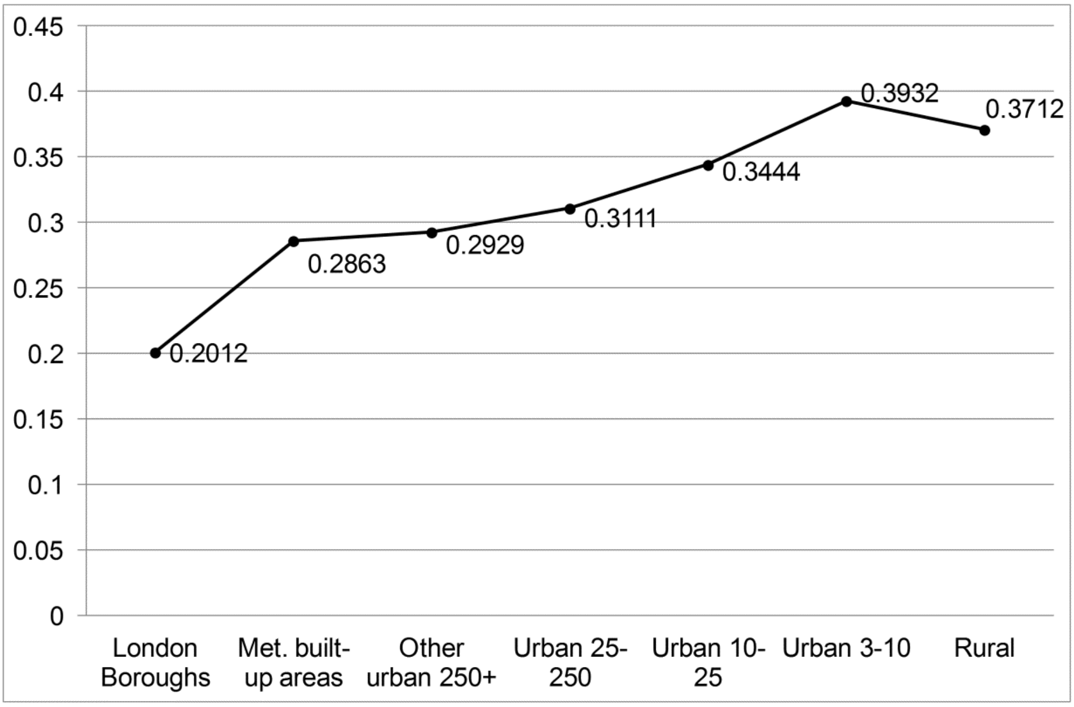


Fig. 7.14 – Values of McFadden's pseudo-R^2 for logistic regression models including only socio-demographic predictors (and survey year), fitted separately for the different types of areas (for details see Tab. 7.14). Unit of analysis: households. Source: own elaboration on NTS 2002-2010 (interview sample).

Fig. 7.14 shows clearly that the values increase significantly in moving from London (0.21) to small urban municipalities (0.39), before declining slightly for rural areas[222]. McFadden suggested that values comprised between 0.2 and 0.4 indicate an excellent fit (McFadden, 1979, p. 307, see §A.1.6): therefore, the values of the statistic in the more peripheral areas should be considered as very high, especially if one acknowledges

[222] The same models have been computed using two alternative geographical variables: population density at the LA and PSU level. The results of these analyses broadly confirm the arguments put forward here. The relative figures and tables are not reported here for the sake of brevity.

that the models deliberately exclude any independent variable related to the area of residence (such as public transport access and the like), which could arguably increase the predictive power of the model 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 once more that the profile of carless households in large urban areas is much less one-sided, predictable and marginal than in other areas.

To sum up, then, the results obtained in this section using different data analysis techniques (descriptive statistics, odds ratios and logistic regression models) suggest 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: non-car ownership is much more associated with socio-demographic factors (and thus much easier to predict based on the relative variables) in sparse areas than in dense, urban areas. This is consistent with the hypothesis that carless households are much more concentrated among marginal social groups in peripheral and rural areas.

	Type of area (thousands of inhabitants)													
	London Boroughs		Metropolitan built-up areas		Other urban over 250		Urban over 25 to 250		Urban over 10 to 25		Urban over 3 to 10		Rural	
	Coef.	**Robust Std. Error**	**Coef.**	**Robust Std. Error**	**Coef.**	**Robust Std. Error**	**Coef.**	**Robust Std. Error**	**Coef.**	**Robust Std. Error**	**Coef.**	**Robust Std. Error**	**Coef.**	**Robust Std. Error**
No. of members	-1.052***	(0.0731)	-1.143***	(0.0713)	-1.411***	(0.0786)	-1.470***	(0.0617)	-1.812***	(0.117)	-1.647***	(0.130)	-1.790***	(0.120)
No. of members (squared)	0.104***	(0.00935)	0.110***	(0.0102)	0.149***	(0.0121)	0.152***	(0.00985)	0.181***	(0.0213)	0.174***	(0.0201)	0.166***	(0.0206)
No. of members under 16	-0.244***	(0.0537)	-0.0188	(0.0536)	0.0203	(0.0641)	0.181***	(0.0550)	0.345**	(0.109)	0.0729	(0.124)	0.516***	(0.118)
HRP female	0.516***	(0.0528)	0.801***	(0.0505)	0.766***	(0.0527)	0.769***	(0.0411)	0.861***	(0.0745)	0.993***	(0.0867)	0.828***	(0.0797)
Age group of HRP (ref. cat. 16-–29) 30 – 39	-0.909***	(0.0953)	-0.608***	(0.0939)	-0.595***	(0.103)	-0.830***	(0.0790)	-0.609***	(0.155)	-0.824***	(0.200)	-1.323***	(0.205)
40 – 49	-1.198***	(0.0973)	-0.734***	(0.0966)	-0.981***	(0.105)	-0.893***	(0.0810)	-0.734***	(0.149)	-1.509***	(0.224)	-1.144***	(0.192)
50 – 59	-1.675***	(0.103)	-1.005***	(0.101)	-1.296***	(0.113)	-1.081***	(0.0848)	-0.949***	(0.160)	-1.767***	(0.202)	-1.633***	(0.205)
60 – 69	-1.902***	(0.109)	-1.339***	(0.105)	-1.633***	(0.116)	-1.491***	(0.0876)	-1.218***	(0.167)	-2.141***	(0.202)	-1.893***	(0.200)
70 +	-1.406***	(0.107)	-0.787***	(0.101)	-1.095***	(0.113)	-0.837***	(0.0832)	-0.556***	(0.151)	-1.388***	(0.202)	-0.894***	(0.191)
No. of employed members	-0.190***	(0.0470)	-0.410***	(0.0478)	-0.493***	(0.0580)	-0.548***	(0.0437)	-0.458***	(0.0766)	-0.735***	(0.103)	-0.620***	(0.101)
Member(s) with mobility difficulties	0.302***	(0.0649)	0.279***	(0.0586)	0.431***	(0.0586)	0.384***	(0.0448)	0.622***	(0.0759)	0.679***	(0.0961)	0.725***	(0.0812)
HRP non-white	0.361***	(0.0631)	0.186	(0.101)	0.339**	(0.116)	0.524***	(0.104)	0.343	(0.359)	0.524	(0.399)	1.358***	(0.357)
Income quintile (ref.cat.: Lowest): Second	-0.366***	(0.0800)	-0.355***	(0.0652)	-0.405***	(0.0684)	-0.418***	(0.0482)	-0.526***	(0.0887)	-0.628***	(0.101)	-0.551***	(0.0929)
Third	-0.873***	(0.0850)	-1.155***	(0.0770)	-1.032***	(0.0827)	-1.056***	(0.0606)	-1.335***	(0.113)	-1.297***	(0.119)	-1.318***	(0.111)
Fourth	-1.234***	(0.0879)	-1.769***	(0.0978)	-1.661***	(0.0991)	-1.692***	(0.0762)	-1.590***	(0.132)	-2.253***	(0.182)	-1.642***	(0.150)
Highest	-1.649***	(0.0920)	-2.385***	(0.119)	-2.158***	(0.112)	-2.147***	(0.0901)	-2.194***	(0.162)	-2.611***	(0.199)	-2.353***	(0.167)
Survey year	0.0316*	(0.0134)	-0.0336**	(0.0118)	-0.000437	(0.0134)	-0.0121	(0.00879)	-0.0386*	(0.0150)	-0.0478**	(0.0164)	-0.0167	(0.0162)
(constant)	2.812***	(0.233)	3.057****	(0.217)	2.761***	(0.231)	2.859***	(0.160)	3.198***	(0.287)	3.750***	(0.327)	2.478***	(0.341)
N	9,910		11,670		12,268		21,860		7,737		6,299		12,051	
McFadden's pseudo R^2	0.201		0.286		0.293		0.311		0.344		0.393		0.371	

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Tab. 7.14 – Logistic regression model for the probability of not owning a household car, by type of area (logit coefficients and robust standard errors). Unit of analysis: households. Source: own elaboration on NTS 2002-2008 data (interview sample).

7.1.3. *Travel behaviour: a typology of carless households*

In the previous section, I have focused on the changing socio-demographic composition of the carless households group across different types of area, thus addressing hypothesis H1.1 (see §3.3.2). In this section, I focus on the travel behaviour of individuals living in households without cars, thus addressing hypothesis H1.3. The hypothesis states that non-car ownership in low-density, peripheral areas corresponds mostly to low levels of mobility, while this relationship should be attenuated in dense urban areas.

As noted above (§5.3), the NTS questionnaire includes a one week travel diary that is completed for every household member. Accordingly, while in previous sections the unit of analysis was the household, I will focus here on the travel behaviour of individuals living in carless households. Fig. 7.15 shows, for individuals living in households without cars, the average weekly travel distance, by different types of areas, with the different fill-in patterns standing for the main transport modes.

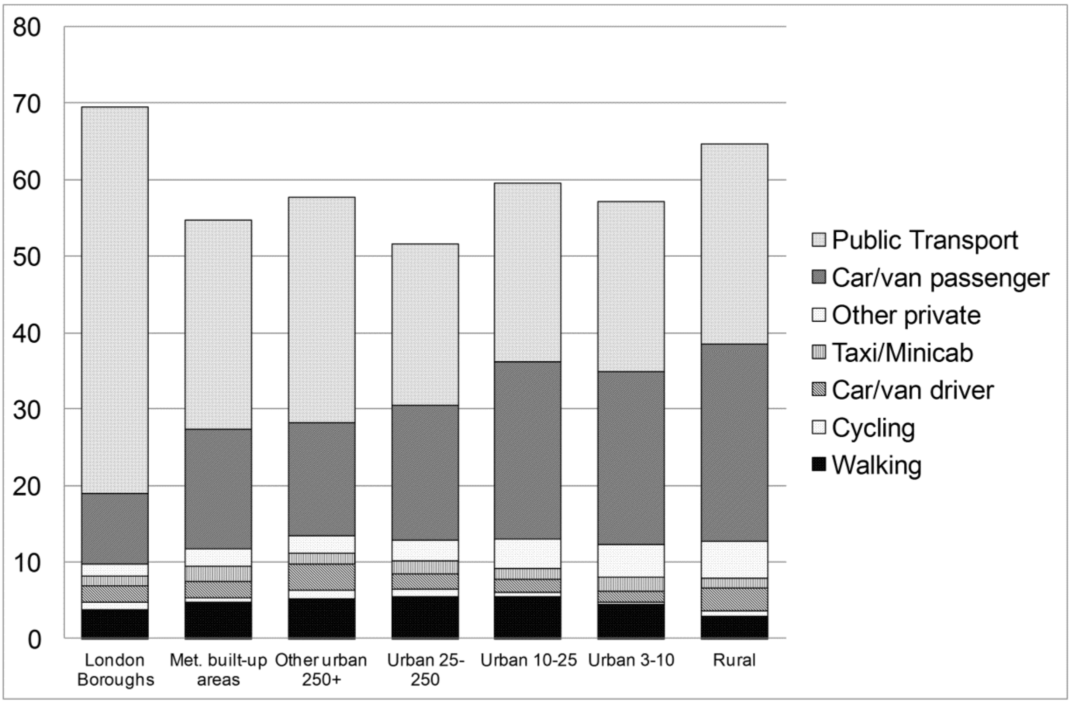


Fig. 7.15 – Weekly travel distance per person (miles), by transport mode and type of area, for carless individuals. Unit of analysis: individuals. Source: own elaboration on NTS 2002-2010 data (diary sample[223]).

As urbanity decreases, the average distance seems to follow a U-shaped curve, but overall it appears that the type of area does not make much of a difference for 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 (ca. 120 miles per week) than their rural counterparts (approximately 200). As a result, the difference between average travel distance for individuals in households with and without cars increases as the degree of urbanity decreases.

When modal split is taken into account, it appears that the stability of travel distance for carless individuals across different types of area is the result of two diverging trends: while the distance covered as car passenger increases steadily as the degree of urbanity decreases, the opposite is true for public transport. As a result, the modal split is very different across types of areas, with London carless individuals covering

[223] In this section and in the following (§7.1.3), all analyses refer to the diary sample, instead of the interview sample.

73% of their travel distance by public transport and only 13% as car passengers, while the corresponding figures for rural areas are 41% and 40%. Also the modal share of other private motorised transport modes (car as driver, other private) and taxis, albeit residual, increases as one moves from London (7%) to rural areas (14%).

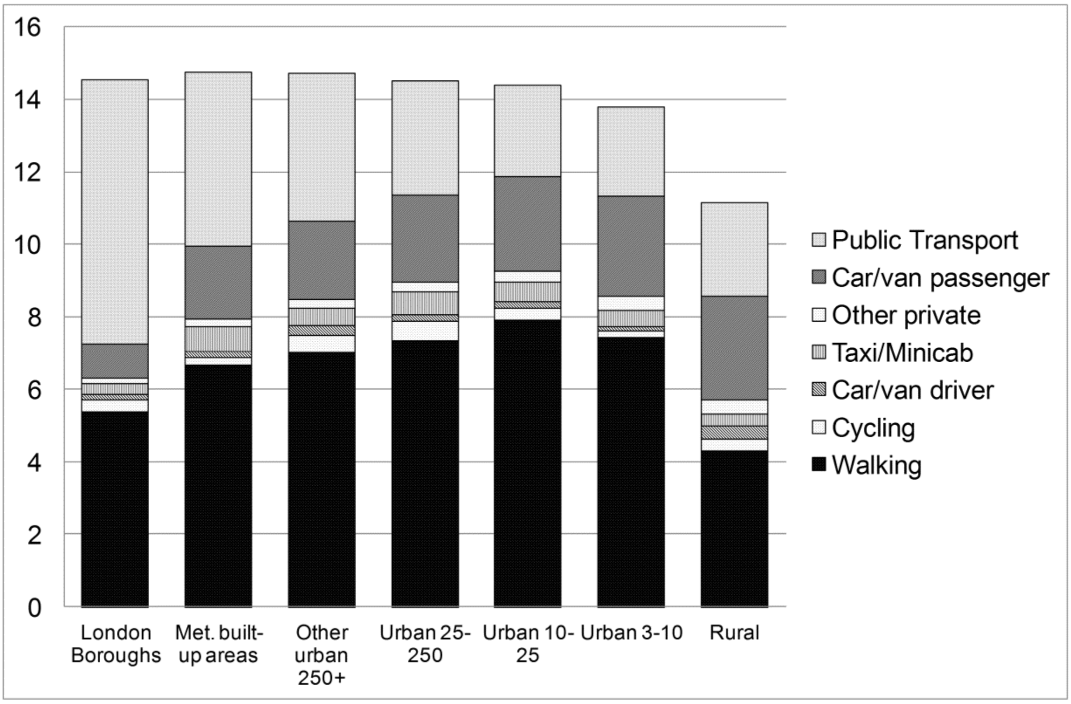


Fig. 7.16 – Trip rates per week, by transport mode and type of area, for carless individuals. Unit of analysis: individuals. Source: own elaboration on NTS 2002-2010 data (diary sample).

Fig. 7.16 is similar to the previous, but refers to trip rates instead of travel distance. The graph shows that overall trip rates for carless individuals are stable around 14 trips per week (two trips per day) across most types of area. It is only in very small municipalities (between 3,000 and 10,000 inhabitants) and rural area that trip rates decline significantly. This trend is different from that observed for individuals in car-owning households (not reported here for the sake of brevity) showing higher trip rates, stable at around 20-21 trips per week across most types of area, except in London where they are lower (approximately 18 trips). As a result, the difference in terms of trip rates between individuals in households with and without cars is greatest in small cities and rural areas, and lowest in London.

In terms of modal split, Fig. 7.16 shows that trip rates for public transport decrease significantly as the degree of urbanity decreases. The opposite trend is observed for 'car as passenger', while trip rates for walking increase as urbanity decreases, but then decrease starting with cities between 10,000 and 25,000 inhabitants. As a result, modal split is very different across types of areas, with London carless individuals making 50% of their trips by public transport and only 7% as car passengers, while corresponding figures for rural areas are 23% and 26%. Also the modal share of other private motorised transport modes and taxis, albeit residual, increases as one moves from London (4%) to rural areas (9%). In all areas except London, walking accounts for the relative majority of trips (between 38 and 45%).

The results for travel time (not reported here in detail for the sake of brevity) indicate that overall journey time (including waiting time and short walks) for carless individuals is particularly high in London (virtually 8 hours per week), it falls to approximately 6 hours in other metropolitan areas, and then declines slightly as the degree of urbanity decreases, reaching 4 hours and 15 minutes in rural areas. Individuals in car-owning households report longer journey times (between 7 and 8 hours) for all types of area. The trend across different types of area is U-shaped, with maximum values in London, decreasing for areas in the middle of the scale and then increasing for smaller cities and rural areas. As a result, the difference in terms of average journey time between individuals in households with and without cars increases steadily as one moves from London (26 minutes) to rural areas (3 hours and 15 minutes).

Overall, these results illustrated provide a first piece of evidence in support of hypothesis H1.3, as illustrated in Fig. 7.17.

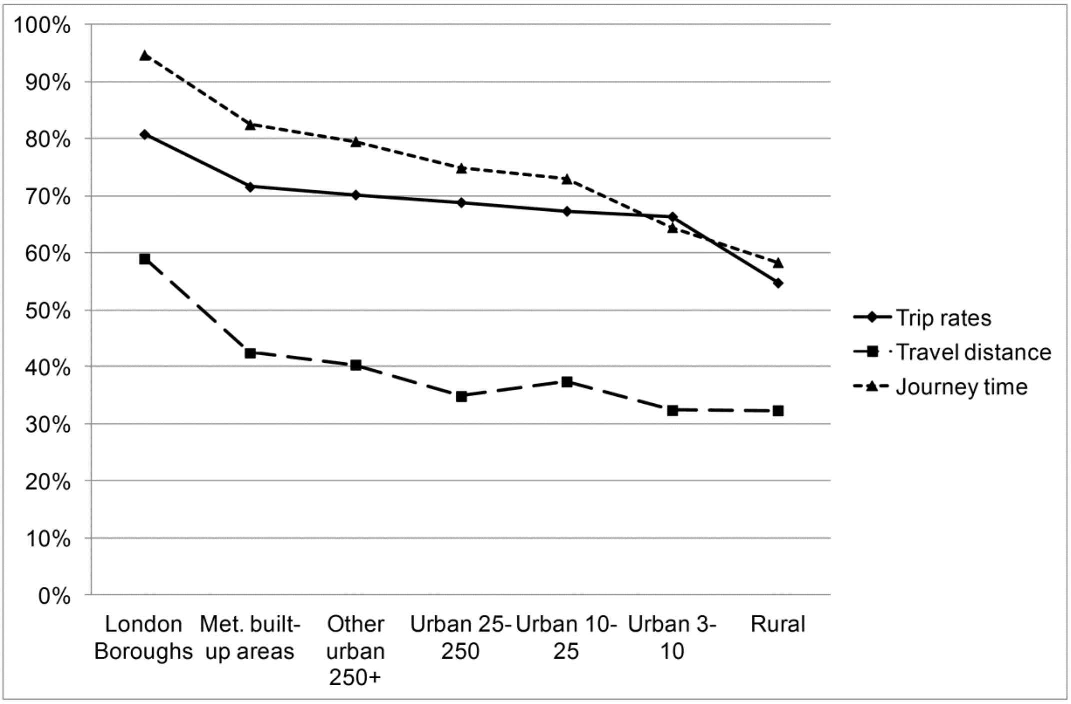


Fig. 7.17 – Travel behaviour indicators for carless individuals, as percentage of the same indicator for individuals in car-owning households, by type of area. Unit of analysis: individuals. Source: own elaboration on NTS 2002-2010 data (diary sample).

The graph shows how the values of three travel behaviour indicators (trips rates, travel distance and journey time) for carless individuals, computed as percentage of the same indicator for individuals in car-owning households, vary across different types of area[224]. The values should be interpreted as follows: in London, carless individuals make on average approximately 80% of the trips of their motorised counterparts. This figure decreases as the degree of urbanity decreases, reaching 55% in rural areas. The same trend is observed for the other two parameters of travel behaviour: travel time and distance. Overall, then, it can be concluded that non-car ownership in low-density, peripheral areas corresponds to lower levels of mobility (as compared to motorised households), while this relationship is attenuated in dense urban areas. This corroborates hypothesis H1.3.

This pattern can be explained with reference to the concept of 'car dependence' put forward in this thesis: as it is more difficult to be mobile without cars in car dependent areas, the carless experience a larger 'mobility deficit' in these areas. By contrast, in large cities, the better provision of modal alternatives and the shorter

[224] The trends illustrated in Fig. 7.17 were doubled-checked using other geographical variables (population density at the LA and PSU level): the results (not reported here for the sake of brevity) are broadly consistent with those reported here.

distances to services and opportunities tend to reduce this gap, making their travel behaviour more similar to that of their motorised counterparts.

While this explanation is plausible, it should not be forgotten that, as demonstrated in the previous section (§7.1.2), the composition of the carless group varies systematically as the degree of urbanity decreases: notably, carless households in peripheral, low density areas are significantly more concentrated among marginal social groups (older people, low-income households, disabled, etc.). This probably has an impact on their travel behaviour, as these socio-demographic characteristics are likely to be associated with lower mobility levels. Therefore, the travel behaviour trends illustrated in Fig. 7.17 can be explained (also) as the by-product of the changing socio-demographic composition of the carless group across different types of area.

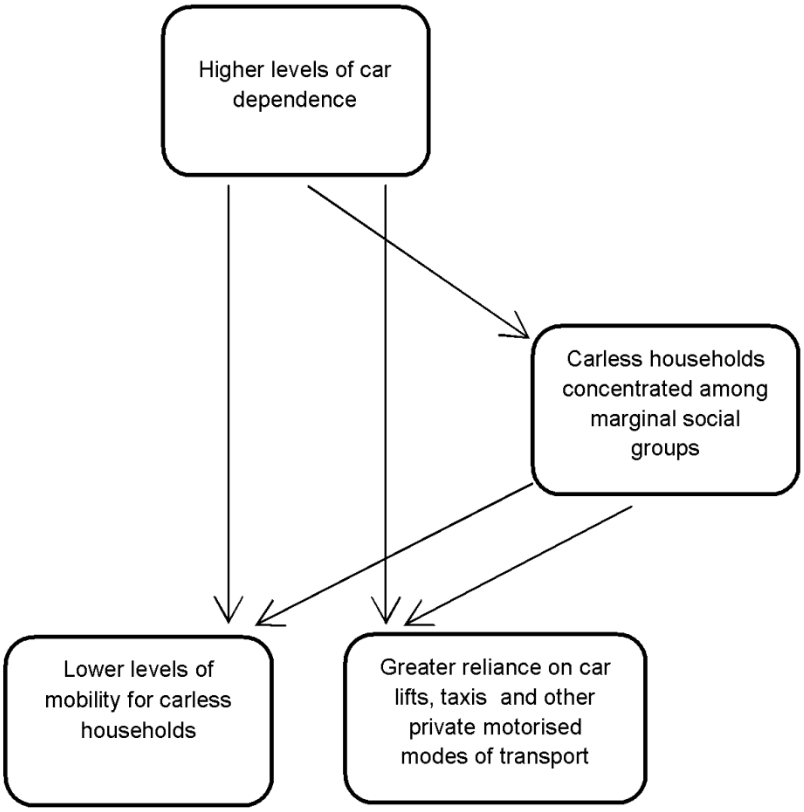


Fig. 7.18 – Diagrammatical representation of the relationships between car dependence, socio-demographic composition of the carless households group and travel behaviour. Source: own elaboration.

Moreover, the modal split figures illustrated in Fig. 7.15 and Fig. 7.16 show the existence of another significant trend: carless individuals in small cities and rural areas rely significantly more on ‘car as passenger’ and less on public transport, than their counterparts in larger urban areas. Also this pattern can be explained by the better public transport service provided in dense cities, and the higher degree of car dependence of peripheral, low density areas. However, this trend might (also) be the by-product of the changing socio-demographic composition of the carless group across different types of area: for example, I have illustrated in §7.1.2 how the proportion of carless experiencing mobility difficulties with alternative modes (walking and public transport) is significantly higher in peripheral, low density areas. This might lead them to rely more frequently on car lifts by others (relatives and friends), as the use of modal alternatives is made difficult not only by attributes of the local area (low density, poor public transport service), but also by individual characteristics.

These observations are summarized in Fig. 7.18, showing the direct and indirect effects of higher levels of car dependence on the travel behaviour of individuals in carless households: 'indirect' effects are mediated by the different changing composition of the carless group across different types area. The diagram suggests an update of hypothesis H1.3, in light of preliminary evidence about how the socio-demographic composition and the modal behaviour of the carless change across different types of area.

To explore this hypothesis more in depth, in this section I present the results of a cluster analysis (§A.3) conducted on the subset of carless individuals, on the basis of travel behaviour variables[225]. The goal is to obtain clusters of carless individuals that are as homogeneous as possible in terms of travel behaviour, and then to describe the typology with respect to other key dimensions (socio-demographics, type of area, etc.).

Two groups are excluded from the cluster analysis: first, persons who did not report travel during the survey week, because obviously information about the mode and purpose of their travel is missing. While this tells something about their travel behaviour, it does not allow me to use travel behaviour variables for the cluster analysis. The second group that is excluded from the analysis is children under the age of 16. the reason for this is that the travel behaviour of children in the formative years is marked by parental dependence and by limited travel needs and distance, even though this becomes less and less true over the course of adolescence (Currie, 2007).

The input variables used for the cluster analysis are the following:

- the weekly travel distance, in order to distinguish more mobile carless individuals from the rest
- the average speed of travel, in order to distinguish carless adults who predominantly rely on 'slow' modes of transport (walking and cycling) from the rest
- the share of the weekly travel distance travelled by car (either as driver or passenger), taxi or other private motorized transport means; this allows to identify people who, despite not owning a household car, rely on car-like transport modes
- the share of trips made in order to carry out work or education-related activities; the goal here is to single out individuals who, despite the lack of a car, are able to participate in employment or education[226]

It is important to point out that these variables are based on a one-week travel diary. This is crucial in that it allows me to assume that the travel behaviour reported in the travel diary is representative of habitual travel behaviour. This would not be possible with a one-day travel diary (such as the one used in the German survey MiD), because a single day is arguably less representative of average travel behaviour[227].

Based on these input variables, I retained a four cluster solution, representing the most distinct clustering, as attested by the maximum value of the Caliński/Harabasz pseudo-F statistic[228]. While the details concerning model selection are reported in §C.3.2, the values of the centroids of the obtained clusters are reported in Tab. 7.15[229]. The table shows results also for a fifth cluster, labelled *Immobile* (IM) and accounting for 8% of carless adults, consisting of those respondents who were excluded from the cluster analysis because they did not travel at all during the survey week[230]. While this group was not obtained with clustering methods, it is

[225] For this reason, the cluster analysis is conducted on the diary sample and takes individuals as the unit of analysis.

[226] Details about the recoding of the travel purposes classified as 'work or education-related' is reported in §C.3.2.

[227] Of course, also the assumption that travel behaviour in the survey week is representative of habitual travel behaviour has limitations: for example, travel behaviour during a holiday week is likely to be very different from the average, in almost every respect (purpose, distance, modal split). However, a one-week travel diary arguably represents a much better starting point for clustering travel behaviour than a one-day travel diary. For a similar use of cluster analysis on NTS travel behaviour data, see Stokes and Lucas (2011).

[228] The clustering has been conducted using k-means algorithm, euclidean distance as dissimilarity measure and standardized input variables. Further technical details about the cluster analysis solution are reported in §C.3.2.

[229] Strictly speaking, Tab. 7.15 does not show the centroids but the value of the four obtained clusters on the four *unstandardized* input variables (standardized variables have been used for the analysis, see §C.3.2). The unweighted mean values for the clusters on the standardized input variables are also reported in §C.3.2.

[230] In fact, given the particular structure of the travel diary used for NTS (see C.1), the 'immobile' group is best described as composed by carless individuals who did not made any trip on travel diary days 1-6 *except for short walks*, and did not make any trip on day 7. Therefore, it cannot be excluded that individuals in these clusters made one or more short walks during the week. This does not changes substantially the conclusion put forward here: the group is characterised by extremely low levels of mobility.

arguably characterized by a very peculiar travel behaviour, and therefore it must be considered as an integral part of the typology put forward here.

Cluster number		1	2	3	4	5	Total (individuals without cars, over 15)
Cluster name		Slow and local (SL)	Car reliant (CR)	Public transport commuters (PTC)	Immobile (IM)	Long distance week (LDW)	
Cluster size		40.3	23.2	22.6	7.9	5.9	100.0
Travel distance	Miles	40	49	65	0	343	62
Average Speed	Mph	6.8	13.1	8.3	-	30.9	10.3
Share of travel distance by car, taxi and other private motorised modes[231]	%	11	86	18	-	48	34
Share of trips for work / education	%	4	5	72	-	27	22

Tab. 7.15 – Cluster analysis results, cluster profile (mean values). Unit of analysis: individuals over 15. Source: own elaboration on NTS 2002-2010 data (diary sample).

Tab. 7.16 shows how the clusters differ with respect to key travel behaviour variables (the same as in Tab. 7.6, §7.1.1), which in turn are strictly 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[232]. The table shows that the IM cluster has by definition 0 or missing values on all travel behaviour variables. 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 (Tab. 7.16). Total travel distance and average length of trips are particularly above average. Tab. 7.15 also shows that the average speed of travel for this cluster is much higher than for all others. Overall, this suggests that the cluster includes individuals who made at least a long distance journey during the survey week, as long-distance trips are usually made with faster travel modes. Arguably, this makes the travel diary week not representative of their usual travel behaviour: for this reason, in the following I will not interpret the figures for this group (although they will be reported in the tables).

The *Car reliant* cluster (CR), accounts for virtually one quarter of the carless and is characterised mainly by the high modal share of the car as passenger (39% of trips, 63% of distance). All car-like transport modes are overrepresented in the modal split of this cluster, and taken together they account for virtually 60% of trips and more than 80% of travel distance (Tab. 7.16). Accordingly, individuals in this group are those who spend the least time travelling, even though they cover 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 (Tab. 7.15). In a nutshell, this group is composed of adults who, despite being carless, rely on car lifts, taxis and the like for most of their travel.

[231] The attentive reader might note that modal share figures for car, taxi and other private motorised modes in Tab. 7.15 differ slightly from the corresponding figures reported in Tab. 7.16 below. The reason for this is that they are computed differently: Tab. 7.15 shows the mean values for the modal share variables in the individual database. Therefore, the results should be interpreted as in the following example: on average, individuals in the SL cluster uses the car, taxi or other private motorised transport modes for 11% of *their* travel distance. By contrast, modal splits in Tab. 7.16 refer to the total travel distance, and should be interpreted as in the following example: 7.4% of the *distance covered* by individuals in the SL cluster during the travel diary week corresponds to the mode' car as passenger'.

[232] Values for the whole NTS 2002-2010 sample differ from those reported in Tab. 7.6 because they refer to the diary sample (instead of the interview sample) and to individuals over the age of 15 only.

On travel diary week		Value	1 - SL	2 - CR	3 - PTC	4 - IM	5 - LDW	Individuals without cars, over 15	Total (NTS 2002-2010 sample)
Trips		**Mean[233]**	16.7	11.8	17.3	0.0	16.3	14.4	19.8
Travel distance (miles)		**Mean**	39.9	48.8	65.3	0	342.6	62.4	147.1
Journey time (h:min)		**Mean**	6:32	4:02	8:26	0	13:03	6:15	7:39
Travelling time (h:min)		**Mean**	6:08	3:51	7:52	0	11:57	5:51	7:21
Average length of trips (miles)		**Mean**	3.5	5.1	4.7	-	24.9	5.8	8.5
Modal split (basis: trips)	**Walking**	%	54.3	29.5	38.0	-	27.7	43.3	21.1
	Cycling		2.6	1.2	4.3	-	2.4	2.8	1.5
	Car / van driver		0.2	3.9	0.9	-	8.6	1.6	50.3
	Car / van passenger		5.5	39.0	8.4	-	21.9	13.8	15.3
	Motorbike/ other private		0.3	5.6	1.1	-	3.4	1.7	1.0
	Taxi / Minicab		2.4	8.3	3.0	-	3.3	3.7	1.2
	Public Transport		34.8	12.6	44.3	-	32.6	33.0	9.6
	Total		*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*
Modal split (basis: distance)	**Walking**	%	15.6	4.4	8.3	-	1.0	7.1	2.1
	Cycling		2.4	0.5	3.2	-	0.3	1.6	0.6
	Car / van driver		0.2	4.9	1.6	-	9.1	4.3	57.8
	Car / van passenger		7.4	63.1	11.8	-	28.8	25.5	21.5
	Motorbike / other private		0.4	8.7	2.1	-	6.6	4.3	2.2
	Taxi / Minicab		2.4	6.3	2.7	-	0.8	2.7	0.7
	Public transport		71.6	12.2	70.4	-	53.4	54.6	15.2
	Total		*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*

Tab. 7.16 – Travel behaviour on travel diary week, by clusters in the carless individuals typology (percentage values and means[234]). Unit of analysis: individuals over 15, trips. Source: own elaboration on NTS 2002-2010 data (diary sample).

The *Public transport commuters* cluster (PTC) also accounts for 23% of the carless, but it could not be more different: if the exceptional LDW cluster is not taken into account, this is the cluster with the highest value on all mobility indicators (except the average length of trips). In terms of journey time, individuals in this cluster even spend on average 50 minutes more travelling than the average Briton (Tab. 7.16). In terms of modal split, this is the group most reliant on public transport (44% of trips, 70% of distance) and cycling, while ‘car as passenger’, taxis and other private motorised modes of transport account for just 18% of travel distance. This explains why the average speed of travel is here lower than for the CR group. Another defining feature of this group is the importance of the daily commute: PTC individuals make on average 72% of their trips for work or education purposes, considerably more than all other clusters (Tab. 7.15). In a nutshell, then, this cluster is composed of quite mobile carless people who rely on public transport in order to reach their work or study place.

[233] Since all individuals who made no trips on the survey week are grouped together in the ‘immobile’ cluster, in Tab. 7.16 I report generic means only (specific means would be identical).

[234] All differences between means in Tab. 7.16 have been tested with adjusted Wald test and are significant at the 5% level.

Finally, the largest cluster (40% of individuals) shows a profile that is intermediate between the two previous. As illustrated in Tab. 7.15, it is defined by the lowest value on all input variables (if the IM group is not taken into consideration): this is the group with the shortest weekly travel distance, the lowest travel speed, the lowest modal share of car-like transport (11% of travel distance) and only a residual share of trips for work and education. Tab. 7.16 shows, however, that the number of trips and travel time indicators for this cluster are significantly higher than the subsample average, and second only to PTC (if LDW is not taken into account). In terms of modal split, individuals in this cluster rely on walking (accounting for more than half of their trips) and on public transport (more than 70% of travel distance) for most of their travel. Finally, the average length of trips is here lowest (3.5 miles) and further analyses show that 50% of those trips cover 2 miles or less. In a nutshell, then, this cluster is composed of individuals who do not work or study and rely mostly on walking and public transport in order to travel short distances in the proximity area. Therefore I label this group as *Slow and local* (SL).

Fig. 7.19 depicts how the size of the clusters varies across types of areas, thus addressing hypothesis H1.3. The corresponding percentage values for the composition of the carless group are reported in Tab. 7.17 below.

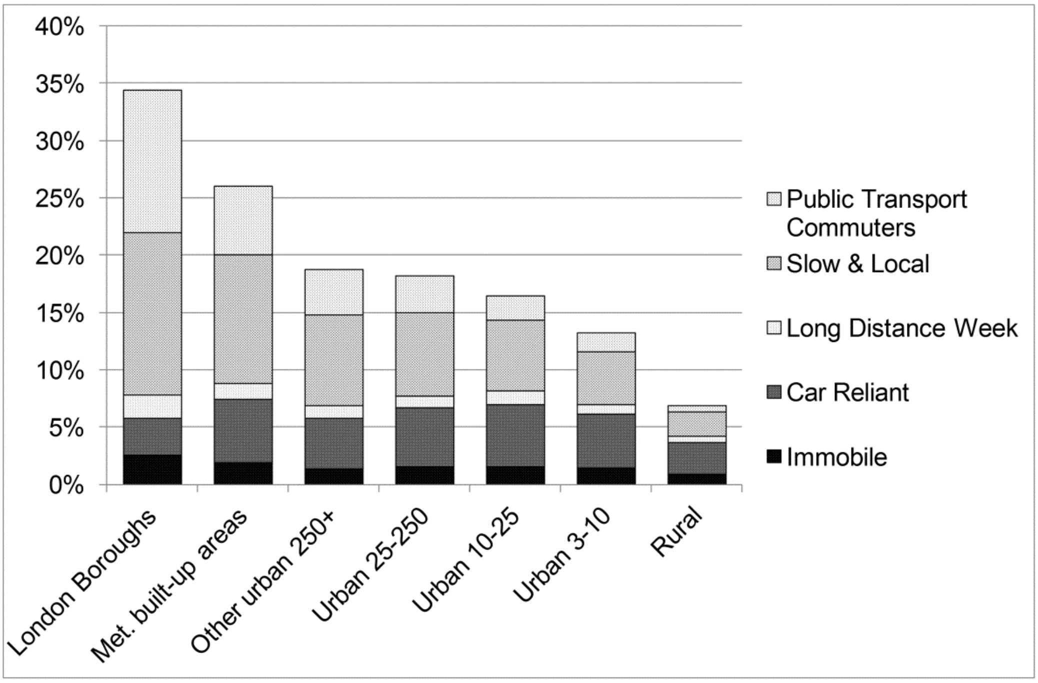


Fig. 7.19 – Size and composition of the group of carless individuals across different types of areas (thousands of inhabitants), by travel behaviour type. Data source: NTS 2002-2010. Unit of analysis: individuals over 15. Source: own elaboration on NTS 2002-2010 data (diary sample).

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 PCT groups (white background patterns). As a result, while in rural areas more than 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 (Tab. 7.17). Accordingly, most of the increase in the share of carless households that is observable between the different areas is attributable to variations in clusters characterised by an intensive use of modal alternatives to the car. 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 the lack of a car corresponds more often to either immobility or to dependence on others for lifts.

	Type of area (thousands of inhabitants)						
	London Boroughs	Metropolitan built-up areas	Other urban over 250	Urban over 25 to 250	Urban over 10 to 25	Urban over 3 to 10	Rural
SL	41.3	43.2	42.1	40.0	37.4	34.9	30.7
CR	9.5	21.3	23.4	28.4	33.4	36.1	40.7
PTC	36.3	23.1	21.4	18.1	13.2	12.7	8.1
IM	7.2	7.3	6.9	7.9	9.0	10.2	12.3
LDW	5.7	5.1	6.2	5.7	7.0	6.1	8.2
Total	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*

Tab. 7.17 – Carless households typology by type of area (percentage values). Unit of analysis: individuals over 15. Source: own elaboration on NTS 2002-2010 data (diary sample).

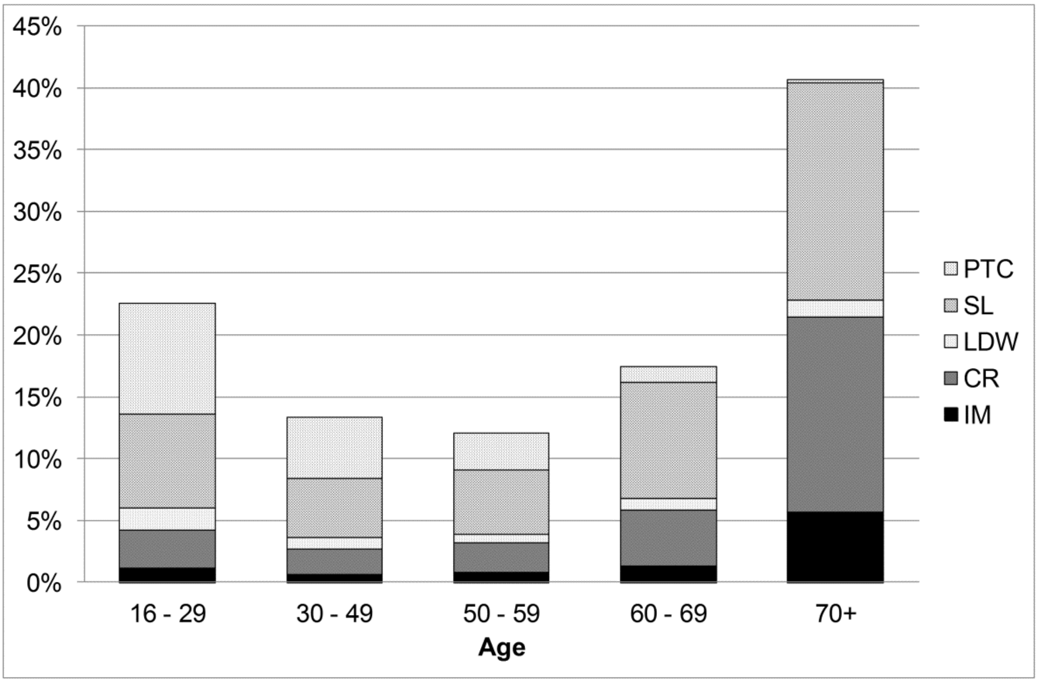


Fig. 7.20 – Size and composition of the group of carless individuals by age group and travel behaviour type. Data source: NTS 2002-2010. Unit of analysis: individuals over 15. Source: own elaboration on NTS 2002-2010 data (diary sample).

This is not the only point where clusters differ: Fig. 7.20 shows how the composition of the carless group, in terms of travel behaviour, changes across different age groups. The graph shows clearly that the CR and IM clusters (depicted with black background patterns) are overrepresented only among people aged 60 years or more. Notably, in the oldest age group (70 years or more), they account for more than half of carless individuals, while the rest is almost entirely classified into the SL cluster. The opposite trend is apparent for the PCT, whose relative weight is maximum in the youngest age group (16-29) and decreases rapidly as age increases: among individuals who are 70 years old or more, this cluster accounts for just 0.6% of the carless. Finally, the SL cluster accounts for at least 30% of carless households in all age groups.

Overall, Fig. 7.20 shows that reliance on car, taxis and other private motorised means of transport is significantly higher for older people without cars. This trend is exactly opposite to that observed for the British population as a whole, where the modal share of car-like modes decreases for the oldest cohorts, because of lower motorisation. For carless individuals, by contrast, the modal share of the car and other private motorised modes of transport *increases* with age, and peaks for people over 70 (detailed figures are not reported here for the sake of brevity). At the same time, also individuals with the lowest mobility levels (IM cluster) are disproportionately concentrated among the elderly.

Fig. 7.21 shows the age distribution for the five cluster in the travel behaviour typology. It confirms that CR and IM are disproportionately composed by older people (more than 60% over 60 years old), while the age distribution for PTC is skewed towards young adults (16-29). The age distribution of the SL group is bimodal and can be considered as intermediate, with the age group '60 or more' accounting for less than half of the cluster.

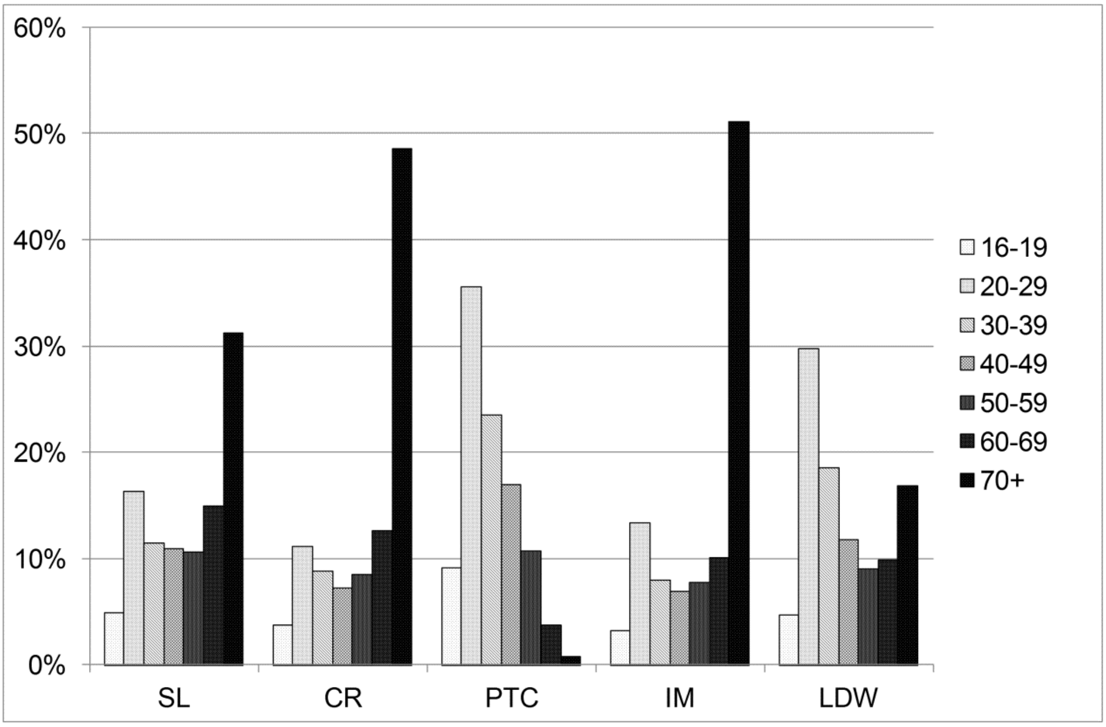


Fig. 7.21 – Age distribution for clusters in the travel behaviour typology. Unit of analysis: individuals. Source: own elaboration on NTS 2002-2010 data (diary sample).

In the remainder of this section, the five clusters are described with respect to variables in three key areas (the same used in §7.1.1 to illustrate systematic differences between households with and without cars): socio-demographics, mobility capital, accessibility to services and opportunities. The question here is: do differences in travel behaviour correspond to 'real' differences in such key areas? Throughout this discussion, differences between clusters in terms of age distribution and distribution across different types of area should be kept in mind, because they are likely to explain many of the differences observed.

Tab. 7.18 shows the composition of the clusters, with respect to six socio-demographic variables (the same illustrated in Tab. 7.2). The table highlights the exceptionality of the PTC cluster: in this cluster, many socio-demographic groups that are underrepresented among the carless as a whole are, by contrast, *overrepresented*. The share of households with two members or more is here over 80%, while it is lower than 60% for all other groups (except LDW). Similarly, this is the only cluster where households with children (46%) and non-retired households without children (52%) are overrepresented. Consistently with the high share of commuting trips, employed persons and students are also overrepresented, accounting for 90% of the cluster. People in the third or higher income quintiles are also less underrepresented here than in other clusters, and account for virtually 50% of individuals. This is also the cluster with the gender distribution most similar to the sample as a whole. Finally, non-whites account for 25% of this cluster, something that is probably related to its concentration in large urban areas (where ethnic diversity is greater).

		1 - SL	2 - CR	3 - PTC	4 - IM	5 - LDW	Households without cars	Total (NTS 2002-2010 sample)
Household size	**1**	40.9	53.9	18.1	46.5	38.0	39.0	14.6
	2	32.4	27.4	32.1	30.1	35.3	31.2	36.5
	3	12.8	9.4	20.9	10.4	13.7	13.7	19.4
	4 or more	13.9	9.3	28.9	12.1	13.0	16.1	29.5
	Total	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*
Household structure	**1 or 2 adults youngest child 0-15**	19.5	16.1	30.9	10.2	14.4	20.3	29.7
	Family adult child(ren)	11.2	8.5	15.6	12.6	9.2	11.5	19.6
	Pensioner household	40.6	55.9	1.8	53.2	23.5	35.4	19.3
	Other household	28.7	19.5	51.7	24.0	52.8	32.8	31.4
	Total	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*
Income quintile[235]	**Lowest**	48.3	41.9	28.9	42.7	27.6	40.8	17.8
	Second	28.6	32.7	21.7	30.7	21.1	27.7	19.0
	Third	11.5	14.5	19.7	14.2	17.3	14.6	21.5
	Fourth	6.6	7.0	16.4	6.7	14.9	9.4	21.7
	Highest	5.0	3.9	13.2	5.7	19.1	7.5	19.9
	Total	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*
Gender	**Female**	59.1	71.5	49.0	59.0	52.6	59.3	48.5
	Male	40.9	28.5	51.0	41.0	47.4	40.7	51.5
	Total	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*
Employment status[236]	**Employed**	17.0	16.1	78.7	13.6	54.6	32.7	59.9
	Unemployed[237]	8.1	3.8	2.6	3.7	3.8	5.3	2.6
	Student	5.3	2.1	11.4	4.3	7.6	6.0	4.4
	Retired / other	69.6	78.0	7.3	78.4	34.0	56.0	33.1
	Total	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*
Ethnic group	**Non-white**	12.5	5.4	25.4	12.1	13.9	13.8	91.3
	White	87.5	94.6	74.6	87.9	86.1	86.2	8.7
	Total	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*

Tab. 7.18 – Distribution of key socio-demographic variables for clusters in the carless individuals typology (percentage values[238]). Unit of analysis: individuals over 15. Source: own elaboration on NTS 2002-2010 data (diary sample).

The opposite is true for the CR and IM clusters: here all socio-demographic characteristics that are positively associated with non-car ownership in the whole sample (see §7.1.1), are overrepresented: single-person households, retired people (accounting for approximately 78% in both groups) and households in the two lowest income quintiles (73-75%). Females, by contrast, are overrepresented only in the CR cluster. Overall, the socio-demographic profile of the CR and IM clusters is explained by their age distribution, strongly skewed towards older people past the retirement age.

The SL group has a socio-demographic profile that is similar to that of CR and IM, but it is less strongly concentrated among single-person and pensioner households. By contrast, this is the poorest cluster (77% in the bottom 40% of the income distribution), and the only one where the unemployed are overrepresented (8%).

[235] Unlike in previous tables, I use here the 'diary sample' version of the 'real household income quintile' variable (see §C.2.1).

[236] Unlike Tab. 7.2, I use the 'employment status' variable here (instead of 'working status'), because the latter is available only for the HRP in NTS 2002-2010.

[237] The NTS uses the International Labour Organization (ILO) definition of unemployment.

[238] All row and column variables in Tab. 7.18 are significantly associated at the 5% level (chi-square tests).

		1 - SL	2 - CR	3 - PTC	4 - IM	5 - LDW	Households without cars	Total (NTS 2002-2010 sample)
Access to car as driver	**Yes**	19.0	17.4	27.6	18.5	38.6	21.7	70.3
	No	81.0	82.6	72.4	81.5	61.4	78.3	29.7
	Total	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*
Driving licence	**Yes**	29.5	27.8	48.8	24.8	54.7	34.6	77.4
	No	70.5	72.2	51.2	75.2	45.3	65.4	22.6
	Total	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*
Own or use a bicycle	**Yes**	16.8	12.5	24.5	8.9	28.0	17.6	36.4
	No	83.2	87.5	75.5	91.1	72.0	82.4	63.6
	Total	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*
Ticket holding (public transport)	**OAP pass / season ticket**	48.1	45.2	33.5	32.4	41.8	42.5	22.8
	Other / no pass	51.9	54.8	66.5	67.6	58.2	57.5	77.2
	Total	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*
Mobility difficulties – Car	**Yes**	9.1	22.9	0.9	31.5	6.0	11.9	5.5
	No	90.9	77.1	99.1	68.5	94.0	88.1	94.5
	Total	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*
Mobility difficulties – Foot and/or Bus	**Yes**	21.4	45.2	2.8	50.9	10.8	24.1	87.9
	No	78.6	54.8	97.2	49.1	89.2	75.9	12.1
	Total	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*
Special transport services available[239]	**0**	21.3	18.9	28.4	27.8	20.3	21.6	21.9
	1	34.2	35.3	32.9	37.4	30.5	35.0	32.4
	2 or more	44.6	45.8	38.7	34.8	49.2	43.4	45.6
	Total	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*

Tab. 7.19 – Mobility capital indicators for clusters in the carless individuals typology (percentage values[240]). Unit of analysis: individuals over 15. Source: own elaboration on NTS 2002-2010 data (diary sample).

Tab. 7.19 shows the frequency distributions for some indicators of mobility capital (the same as in Tab. 7.4) for the five-clusters typology. Tab. 7.20 does the same for indicators of public transport service (the same as in Tab. 7.5). Taken together, the tables confirm the exceptional status of the PTC cluster: despite reporting a low modal share for ‘car as driver’ (less than 1 trip in 100, see Tab. 7.16), this is the group with the largest ‘car-related’ mobility capital, as attested by the high share of licensed drivers (49%). 28% of individuals in this cluster (more than all other clusters except LDW) report that they usually have access to a car as a driver. Interestingly, this group includes a substantial number of people who, *despite* car availability, use mostly other modes. PTC individuals are also the most likely to own or use a bicycle, and the incidence of mobility difficulties is here lowest. Ticket holding is higher for both the CR and the SL cluster, but this is probably related to the fact that the indicator does not distinguish ‘Old Age Pensioner’ passes from other season tickets. In terms of access to public transport (Tab. 7.20), all indicators consistently show that the PCT cluster enjoys on average the best service, as compared to other clusters[241]. This is probably related to its concentration in large urban areas (notably London), where public transport service is generally better.

By contrast, CR and IM clusters have the worst performance on most mobility capital indicators. Notably, a substantial proportion of people in these clusters reports mobility difficulties with different transport modes: this is clearly related to the concentration of these clusters among older people. Tab. 7.20 shows that people in the CR and IM clusters systematically report the worst levels of public transport service: this is probably related to the fact that, unlike other clusters, they are not concentrated in large urban areas, and thus also

239 The question was asked only of respondents with “disability or long standing health problem that makes it difficult to go out on foot, use a local bus or get in or out of a car” (Rofique et al., 2011, p. 79).

240 All row and column variables in Tab. 7.19 are significantly associated at the 5% level (Chi-square tests).

241 The exception here is the availability of specialist transport services (Tab. 7.19), but this indicator was computed based on the answer of the very small number of individuals in the PCT cluster who reported mobility difficulties.

include a substantial share of individuals living in low-density, peripheral areas. The exception here is the availability of special transport services, that is slightly above average for the CR cluster (but not for IM).

			1 - SL	2 - CR	3 - PTC	4 - IM	5 - LDW	Households without cars	Total (NTS 2002-2010 sample)
Bus	**Walk time to stop**	**6 minutes or less**	88.7	84.1	92.1	85.6	89.6	88.2	86.5
		7 minutes or more	11.3	15.9	7.9	14.4	10.4	11.8	13.5
		Total	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*
	Frequency	**At least 1 every half hour**	88.9	79.6	93.7	82.6	85.8	87.1	74.8
		Less than 1 every half hour	11.1	20.4	6.3	17.4	14.2	12.9	25.2
		Total	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*
Railway	**Time to station (by foot or bus)**	**13 minutes or less**	44.3	34.9	52.7	39.4	48.8	43.9	36.3
		14 minutes or more	55.7	65.1	47.3	60.6	51.2	56.1	66.7
		Total	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*
	Frequency	**Frequent service all day**	91.4	89.3	92.4	90.1	91.6	91.0	89.0
		Frequent service rush hour only / less	8.6	10.7	7.6	9.9	8.4	9.0	11.0
		Total	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*
	Rail/metro/tram stop closer than railway	**Yes**	16.5	8.5	24.5	15.0	14.4	16.2	8.8
		No	83.5	91.5	75.5	85.0	85.6	83.8	91.2
		Total	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*

Tab. 7.20 – Public transport access indicators for clusters in the carless individuals typology (percentage values[242]). Unit of analysis: individuals over 15. Source: own elaboration on NTS 2002—2010 data (diary sample).

With regard to the SL cluster, the mobility capital profile is intermediate between PCT, on one hand, and CR and IM, on the other. Most indicators in Tab. 7.19 are below average for SL, even though the incidence of mobility difficulties is much lower than for CR and IM, and access to specialist services is above average. This is probably explained by the substantial proportion of older people in these cluster. By contrast, Tab. 7.20 shows that the score of SL on most indicators of public transport services is above average, even though lower than PCT. This is probably a by-product of the concentration of this group in large urban areas.

The same reason probably explains why PCT and SL clusters perform better than CR and IM on all indicators of accessibility to essential services and opportunities by foot or public transport, as illustrated in

242 All row and column variables in Tab. 7.20 are significantly associated at the 5% level (chi-square tests).

Tab. 7.21[243]. The accessibility disadvantage for the CR and IM clusters is particularly apparent for the hospital, with respectively 65% and 58% of individuals unable to reach it in less than 20 minutes. This is particularly problematic for older people in these clusters, given the association between age and health problems.

"How long would it take (me) to get to the nearest (X) (even if it is not the one you use) on foot or by public transport using whichever is the quickest?"[244]		**1 - SL**	**2 - CR**	**3 - PTC**	**4 - IM**	**5 - LDW**	**Households without cars**	**Total (NTS 2005-2010 sample)**
General Practitioner	**15 min or less**	85.1	80.9	89.1	79.0	85.8	84.7	78.8
	Over 15 min	14.9	19.1	10.9	19.0	14.2	15.3	21.2
	Total	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*
Chemist	**15 min or less**	91.8	84.9	94.7	86.3	89.9	90.4	83.1
	Over 15 min	8.2	15.1	5.3	13.7	10.1	9.6	16.9
	Total	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*
Hospital	**20 min or less**	43.8	35.2	52.1	41.7	48.3	43.7	36.3
	Over 20 min	56.2	64.8	47.9	58.3	51.7	56.3	63.8
	Total	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*
Shopping centre	**15 min or less**	66.9	58.5	69.7	62.2	64.9	65.1	53.9
	Over 15 min	33.1	41.5	30.3	37.8	35.1	34.9	46.1
	Total	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*
Grocer	**15 min or less**	97.0	94.3	97.3	94.5	96.2	96.2	92.6
	Over 15 min	3.0	5.7	2.7	5.5	3.8	3.8	7.4
	Total	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*
Post office	**15 min or less**	90.4	85.6	93.7	86.9	92.0	89.9	85.2
	Over 15 min	9.6	14.4	6.3	13.1	8.0	10.1	14.8
	Total	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*

Tab. 7.21 – Journey time to essential services and opportunities for clusters in the carless individuals typology (percentage values[245]). Unit of analysis: individuals over 15. Source: own elaboration on NTS 2005—2010 data (diary sample).

Tab. 7.22 shows frequency distributions for indicators of travel difficulties in accessing key services and opportunities, for the different clusters. While all clusters perform worse than the NTS sample average (with the only exception of 'travelling to doctors / hospital' for the PTC cluster), the table confirms that this accessibility disadvantage is worse for individuals in the CR and IM clusters: 30-33% of individuals in these clusters report travel difficulties with at least one destination listed in the table. This figure is significantly lower for people in the SL and PTC clusters, probably as a result of their concentration in large urban areas.

243 Unlike Tab. 7.7 , Tab. 7.21 does not report figures for access to schools, because the number observations is too low, given the low share of households with children in most clusters.

244 All 'journey time' variables in Tab. 7.21 were asked in this form only from 2005 onwards. However, some of them were asked on alternate years, or to subsamples. Therefore, the reference sample is different between variables. For details see §C.2.4. The analysis of similar variables for previous waves (2002-2004) shows similar results (not reported here for the sake of brevity).

245 All row and column variables in Tab. 7.21 are significantly associated at least at the 5% level (chi-square tests).

Travel difficulties[246]	1 - SL	2 - CR	3 - PTC	4 - IM	5 - LDW	Households without cars	Total (NTS 2002-2008 sample)
Travelling to doctor / hospital	13.2	21.4	6.6	26.5	8.6	14.4	7.9
Visiting friends / relatives at their home	11.2	16.4	9.6	21.7	14.5	13.1	6.9
Travelling to other social activities, including taking children	6.4	11.4	5.6	16.6	9.1	8.4	4.5
Taking the children to school[247]	4.4	4.6	5.2	3.5	5.0	4.7	4.1
Travelling for any other reason[248]	1.5	2.5	1.3	3.4	2.3	1.9	1.4
No difficulties with any of these	77.5	70.4	81.4	67.7	76.1	75.9	84.2

Tab. 7.22 – Travel difficulties for clusters in the carless individuals typology (percentage values[249]). Unit of analysis: individuals over 15. Source: own elaboration on NTS 2002—2008 data (diary sample).

To sum up then, descriptive analysis indicates that there are three main models of non-car ownership. The first (clusters CR and IM) is associated mainly with old age, retirement and mobility difficulties: carless individuals in this macro-group have low levels of mobility capital, and tend to make fewer trips; accordingly, they either have extremely low levels of mobility (not detectable with a one-week travel diary) or they rely on others for car lifts (on which they probably depend for many important trips). When they do so, they end up covering great distances as car passengers, even though trip rates and travel time are still lower than other clusters. This macro-group is best conceived as the hard-core of the carless, and represents about the same share of the total population across types of area: it seems to be more associated with socio-demographic characteristics (old age, mobility difficulties, etc.) than with attributes of the local area. It is an interesting case in that it shows how also non-drivers (more than 60% do not have a driving licence) can be extremely dependent on the automobile for their daily activities. Crucially, the sum of these two contrasting factors (lack of car availability and driving licence but difficulties in using modal alternatives) 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 model is that of the ‘commuters’ in the PTC cluster: younger and more varied in terms of socio-demographics, it includes most carless who are employed or in education. People in this cluster have on average a higher mobility capital and access to public transport, and tend to spend quite a lot of time travelling to and from work (or school/university), mostly with public transport. This is partly the result of the fact that the PCT cluster is concentrated in large cities and metropolitan areas, where public transport service is better. From a transport and social exclusion perspective, even though PCT individuals might seem better off than other carless, it would be unwise to conclude that they do not experience any kind of disadvantage: in fact, they spend a great amount of time travelling and they do not seem to travel much for reasons other than work or education. This might suggest that the lack of a household car results in longer commuting times (than would be otherwise), and the resulting ‘time poverty’ might lead people to miss out activities that are essential for participation in society, and thus to social exclusion. Further research is probably required to explore this point more in depth.

Between these two “extreme” profiles there is a third one, actually accounting for the relative majority of carless households: ‘slow and local’ (SL) carless individuals. They are characterized by rather high levels of

[246] All questions in Tab. 7.22 were asked only to individuals over 15 in the waves 2002-2008.

[247] For this answer category, the percentages refer to the subsample of individuals living in households including at least one child under 16. The chi-square test shows that the row and column variables are not significantly associated at the 5% level (P = 0.7535).

[248] Unlike Tab. 7.8, Tab. 7.22 does not report figures for ‘travelling to school / college / university’ because the number observations is too low, given the low share of students in most clusters. However, it should be noted that the variables ‘travelling for any other reasons’ and ‘no difficulties with any of these’ implicitly refer also to these activities.

[249] All row and column variables in Tab. 7.22 are significantly associated at the 5% level (chi-square tests) unless where otherwise noted. As this was a multiple choice battery, and the percentages reported in the table refer to different subsamples, the values do not add up to 100%.

mobility (at least in terms of time and trips), but also by reliance on 'slow' modes of travel and by short travel distances. From a socio-demographic point of view the cluster exhibits a profile that is intermediate between the previous groups, even though it is the cluster that is most concentrated among the low-income households. However, in terms of accessibility to public transport and services and opportunities, the SL cluster is much more similar to the PTC group, probably because it is also relatively concentrated in large urban areas.

Overall, the results of the cluster analysis and of the descriptive analysis of the clusters corroborate hypothesis H1.3, and its updated version put forward at the beginning of this section (Fig. 7.18). Non-car ownership in peripheral, low-density areas is associated with lower mobility levels *but also* with greater reliance with motorised private transport modes. This, in turn, is at least in part a by-product of the greater concentration of carless households among marginal social groups in low-density areas. As the degree of urbanity increases, the carless households group becomes more diverse in terms of travel behaviour, including an increasing share of public transport commuters and other users of modal alternatives. These groups are also more mobile, thus reducing the mobility-gap between individuals in households with and without cars (see Fig. 7.17).

Moreover, these results suggest that also in the British case, the carless group can be described as the mixture of a 'clustered' and a 'scattered' form of non-car ownership[250]. The first (including clusters PTC and SL) is defined by the ability to undertake autonomous travel using *modal alternatives* to the car (active travel in the local area or public transport for longer distances). For this reason, I define these clusters collectively as 'Alternative Modes' clusters (AM). I explain the positive relationship between the degree of urbanity of the local area and the size of AM clusters with the lower intensity of car dependence in dense cities. The second form of non-car ownership (CR and IM) is *scattered*, as the size of the clusters does not vary much across different types of area. 'Non-Alternative Modes' clusters (NAM) are defined by the low use of modal alternatives to the car, as well as by lower levels of mobility (at least in terms of trips and travel time). They are also defined by old age and by related consequences in terms of mobility difficulties.

In order to test this hypothesis, I present here the results of a multinomial logistic regression model[251] (Tab. 7.23). As explained in §A.2, a multinomial logistic regression model consists of n-1 logistic regression models, where n is the number of categories of a variable with two outcomes or more. In this case, the outcome variable is the following household typology: 0 = household with cars; 1 = household without cars, AM cluster 2 = household without cars, NAM clusters.

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[250] As illustrated in Chapter 2, Hine and Grieco put forward the idea that trasnsport disadvantage takes the form of "scatters and clusters" (Grieco et al., 2000; Hine & Grieco, 2003). In this section, I borrow the notion of 'scatters vs. clusters' from Hine and Grieco, but I apply it to non-car ownership. With this, I do not mean to imply that lack of a household car necessarily entails transport disadvantage.

[251] In order to discuss a model as similar as possible to the logistic regression model for non-car ownership presented in §7.1.1, the analysis refers to households (instead of individuals). Households were assigned to the macro-cluster of the HRP; households with an HRP belonging to the LDW cluster have been either assigned to one of the two macro-clusters or considered as missing. Details about this operation are provided in §C.3.2. Since the multinomial logistic regression model includes two 'population density' predictors, the analysis is limited to the waves 2002-2008.

	1/0		2/0	
	Coef.	**Robust Std. Error**	**Coef.**	**Robust Std. Error**
No. of HH members	-1.197^{***}	(0.0452)	-1.537^{***}	(0.0537)
No. of HH members (squared)	0.116^{***}	(0.00680)	0.143^{***}	(0.00890)
No. of members under 16	0.0342	(0.0373)	0.293^{***}	(0.0595)
HRP female (dummy)	0.646^{***}	(0.0308)	1.136^{***}	(0.0390)
Age group of HRP (ref. cat. 16 – 29) 30 – 39	-0.776^{***}	(0.0573)	-0.845^{***}	(0.0852)
40 – 49	-0.895^{***}	(0.0583)	-1.123^{***}	(0.0900)
50 – 59	-1.116^{***}	(0.0608)	-1.276^{***}	(0.0894)
60 – 69	-1.412^{***}	(0.0637)	-1.382^{***}	(0.0876)
70 +	-0.931^{***}	(0.0616)	-0.384^{***}	(0.0812)
No. of employed members	-0.297^{***}	(0.0309)	-0.653^{***}	(0.0501)
Presence of member(s) with mobility difficulties (foot and/or bus) (dummy)	0.0707^{*}	(0.0351)	1.103^{***}	(0.0387)
HRP non-white (dummy)	0.285^{***}	(0.0610)	0.0980	(0.0955)
Real household income equivalent quintile[252]				
(ref.cat.: Lowest): Second	-0.465^{***}	(0.0377)	-0.414^{***}	(0.0438)
Third	-1.284^{***}	(0.0475)	-0.999^{***}	(0.0545)
Fourth	-1.873^{***}	(0.0559)	-1.462^{***}	(0.0749)
Highest	-2.371^{***}	(0.0642)	-1.866^{***}	(0.0861)
Region (ref. cat.: England) Wales	0.170^{*}	(0.0758)	0.316^{***}	(0.0797)
Scotland	0.567^{***}	(0.0517)	0.508^{***}	(0.0655)
Type of area (thousands of inhabitants) (ref. cat.: London Boroughs)				
Metropolitan built-up areas	0.241^{***}	(0.0718)	0.506^{***}	(0.0913)
Other urban over 250	0.0268	(0.0765)	0.269^{**}	(0.0968)
Urban over 25 to 250	0.108	(0.0791)	0.534^{***}	(0.0994)
Urban over 10 to 25	0.140	(0.0949)	0.680^{***}	(0.116)
Urban over 3 to 10	0.0497	(0.102)	0.617^{***}	(0.123)
Rural	-0.640^{***}	(0.109)	0.226	(0.123)
Population density – Local Authority (persons / hectare)	0.00809^{***}	(0.000957)	0.00847^{***}	(0.00119)
Population density - primary sampling unit (persons / hectare)	0.0164^{***}	(0.00149)	0.00758^{***}	(0.00194)
Walk time to bus stop: 7 minutes or more (dummy)	-0.149^{**}	(0.0460)	-0.0447	(0.0492)
Frequency of bus service: less than 1 every half hour (dummy)	-0.440^{***}	(0.0454)	-0.232^{***}	(0.0476)
Time to railway station (by quickest mode) (ref. cat.: 13 minutes or less): 14-26 minutes	-0.106^{**}	(0.0348)	-0.0337	(0.0430)
27 minutes or longer	-0.264^{***}	(0.0424)	-0.0900	(0.0494)
Type of railway station: frequent service rush hour only or less (dummy)	-0.154^{**}	(0.0538)	-0.0928	(0.0569)
Rail/metro/tram stop not closer than railway (dummy)	-0.329^{***}	(0.0607)	-0.323^{***}	(0.0738)
Survey year	-0.0196^{*}	(0.00820)	-0.0120	(0.00937)
(constant)	2.221^{***}	(0.172)	0.808^{***}	(0.211)
N	56,343			
McFadden's pseudo R^2	0.303			

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Tab. 7.23 – Multinomial logistic regression model for the probability of being in AM clusters, rather than owning cars (1/0) and the probability of being in NAM clusters, rather than owning cars (2/0) (logit coefficients and robust standard errors). Unit of analysis: households. Source: own elaboration on NTS 2002-2008 data (diary sample).

252 Unlike in other regression models, I use here the 'diary sample' version of the 'real household income quintile' variable (see §C.2.1).

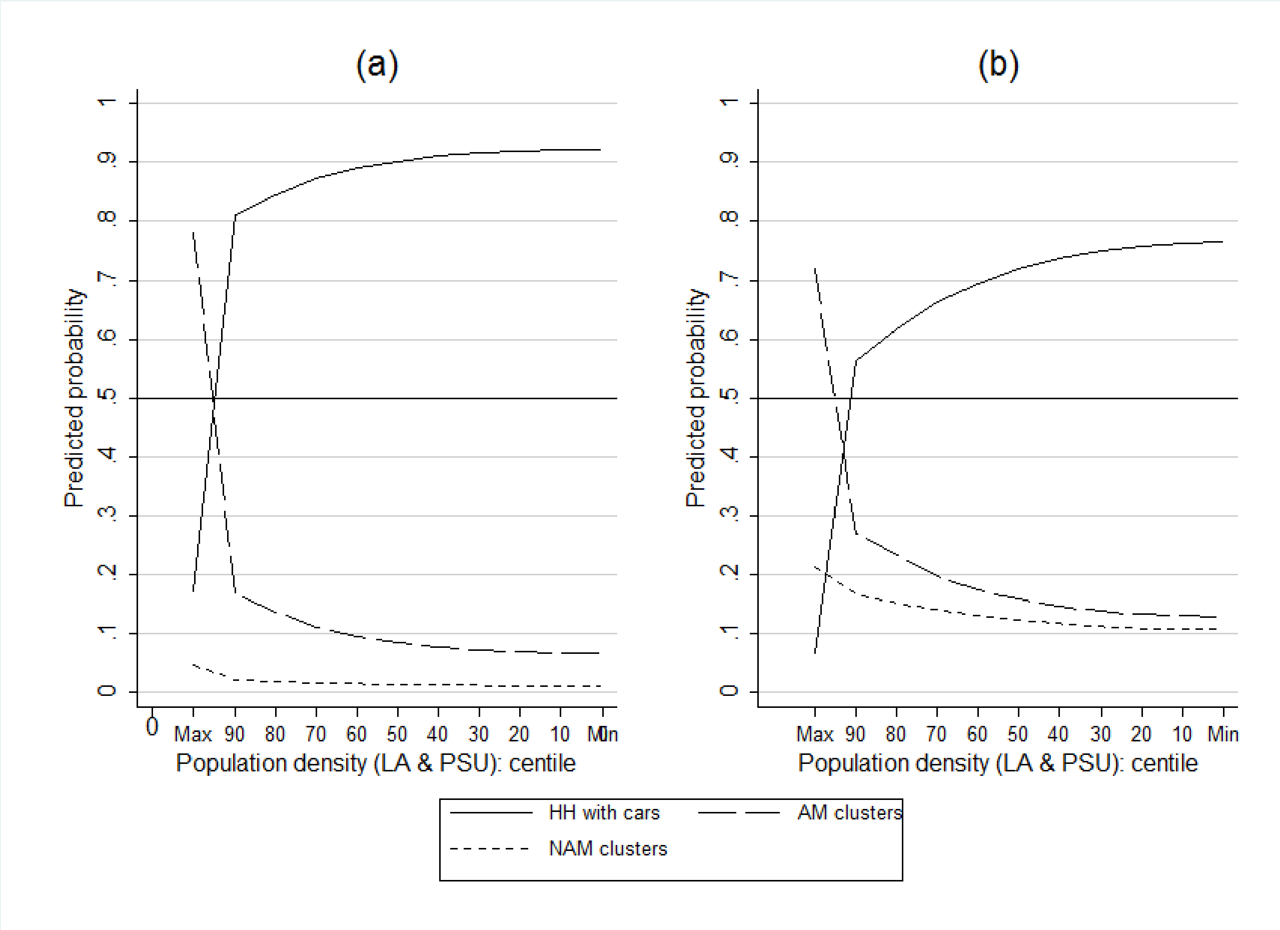

Fig. 7.22 – Predicted probabilities of owning cars, belonging to AM clusters and belonging to NAM clusters, by population density in the LA and PSU (joint distribution, centiles), for two socio-demographic profiles: (a) average British household (b) average household with at least one member reporting mobility difficulties (by foot / bus). The probabilities are predicted using the multinomial logistic regression model reported in Tab. 7.23. Unit of analysis: households. Source: own elaboration on NTS 2002-2008 data (diary sample).

The first column in Tab. 7.23 presents the logistic regression model for the probability of belonging to a AM cluster of carless households, rather than owning cars. The second column does the same for NAM clusters. The model fit is high (Mc Fadden's Pseudo-R^2=0,30), indicating that the model is a good representation of the data[253]. With regard to the question of interest, a superficial look at the coefficients reported in Tab. 7.23 might lead to the conclusion that the hypothesis is not confirmed: indeed, most logit coefficients associated with predictors in the 'territorial variables' subset are statistically significant. It is true that four 'public transport service predictors' are statistically significant in the first sub-model (AM clusters) but not in the second (NAM), but the opposite is true for a few coefficients for the 'type of area' predictor, and this *contradicts* expectations[254]. On the other hand, however, most logits for other predictors in the territorial variables subset (with the exception of 'region' and 'population density' in the LA) are of greater magnitude in the first model than in the second. However, logit coefficients are notoriously difficult to interpret, and might lead to wrong conclusions. For this reason, in Fig. 7.22 I show the probabilities predicted using the model in Tab. 7.23, for two socio-demographical profiles.

253 Further methodological details about the model are reported in §C.3.3.

254 However, in both cases the relationship between the predictor and the outcome is unclear, probably because population density and public transport service are controlled for.

The graph shows (on axis y), how the probabilities for the three outcomes (depicted with lines with different patterns) vary across different levels of the joint distribution of two 'population density' predictors (on axis x), ranging from maximum to minimum density[255]. Fig. 7.22a refers to an 'average' socio-demographic profile for the household, obtained by holding all variables not represented in the graph (including other territorial variables) at their mean or modal value in the diary sample. Fig. 7.22b refers to a household including at least one member with mobility difficulties (by foot and/or bus), with all other predictors held to their mean or modal values[256].

Fig. 7.22a shows that, for an average British household, the probability of belonging to NAM clusters is very low virtually everywhere, and it does not vary substantially across the population density scale. By contrast, the probability of belonging to AM clusters, which is higher everywhere, increases significantly in denser areas. This happens notably in the last decile of the population density distribution: for households in a maximum population density scenario, the probability of belonging to NAM clusters is very high (almost 0.8). Overall, this confirms that AM clusters represent a form of non-car ownership that is 'clustered' in the most dense areas (corresponding roughly to the top 10% of the population density distribution[257]).

In Fig. 7.22b the probabilities of belonging to AM and NAM clusters are higher, because the graph refers to the average household including at least one member with mobility difficulties. The curves are also closer to each other, suggesting that, in most areas, the probability of belonging to AM clusters is not substantially higher than that of belonging to NAM clusters. However, in the top decile of the population density distribution, the probability of belonging to NAM clusters sky-rockets, as observed in Fig. 7.22a, while the increases is much less pronounced for the other curve.

Overall, Fig. 7.22 confirms the hypothesis put forward above: in the British case, the carless group can be conceived as a mixture of a 'clustered' form of car ownership (concentrated at the top of the population density distribution) and 'scattered' form, that is much more associated with socio-demographic determinants of non-car ownership (old age, mobility difficulties, etc.) than with geographical attributes of the local area.

7.1.4. Accessibility to services and opportunities for carless households across different types of area

In §3.3.2 four specific hypotheses about the changing composition of the carless group across different types of areas have been put forward. The first and the third have been explored in the previous sections and concerned socio-demographics (§6.1.2) and travel behaviour (§7.1.3). The second, concerning reasons for not owning cars, is not explored for the British case, because the necessary variables are not available in NTS 2002-2010. The fourth hypothesis (H1.4) concerned accessibility, and posited that many carless individuals in low-density areas suffered from a significant lack of accessibility to services and opportunities, as compared to members of car-owning households. By contrast, I expect the carless group in inner cities to be more diverse, including a substantial proportion of individuals who enjoy good access to essential services and opportunities

In the previous section, a typology of carless individuals, based on their travel behaviour, has been proposed. The results of this analysis show that AM clusters report better accessibility to basic services and opportunities, as compared to NAM clusters. Since the proportion of carless households belonging to AM clusters is directly correlated with the degree of population density and urbanity, this could be taken as evidence in support of hypothesis H1.4.

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[255] Each 'tick' on axis x represents a decile in the joint distribution, and should be interpreted as follows: at 'max' both variables have the maximum value. At '90' both variables are held at their 90th percentile, and so on. Percentiles have been computed using the unweighted interview sample. However, the values are only slightly different from those that would be obtained using the weighted diary sample

[256] In detail, the presence of members with mobility difficulties is held constant to 'yes'. Other socio-demographic variables are held constant at their mean or modal values in the subsample of households including members with mobility difficulties. Other geographical variables are held constant at their mean or modal values in the diary sample.

[257] A similar graph plotting 'population density in the LA' on the x-axis (instead of the percentiles) would show a much more gradual decline in the probability of belonging to AM clusters, as one moves from maximum to minimum density. The graph presented here, however, has the merit to highlight the extent to which AM clusters are clustered at one extreme of the population density distribution.

"How long would it take (me) to get to the nearest (X) (even if it is not the one you use) on foot or by public transport using whichever is the quickest?"[258]		**Type of area (thousands of inhabitants)**							
		London Boroughs	**Met. built-up areas**	**Other urban 250+**	**Urban 25-250**	**Urban 10-25**	**Urban 3-10**	**Rural**	**Total**
General Practitioner (15 min or less)	**HH with cars**	90.6	83.4	*83.2*	79.1	*77.4*	*84.3*	52.1	77.3
	HH without cars	92.6	87.0	*85.1*	82.1	*77.5*	*86.2*	61.5	84.8
	AM	*92.8*	*87.2*	86.9	*82.2*	*79.7*	90.5	*64.4*	86.5
	NAM	*91.5*	*86.4*	81.2	*81.2*	*76.2*	81.7	*58.8*	80.9
Chemist (15 min or less)	**HH with cars**	*96.1*	90.7	90.0	85.9	*82.8*	87.5	44.5	81.4
	HH without cars	*96.8*	93.5	92.9	88.4	*83.8*	92.2	56.6	90.4
	AM	*97.3*	94.6	94.6	*89.1*	88.9	94.3	*62.2*	92.8
	NAM	*95.1*	90.3	88.6	*86.4*	81.2	89.5	*52.6*	85.3
Hospital (20 min or less)	**HH with cars**	51.6	40.1	35.4	*39.2*	*32.6*	*22.9*	*16.4*	34.5
	HH without cars	60.0	45.1	41.1	*41.5*	*33.9*	*22.8*	*19.8*	43.7
	AM	61.2	47.1	*42.3*	*42.4*	*35.2*	*24.5*	*20.7*	46.8
	NAM	53.4	37.7	*37.8*	*38.9*	*33.9*	*20.6*	*18.1*	36.8
Shopping centre (15 min or less)	**HH with cars**	62.7	62.2	51.9	58.7	63.5	38.5	*21.2*	51.2
	HH without cars	72.5	69.6	59.6	65.9	72.3	49.4	*25.1*	64.6
	AM	*73.8*	71.5	63.4	67.7	*75.4*	*51.6*	*26.1*	67.9
	NAM	*71.0*	66.7	54.9	62.6	*72.5*	*47.9*	*21.1*	59.4
Grocer (15 min or less)	**HH with cars**	*98.0*	*96.9*	95.5	95.9	95.8	*93.5*	70.2	91.7
	HH without cars	*97.7*	*97.6*	96.9	96.9	94.2	*95.7*	81.7	96.2
	AM	*97.9*	*97.9*	97.6	*97.3*	*95.7*	97.5	*84.0*	97.1
	NAM	*97.3*	*97.0*	95.5	*96.2*	*92.3*	93.2	*79.5*	94.3
Post office (15 min or less)	**HH with cars**	91.3	*90.3*	87.5	*84.4*	*86.6*	*89.9*	66.5	84.1
	HH without cars	94.8	*91.2*	91.8	*86.2*	*87.1*	*91.2*	76.3	89.9
	AM	95.8	92.5	93.2	*86.2*	90.8	*91.8*	*79.0*	91.6
	NAM	89.9	87.4	88.2	*85.4*	83.7	*89.4*	*74.7*	85.9

Tab. 7.24 – Journey time to essential services and opportunities for households with and without cars and for AM and NAM clusters of carless individuals (percentage values[259]). Unit of analysis: individuals over 15 . Source: own elaboration on NTS 2005—2010 data (diary sample).

[258] All 'journey time' variables in Tab. 7.24 were asked in this form only from 2005 onwards. However, some of them were asked on alternate years, or to subsamples. Therefore, the reference sample is different between variables. For details see §C.2.4.

[259] All differences between types of area in Tab. 7.24 are significantly associated at least at the 5% level (chi-square tests). All percentages refer to individuals over 15 in the diary sample only. All estimates were computed using samples of at least 100

However, this conclusion has some limitations: in fact, accessibility is correlated with population density and urbanity. Therefore, average values for the two macro-clusters might be just the by-product of their different territorial distribution (with AM clusters 'clustered' in dense cities, and NAM clusters 'scattered' across different types of area). If this is true, it would mean that, inside each type of area there is no difference between AR and NAR clusters, in terms of accessibility to essential services and opportunities.

It is therefore necessary to analyse the differences between AM and NAM clusters inside each type of area: this section focuses on this. Tab. 7.24 shows how the journey time necessary to reach key services and opportunities on foot or by public transport varies across different types of area. It shows this for individuals in households with and without cars and for AM and NAM clusters of carless households[260].

Three main conclusions can be drawn from Tab. 7.24:

- individuals in households without cars report on average shorter journey times than their motorised counterparts. This was illustrated previously in Tab. 7.7 (§7.1.1): Tab. 7.24 shows that it holds true even after controlling for type of area, even though in several occasions the difference is too small (and/or the number observations too low) to be statistically significant. However, this 'accessibility advantage' for the carless is only apparent, as individuals in households with cars might experience shorter journey times by car (not measured in the NTS survey), and this is likely to offset the gap
- broadly speaking, journey times increase as the degree of urbanity decreases, for all groups. However, there are a few exceptions in which the percentage of people experiencing short journey times increases for small cities, before declining again for rural areas (e.g. chemist, post office)
- with regard to differences between AM and NAM clusters, most differences are not statistically significant, probably because of the low number of observations. However, in all comparisons that are statistically significant AM clusters report shorter journey times than NAM clusters. This was illustrated previously in Tab. 7.21 (§7.1.3): Tab. 7.24 suggests that it holds true even after controlling for type of area. Therefore, I find no evidence in support of the hypothesis that differences observed between AM and NAM clusters in the sample as a whole are just the by-product of the different territorial distribution of the two groups

Taken together, these conclusions provide evidence in support of hypothesis H1.4. Journey times to key services and opportunities for individuals in carless households are longest in peripheral, low density areas, and this is due also to the fact that in these areas the carless group is more concentrated among NAM clusters, that in every area report worse accessibility than AM clusters (even though many differences are not statistically significant). This difference between the macro-clusters might be explained by the older age and the higher incidence of mobility difficulties (by foot and public transport) among individuals in NAM clusters. Difficulties in reaching services with alternative modes might in turn explain the high reliance on car lifts for the CR cluster and the absence of mobility during the survey week for the IM cluster. Conversely, the carless group in inner cities is more diverse, including a substantial proportion of individuals reporting better accessibility levels. In a nutshell, then, Tab. 7.24 suggests that the varying socio-demographic composition of the carless group is a key factor to explain how the accessibility levels reported by individuals without cars vary across different types of area.

Further support for these conclusions is provided by Tab. 7.25: it shows how the values for indicators of 'travel difficulties' to reach key services and opportunities varies across different types of area. It shows this for individuals in households with and without cars and for AM and NAM clusters of carless households.

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observations. Values for which the difference between households with and without cars (or between AM and NAM clusters) is not significant at the 5% level are written in italic and in a smaller font size.

[260] In Tab. 7.24 and Tab. 7.25, values for the LDW cluster are not reported.

Travel difficulties		London Boroughs	Met. built-up areas	Other urban 250+	Urban 25-250	Urban 10-25	Urban 3-10	Rural	Total
		Type of area (thousands of inhabitants)							
Travelling to doctor / hospital	HH with cars[261]	*6.0*	6.2	6.4	6.4	7.1	6.2	6.2	6.3
	HH without cars	*7.1*	13.7	14.9	15.7	19.5	19.3	28.5	14.4
	AM	5.7	10.7	11.7	12.6	15.4	12.7	*27.6*	10.8
	NAM	15.8	21.5	22.3	21.8	25.1	27.0	*31.4*	22.7
Visiting friends / relatives at their home	HH with cars	8.0	3.8	6.3	5.2	4.3	4.7	5.6	5.4
	HH without cars	10.3	11.5	14.8	13.7	14.6	14.8	19.6	13.1
	AM	9.7	8.5	12.2	11.5	12.6	10.1	15.3	10.6
	NAM	12.7	17.7	19.3	17.4	17.0	19.3	22.7	17.8
Travelling to other social activities, including taking children	HH with cars	4.7	2.7	3.5	3.2	2.9	3.6	4.4	3.5
	HH without cars	6.2	7.6	8.4	8.4	10.9	10.9	14.5	8.4
	AM	5.3	5.0	6.8	6.4	7.5	8.1	10.9	6.1
	NAM	10.1	13.3	11.4	11.7	14.2	14.5	17.5	12.7
Travelling for any other reason[262]	HH with cars	*1.5*	*1.1*	1.5	1.0	1.2	1.3	1.4	1.3
	HH without cars[263]	*1.6*	*1.6*	2.1	1.9	2.0	2.7	2.7	1.9
	AM[264]	*1.4*	1.1	1.6	*1.7*	1.2	*2.7*	1.2	1.5
	NAM[265]	*2.3*	2.8	2.9	*2.2*	3.0	*2.8*	3.9	2.7
No difficulties with any of these	HH with cars	83.9	87.3	84.8	86.6	86.3	86.9	86.8	86.1
	HH without cars	81.5	77.9	73.7	75.2	72.8	71.6	62.3	75.9
	AM	82.5	81.1	76.9	77.4	76.1	76.3	*63.0*	78.9
	NAM	77.3	70.7	67.9	71.2	69.0	66.1	*60.4*	69.8

Tab. 7.25 – Travel difficulties for households with and without cars and for AM and NAM clusters of carless individuals (percentage values[266]). Unit of analysis: individuals over 15. Source: own elaboration on NTS 2002-2008 data (diary sample).

[261] In this case, there is no statistically significant association between the travel difficulties variable and the type of area (chi-square test, P = 0.7445).

[262] Unlike Tab. 7.8, Tab. 7.25 does not report figures for 'taking the children to school' nor 'travelling to school / college / university' because the number observations is too low when different types of area are taken into account. However, it should be noted that the variables 'travelling for any other reasons' and 'no difficulties with any of these' implicitly refer also to these activities.

[263] In this case, there is no statistically significant association between the travel difficulties variable and the type of area (chi-square test, P = 0.1815).

[264] In this case, there is no statistically significant association between the travel difficulties variable and the type of area (chi-square test, P = 0.2917).

[265] In this case, there is no statistically significant association between the travel difficulties variable and the type of area (chi-square test, P = 0.5597).

[266] All row and column variables in Tab. 7.25 are significantly associated at the 5% level (chi-square tests) unless where otherwise noted. As this was a multiple choice battery, and the percentages reported in the table refer to different subsamples, the values do not add up to 100%. All percentages refer to individuals over 15 in the diary sample only. All estimates were computed using samples of at least 100 observations. Values for which the difference between households with and without cars (or between AM and NAM clusters) is not significant at the 5% level are written in italic and in a smaller font size.

Four main conclusions can be drawn from Tab. 7.25:

- individuals in households without cars are more likely to report travel difficulties than their motorised counterparts. This was illustrated previously in Tab. 7.8 (§7.1.1): Tab. 7.25 shows that it holds true even after controlling for type of area, even though in a few occasions the difference is too small (and/or the number observations too low) to be statistically significant. This contradicts the disadvantage observed for car-owning individuals in Tab. 7.24. I argue that the conclusion that there is an 'accessibility advantage' for individuals in car-owning households is more trustworthy, since travel difficulties items in Tab. 7.25 implicitly refer to all transport modes (car included).
- for most groups, the incidence of travel difficulties increases as the degree of urbanity decreases. The exception here is individuals in households with cars, for whom differences between types of area are small and trends often unclear: overall, the percentage of individuals reporting at least one travel difficulty is comprised between 13 and 16% in all types of area
- by contrast, for most indicators, the percentage of carless individuals reporting travel difficulties increases strongly as the degree of urbanity decreases: overall, the percentage of individuals reporting at least one travel difficulty varies between 18% (in London) and 38% (in rural areas). As a result, for most indicators the difference between individuals in households with and without cars is greatest in small cities and rural areas, and smallest in London
- for virtually all indicators, in virtually all types of areas NAM clusters report more travel difficulties than AM. This was illustrated previously in Tab. 7.22 (§7.1.3): Tab. 7.25 suggests that it holds true even after controlling for type of area. Therefore, I find no evidence in support of the hypothesis that differences observed for these indicators between AM and NAM clusters in the sample as a whole are merely the by-product of the different territorial distribution of the two groups

Taken together, these conclusions provide further evidence in support of hypothesis H1.4: the accessibility disadvantage of carless individuals increases in peripheral low-density areas: part of this, however, is due to the fact that in these areas carless households are more concentrated among NAM clusters, that in every area are more likely to report travel difficulties, probably because of old age and related mobility difficulties. In a nutshell, then, Tab. 7.25 confirms that the varying composition of the carless group is a key factor to explain how the accessibility levels reported by individuals without cars vary across different types of area[267].

7.1.5. Conclusions

In the previous sections (§7.1.2 to §7.1.4) three hypothesis related to Question 1 have been explored separately. In this final section, I review the empirical findings, highlighting the interrelationship between findings for the different hypothesis.

With regard to H1.1 (different socio-demographic composition of the carless group across different types of area), the hypothesis is corroborated by the British data. Descriptive analysis shows that the carless households group is significantly more concentrated among marginal groups in peripheral low-density areas. Odds ratios show that the association between non-car ownership and most of its socio-demographic determinants is considerably stronger in these areas too. Finally, the results of logistic regression models show that it is much easier to predict non-car ownership using socio-demographic variables in small municipalities, as compared with large cities. However, the values of the odds ratios also suggest that this is not true for ethnic group and (unlike what observed for the German case), probably less true for the lack of children in the household. This suggests that, in Britain, carless households in peripheral, low density areas are not more concentrated among households without young children, as compared to dense urban areas.

Overall, the hypothesis of varying socio-demographic composition of the carless group across different types of area is corroborated also by British data. The results of the regression analysis illustrated in §7.1.1 suggest a tentative explanation of *why* this happens. The analysis of the predicted probabilities illustrated in Fig. 7.3 and Fig. 7.4 shows that there exist two main conditions that make it very unlikely for households to

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[267] Of course, given the limitations of the accessibility variables used in this chapter (see §C.2.4) and the low number of observations for many cells in Tab. 7.24, this conclusion should be considered with care.

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. Secondly, there are also socio-demographic situations which make it very unlikely not to own cars: this is true for example for working couples with young children. For these households, on average, income and the spatial characteristics of the residential area are unlikely to make a difference to their propensity to join the ranks of the carless. My argument here is that *it is the interweaving of these two impeding conditions, one related to geography, the other to social practices* (see §1.4.1)*, 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 'female' 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, non-employment etc.. Similarly, for working households with children, simply living in a densely populated area is not a condition sufficient to induce non-car ownership; 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 process potentially explains the greater diversity of household without cars that is observed in large British cities.

With regard to H1.3 (different composition of the carless group across different types of area in terms of travel behaviour) and H1.4 (in terms of accessibility to services and opportunities) the empirical results corroborate the hypotheses. In peripheral, low density areas, carless households are considerably more concentrated among NAM clusters, that are less mobile and more likely to experience low levels of accessibility to essential services and opportunities, mostly because of reasons related to old age. Individuals in these clusters are also more likely to rely on car lifts or other private motorised modes of transport for their daily travel. Conversely, the large majority of the carless group in dense urban areas consists of AM clusters, characterised first and foremost by their intensive use of modal alternatives to the car (public transport, walking, etc.). These clusters also report levels of mobility and accessibility that are closer to those of individuals in car-owning households.

Considering the empirical results for hypothesis H1.3 and H1.4 in light of the findings for the other two hypothesis, it is possible to put forward a simple theoretical scheme to explain why travel behaviour and accessibility for carless households vary across different types of area (Fig. 7.23). As illustrated in the graph, higher levels of car dependence in peripheral, low density areas have both *direct* and *indirect* effects on the levels of mobility and accessibility for carless households. The direct effect is that, since it is more difficult to access services and opportunities without a car, carless households experience lower levels of accessibility, even when all other factors are equal. Accordingly, they also limit their own mobility (in terms of trips and travel distance), especially with alternative travel modes, while the share of travel that they make as car passengers, by taxi or with other private motorised means of transport increases. The indirect effect is the following: non-car ownership in car dependent areas is disproportionately concentrated among NAM clusters, characterized by old age and high incidence of mobility difficulties. For the same reasons, individuals in these clusters are, in every type of area, less mobile, more reliant on the car (§7.1.3) and more likely to experience lower levels of accessibility (§7.1.4). To sum up, then, the low levels of mobility and accessibility observed for carless households in peripheral, low density areas are the result of higher levels of car dependence *and* of a different composition of the carless household group which, in turn, is also the result of higher levels of car dependence.

Overall, the empirical evidence for the three hypotheses suggests that the composition of the carless group in dense urban areas is more diverse in terms of socio-demographics, travel behaviour and accessibility, as compared to peripheral, low density areas. This can be explained as follows: as in inner cities it is much easier to access services and opportunities with alternative modes, carless living is here not confined to the elderly, but it is an option also for households who, in other types of area, are quite unlikely to be carless. In that sense, evidence for the British case strengthens the hypothesis that the composition of the carless group is a good indicator for the level of car dependence of a local area.

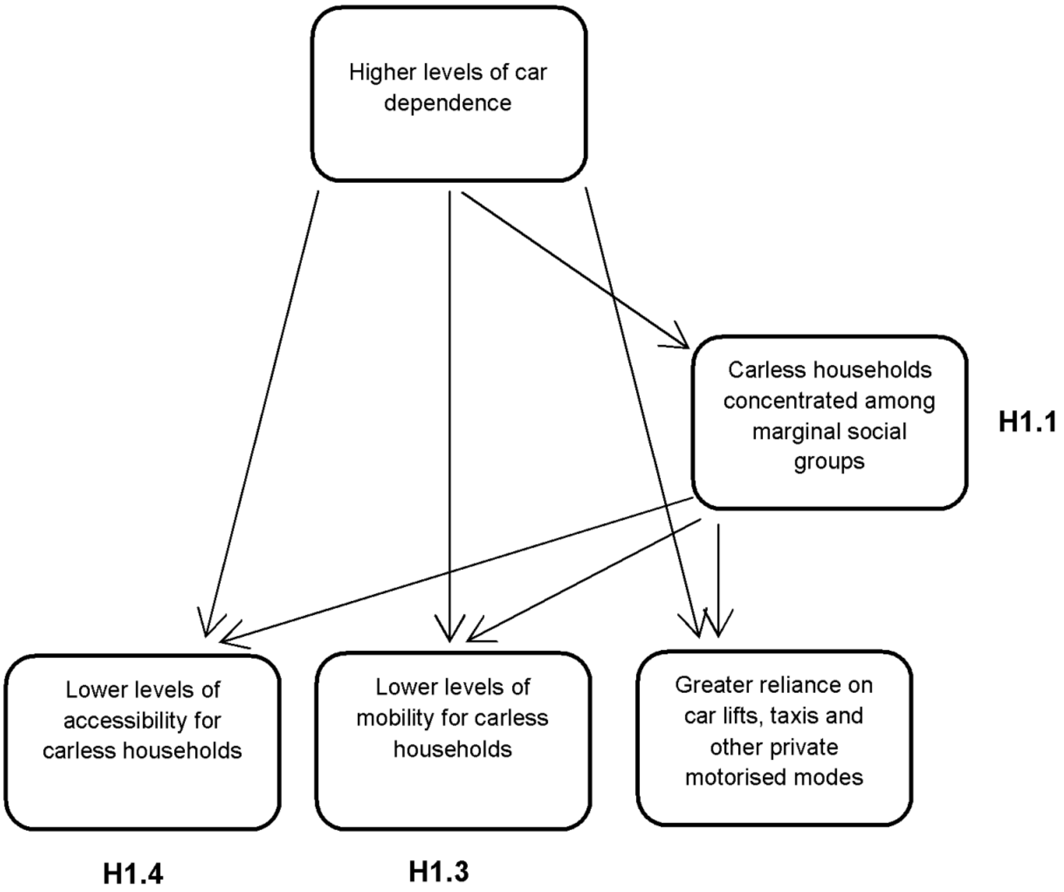

Fig. 7.23 – Diagrammatical representation of the relationships between car dependence, socio-demographic composition of the carless households group and mobility and accessibility levels. Source: own elaboration.

7.2. Question 2

This section illustrates the empirical results for Question 2: the focus is therefore on how the socio-demographic composition of the group of households without cars has changed in Great Britain in the period 2002-2010. Occasionally, I will also show figures for the period 1995-2001. The section is structured as follows: section §7.2.1 focuses on the empirical results, and the theoretical conclusions are presented in §7.2.2.

7.2.1. Empirical results

As illustrated in §3.3.3, Question 2 focuses on trends in the socio-demographic composition of the carless group over time, and notably how they vary across different types of area. Notably, I have put forward two alternative hypotheses: according to H2.1, over time the carless households group becomes more concentrated among marginal social groups, notably in peripheral, low density areas. According to H2.2, in recent years the composition of the carless households group has changed, with an increasing proportion of younger adults offsetting a decrease in the proportion of older households.

Tab. 7.26 shows the distribution of the NTS 2002-2010 sample in terms of household car ownership, by survey year. It shows that the percentage of carless households has decreased, in terms of households and individuals. While in 2002 26.8% of households, accounting for 19.7% of individuals, did not own cars, the corresponding figures were 25.1% and 19.0% in 2010. Although the decrease is small (around 1-2 percentage points), it is statistically significant according to chi-square tests[268] ($p<0.05$). Overall, this corresponds to a percent reduction of 6% (in terms of households) over 8 years (-4% if individuals are considered).

	No. of household cars	***2002***	***2003***	***2004***	***2005***	***2006***	***2007***	***2008***	***2009***	***2010***
Households	**0**	26.8	26.8	25.9	25.0	24.6	25.4	24.9	25.3	25.1
	1	44.3	42.5	43.8	42.8	43.6	42.6	42.9	42.8	42.2
	2	24.2	25.6	25.5	26.5	26.0	26.2	26.2	25.9	26.0
	More than 2	4.6	5.0	4.8	5.7	5.9	5.8	5.9	6.0	6.7
	Total	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*
Individuals	**0**	19.7	19.7	19.1	18.3	18.1	18.6	18.1	18.9	19.0
	1	42.9	40.5	41.6	40.4	40.8	40.0	40.2	40.1	38.6
	2	30.5	32.4	32.05	32.5	32.5	32.5	32.6	32.0	32.2
	More than 2	6.9	7.4	7.3	8.8	8.6	8.9	9.1	9.0	10.1
	Total	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*

Tab. 7.26 – Number of household cars, by year of survey (percentage values). Unit of analysis: households, individuals. Source, own elaboration on NTS 2002-2010 data (interview sample).

These figures are consistent with the historical trend towards increasing motorisation during the last decades, as illustrated in Fig. 7.24. The graph shows that the share of households without cars has declined in Great Britain since the mid 1980s: however, it is apparent that the last five years (2005-2010) are the longest period of stability in the last 25 years. This is consistent with the results of studies carried out in Britain and in other industrialized countries, showing that in recent years, the historical trends towards more car ownership, car use and travel distance have slowed down and even come to a halt (§1.1.4, §5.2.1).

As illustrated in §5.2.1, in the last few decades the trend towards increasing motorisation has been faster in rural areas, as compared to large cities (notably London), leading to a widening gap in motorisation levels between areas. This trend is apparent also in the NTS 2002-2010 database (Tab. 7.27): while the detailed results vary depending on the variable used, it appears that while in peripheral, low density areas non-car ownership is still decreasing, the same cannot be said for the dense areas in core cities.

[268] As illustrated in §C.1.2, since 2002 the annual NTS sample is clustered in 684 (or 683, depending on the year) primary sampling units, corresponding to postcode sectors in Great Britain (Rofique et al., 2011, p. 6-12). PSUs are stratified "using a a regional variable, car ownership and population density" (p.7). However, the regional stratification variable is not available in the NTS 2002-2010. For this reason, in all multivariate analysis and statistical tests in this chapter, I have taken into account case weighting and sample clusterization, but not the stratification of PSU into strata. Since taking into account stratification reduces the standard errors associated with the estimates (while taking into account the clusterization into PSUs increases them) this implies an increased risk of false acceptance of the null hypothesis (that there is no difference in the population). This problem is particularly significant in this section because, as illustrated in §C.1.2, the NTS 2002-2010 has a quasi-panel sample design, whereby each year half of the primary sampling units from the previous year are retained, while the other half is extracted again. As a result, when confronting two subsequent waves, up to 50% of the cases are extracted in different PSUs. Therefore, taking into account clusterization but not stratification results in huge standard errors: indeed, preliminary analysis shows that the large majority of chi-square tests involving survey year and another variable made this way result in acceptance of the null hypothesis (that there is no difference between waves). For this reason, in this section chi-square tests do not take into account the clusterization of cases into PSUs: this results in a reduction in the standard errors of the estimates.

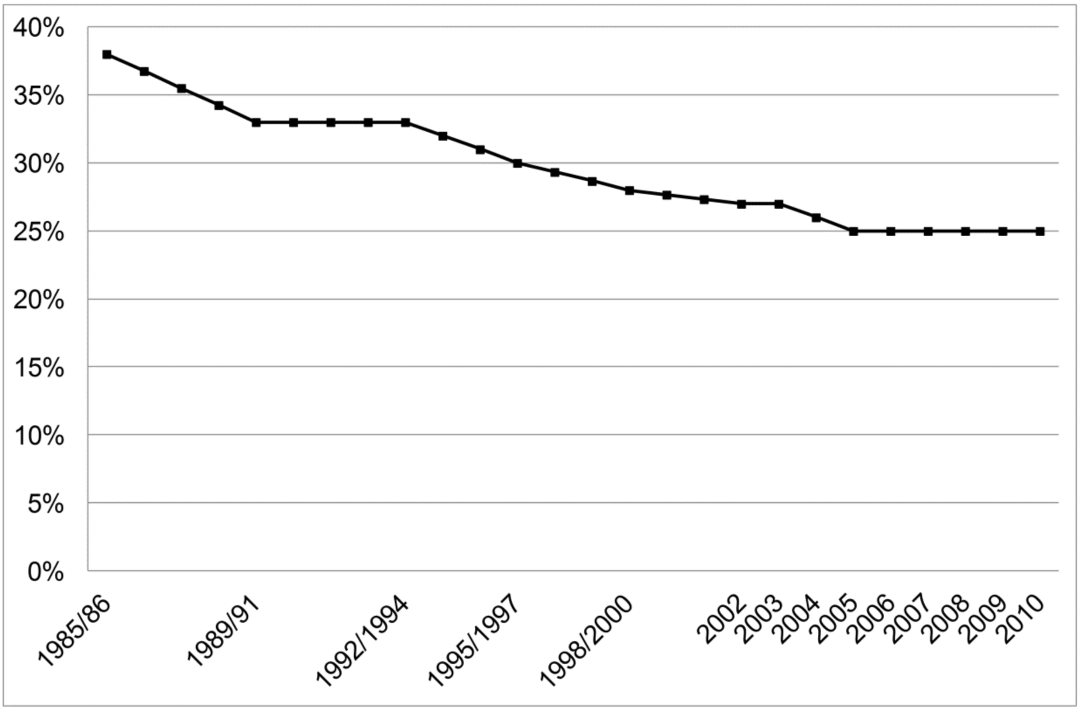

Fig. 7.24 – Households without cars in Great Britain, 1985-2010 (percentage values). Unit of analysis: households. Sources: Department for Transport (2004f, p. 4) for the years 1985-2001; own elaboration on NTS 2002-2010 data (interview sample) for subsequent years.

		2002	2003	2004	2005	2006	2007	2008	2009	2010	*Percent change*
Type of area (thousands of inhabitants)	**London**	39.5	41.4	.4188	38.9	37.6	42.7	43.1	42.1	43.2	
	Met. Built-up areas	34.9	35.0	33.4	32.3	31.4	31.2	32.4	33.0	31.2	
	Urban 25+	26.9	25.2	24.2	24.6	23.9	24.7	23.8	25.6	23.8	*-12%*
	Other	17.3	19.0	18.4	16.6	16.2	15.5	14.9	13.6	15.6	*-10%*
Population density, LA (persons / hectare)	**20+**	35.6	37.8	36.5	34.6	33.5	36.6	37.7	-	-	*+6%*
	5-20	28.1	24.7	24.1	23.1	23.2	24.0	22.2	-	-	*-21%*
	less than 5	18.3	20.0	18.5	18.6	17.8	17.9	17.7	-	-	
Population density, PSU (persons / hectare)	**35+**	37.7	37.9	39.1	37.1	36.3	38.3	37.2	-	-	
	5-35	26.3	25.6	23.0	23.7	23.8	23.5	23.3	-	-	*-11%*
	less than 5	14.9	16.7	16.8	15.0	13.8	14.6	13.6	-	-	*-9%*

Tab. 7.27 – Households without cars across different types of area, 2002-2010 (percentage values and percent change[269]). Unit of analysis: households. Source: own elaboration on NTS 2002-2010 data (interview sample).

[269] All differences between waves in Tab. 7.27 are significantly associated at the p<0.05 level (chi-square tests), except where the value of the percent change is not reported. In order to have a healthy number of observations in each cell, the geographical variables have been recoded.

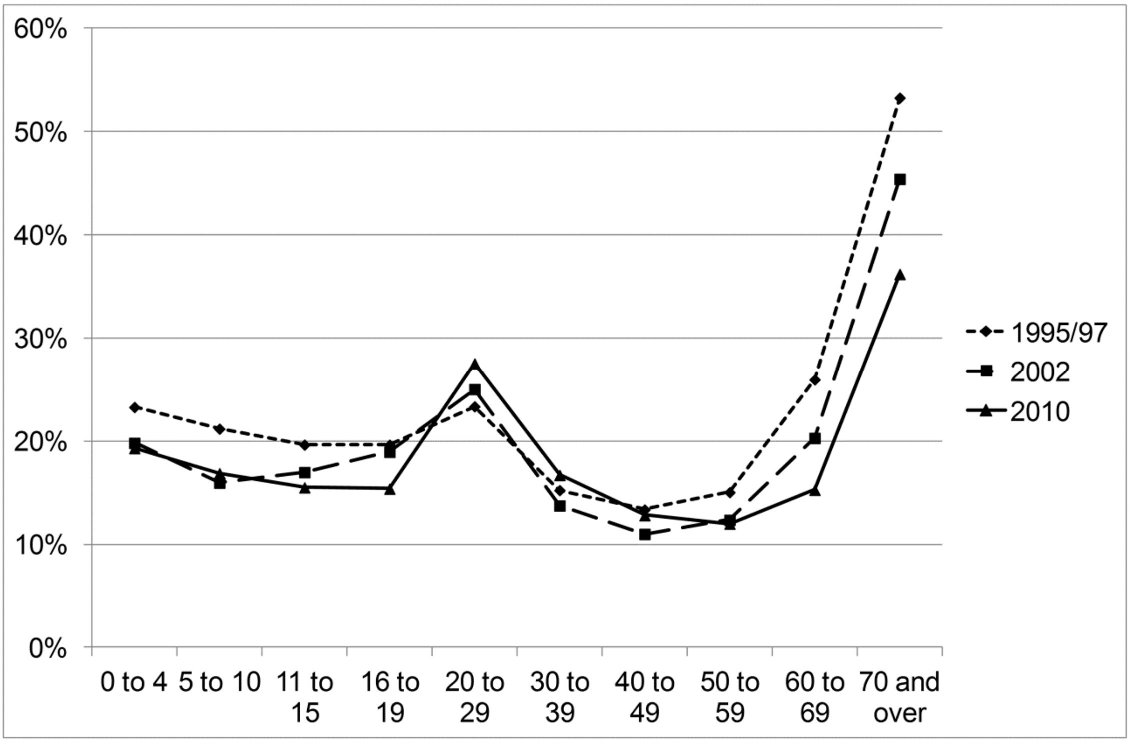

Fig. 7.25 – Proportion of individuals in households without cars in Great Britain, by age, in 1995/97, 2002 and 2010 (percentage values). Unit of analysis: individuals. Source: own elaboration on NTS 1995-2001 and 2002-2010 data (interview sample).

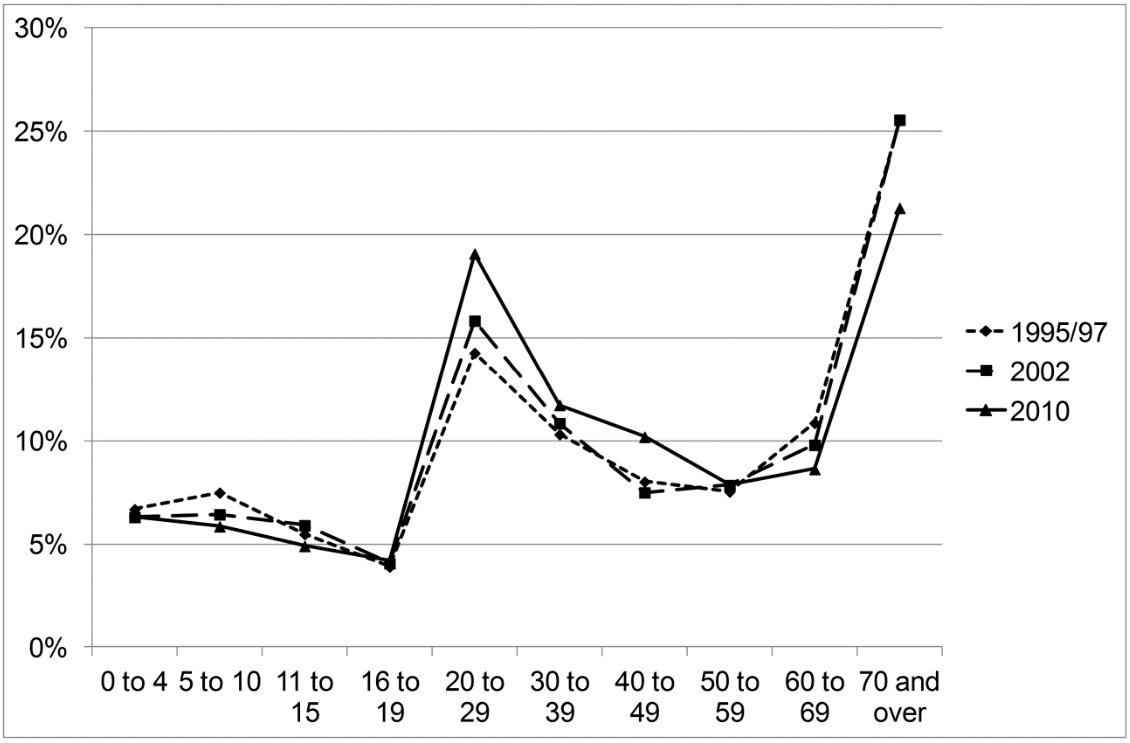

Fig. 7.26 – Age distribution of the subset of individuals in carless households, in 1995/97, 2002 and 2010 (percentage values). Unit of analysis: individuals. Source: own elaboration on NTS 1995-2001 and 2002-2010 data (interview sample).

As argued in §1.1.5, increasing car ownership among older people is one of the most important trends of the last decades in the domain of transport. Fig. 7.25 shows the percentage of individuals living in households without cars, by age group, for three NTS survey waves between 1995 and 2010. It confirms the rapid decrease of non-car ownership in the oldest age groups: the proportion of carless among people aged 70 or more was 53% in 1995/97, 45% in 2002 and 36% six years later; corresponding figures for the age group '60-69' are 26%, 20% and 15%. A sizeable decrease is observed also for children and young people (up to the age of 19). By contrast, the percentage of carless individuals in the age group 20-29 has increased slowly, going from 23% (1995/97) to 25% (2002) to 28% (2010). This also confirms the results of the studies reviewed in §1.1.5 and §5.2.1. As a result, while in the mid-1990s a single age group (70 years or more) was significantly more likely than all others to live without cars, as of 2010 the curve is more bimodal, with two peaks of autolessness, one corresponding to young adulthood, the other to old age.

Also the age distribution of the subset of carless individuals has changed between 1995 and 2010 (Fig. 7.26): the relative weight of young adults (20-29) has increased from 14% (1995/97) to 19% (2010) while that of people over 70 has gone from 26% to 21%. Overall, it appears that increasing car ownership among the elderly and decreasing car ownership among young adults are changing the age distribution of the carless group, making it younger than it used to be (although change is quite slow).

Tab. 7.28 shows how the composition of the carless group varies across different survey waves, according to key socio-demographic variables associated with non-car ownership (the same used in Tab. 7.2, with the addition of mobility difficulties). The percent variation between 2002 and 2010 is also reported in the rightmost column when the association between the row variable and survey year is significant at the 5% level (chi-square test). The table shows that in some respects (size, income and gender of the HRP) the composition of the carless population does not change significantly over the period of interest. While for size and income this is consistent with stability in the population as a whole, the proportion of female headed households on the NTS sample increases significantly between 2002 (35%) and 2010 (38%): the fact that this does not happen among the carless suggests that the likelihood of being carless is decreasing for female-headed households.

Other variables in Tab. 7.28 show a change in the composition of the carless group. In some cases, this is due to broader trends in the composition of the British population (data not reported here for the sake of brevity). For example, the decline in the percentage of households including members with mobility difficulties is observed also in the NTS sample, and the same applies to the increasing share of households with non-white HRP. For other variables, however, Tab. 7.28 shows a trend divergence between the total sample and the carless group. This is the case for example for household structure: in the carless population, the proportion of pensioner households declines, while all other types of household increase. In the NTS sample, however, the proportion of pensioner households increases, rather than decreasing. This suggests that the likelihood of being carless is decreasing rapidly for pensioner households. Similarly, the percentage of households with a working HRP is increasing more rapidly among the carless (27% in 2002, 32% in 2010), than in the sample as a whole. Overall, as illustrated above, these results can be explained by the increasing motorisation of older people, resulting in a decreasing weight of people over 60 among the carless, offset by an increase in younger age groups. This corroborates hypothesis H1.2.

			2002	2003	2004	2005	2006	2007	2008	2009	2010	% var.
Household	Size	1	58.3	57.0	56.0	57.4	57.3	58.6	57.0	56.7	55.2	
		2	24.4	26.0	26.2	24.4	24.0	23.8	24.9	25.2	25.1	
		3	9.6	8.4	9.4	9.7	10.5	9.1	10.5	8.6	10.4	
		4 or more	7.7	8.7	8.5	8.6	8.2	8.6	7.6	9.5	9.3	
		Total	*100*	*100*	*100*	*100*	*100*	*100*	*100*	*100*	*100*	
	Structure	1 or 2 adults youngest child 0-15	17.7	16.8	17.2	17.1	17.3	16.5	16.1	17.6	18.4	*+4%*
		Family adult child(ren)	5.5	6.0	6.8	7.2	6.5	6.4	6.4	5.8	7.2	*+31%*
		Pensioner household	46.1	46.7	45.2	44.4	45.1	43.9	43.1	42.9	40.8	*-11%*
		Other household	30.7	30.5	30.8	31.2	31.1	33.2	34.4	33.7	33.6	*+9%*
		Total	*100*	*100*	*100*	*100*	*100*	*100*	*100*	*100*	*100*	
	Income quintile	Lowest	40.8	41.8	41.0	42.3	41.5	42.8	40.7	41.4	38.8	
		Second	31.1	28.7	29.0	26.8	28.5	28.6	29.1	28.0	30.2	
		Third	13.7	13.7	14.7	14.3	14.4	13.1	12.7	13.6	14.1	
		Fourth	7.9	8.7	8.7	8.9	8.0	7.8	9.0	9.2	9.6	
		Highest	6.5	7.2	6.6	7.8	7.6	7.7	8.4	7.8	7.4	
		Total	*100*	*100*	*100*	*100*	*100*	*100*	*100*	*100*	*100*	
	Mobility difficulties (foot / bus)	At least one member	39.3	40.9	40.9	40.3	38.5	34.1	32.3	31.9	32.0	-19%
		None	60.7	59.1	59.1	59.7	61.5	65.9	67.7	68.1	68.0	+12%
		Total	*100*	*100*	*100*	*100*	*100*	*100*	*100*	*100*	*100*	
HRP	Age	16-29	15.4	14.7	15.3	13.6	13.9	14.1	15.1	15.8	16.7	*+8%*
		30-59	34.3	33.8	34.9	37.0	35.7	37.1	36.8	37.1	38.1	*+12%*
		60+	50.3	51.6	49.8	49.4	50.5	48.8	48.1	47.1	45.2	*-10%*
		Total	*100*	*100*	*100*	*100*	*100*	*100*	*100*	*100*	*100*	
	Gender	Female	60.2	60.9	60.9	58.9	60.9	59.6	59.2	57.9	58.2	
		Male	39.8	39.1	39.1	41.1	39.1	40.4	40.8	42.1	41.8	
		Total	*100*	*100*	*100*	*100*	*100*	*100*	*100*	*100*	*100*	
	Working status	Working	27.3	28.9	29.2	28.7	28.8	29.7	31.9	30.1	31.6	*+16%*
		Retired / permanently sick	54.1	53.8	53.7	54.5	54.5	55.0	52.1	51.6	49.8	*-8%*
		Other non working	18.6	17.3	17.1	16.7	16.7	15.3	16.0	18.3	18.6	*0%*
		Total	*100*	*100*	*100*	*100*	*100*	*100*	*100*	*100*	*100*	
	Ethnic group	Non-white	8.6 .	10.5	10.2	11.1	9.6	11.5	11.3	12.2	12.6	*+47%*
		White	91.4	89.5	89.8	88.9	90.4	88.5	88.7	87.8	87.4	*-4%*
		Total	*100*	*100*	*100*	*100*	*100*	*100*	*100*	*100*	*100*	

Tab. 7.28 – Distribution of key socio-demographic variables for households without cars, 2002-2010 (percentage values). Unit of analysis: households. Source: own elaboration on NTS 2002-2010 data (interview sample).

Overall, the results illustrated in Tab. 7.28 show that the composition of the carless group has changed slightly over the period of interest. While in some cases these changes are consistent with broader socio-demographic trends in British society, at other times different trends are observed for the carless group. However, it is impossible to disentangle these effects by looking just at the composition of the carless group. It is thus necessary to see how the *propensity* to be carless has changed over time, for the socio-demographic groups of interest (Tab. 7.29).

			Households without cars									
			2002	2003	2004	2005	2006	2007	2008	2009	2010	% var.
Household	Size	1	54.3	54.1	52.1	52.6	50.8	52.2	51.1	51.5	49.6	-9%
		2 or more	15.7	16.1	15.8	14.7	14.5	14.7	14.9	15.2	15.6	
	Structure	1 or 2 adults youngest child 0-15	17.6	16.6	16.2	15.9	15.6	15.7	14.9	16.8	17.2	
		Family adult child(ren)	13.5	13.9	14.5	14.6	13.2	14.2	13.3	12.0	13.9	
		Pensioner household	48.9	49.0	46.1	44.0	43.5	43.4	41.6	41.5	38.9	-20%
		Other household	22.3	23.0	22.7	22.1	21.7	23.3	24.4	24.2	25.1	
	Income quintile	Lowest	54.8	56.0	53.1	53.0	51.0	54.3	50.8	52.3	48.7	-11%
		Second	41.7	38.5	37.5	33.5	35.0	36.4	36.3	35.5	37.9	-9%
		Third	18.4	18.4	19.0	17.9	17.7	16.6	15.9	17.3	17.7	
		Fourth	10.5	11.7	11.3	11.1	9.8	9.9	11.3	11.6	12.0	
		Highest	8.7	9.6	8.6	9.7	9.3	9.8	10.5	9.8	9.3	
	Mobility difficulties (foot / bus)	At least one member	42.1	42.6	43.2	42.0	40.0	40.3	38.7	39.4	40.3	-4%
		None	21.7	21.4	20.3	19.7	19.8	21.3	21.3	21.7	21.3	-2%
HRP	Age	16-29	39.0	38.7	40.2	36.2	36.2	35.2	38.2	39.5	43.1	
		30-59	16.1	16.0	15.8	16.1	15.4	16.8	16.4	17.0	17.3	
		60+	41.7	41.8	39.1	37.5	37.0	36.5	34.9	34.5	32.6	-22%
	Gender	Female	44.7	45.1	43.4	41.8	40.7	41.4	40.0	38.5	38.5	-14%
		Male	16.7	16.5	15.9	15.9	15.2	16.2	16.2	17.2	16.9	
	Working status	Working	12.3	12.8	12.4	11.8	11.5	12.3	12.9	12.7	13.0	
		Retired / permanently sick	45.5	45.2	44.3	43.1	43.0	43.8	41.6	41.6	40.3	-11%
		Other non working	59.2	60.2	57.8	56.1	57.0	55.7	55.8	54.5	58.5	
	Ethnic group	Non-white	35.3	39.8	37.8	37.3	32.6	37.8	36.0	38.0	34.7	
		White	26.2	25.9	25.0	24.1	24.0	24.4	24.0	24.2	24.2	-8%

Tab. 7.29 – Households without cars 2002-2010, by key socio-demographic variables (percentage values). Unit of analysis: households. Source: own elaboration on NTS 2002-2010 data (interview sample).

For most socio-demographic groups identified in the table, chi-square tests do not allow to affirm that non-car ownership has changed between 2002 and 2010: in these cases, no value is reported in the 'percentage variation' column. However, the table also suggests that there has been a significant reduction for groups where non-car ownership is higher, such as singles, older people, low-income households, households with members with mobility difficulties and female-headed households. The exception here is 'ethnic group', showing that non-car ownership is decreasing among whites, but not among non-whites: this is probably due to the small share of households with a non-white HRP. Overall, it seems that socio-demographic groups traditionally more likely to be carless are 'closing the gap' with the rest of the population.

Overall then, the data reported in Tab. 7.29 suggest that, contrary to hypothesis H2.1, we are *not* witnessing an increasing concentration of non-car ownership among specific social groups. Indeed, if non-car ownership does not decrease for social groups who already have a higher motorisation rate, but it does for others, this necessarily reduces the gap between the two. If this is true, we should observe a *decreasing* association between the socio-demographic variables of interest and non-car ownership.

To test this hypothesis, in Tab. 7.30 I show the odds ratios for selected socio-demographic characteristics that are associated with non-car ownership, by survey year[270]. For each category, the value of the odds ratio

[270] Tab. 7.30 includes the same variables and odds ratios as Tab. 7.13.

is equivalent to the value of the odds of not owning a car (rather than owning it) for the category of interest, divided by the same odds for the rest of the sample. The table shows that, for most variables (household size, sex of the HRP, old age, presence of employed members and income), the association with non-car ownership has decreased between 2002 and 2010. For others, however (presence of young children, presence of members with mobility difficulties, HRP non-white), differences between years are small and the trend is unclear: incidentally, these are also the socio-demographic characteristics that were the least associated with non-car ownership in 2002. Additional figures for the years 1995-2000 show that in the 1990s the association between socio-demographics and non-car ownership was much stronger than today.

The odds ratios for the additive index in the last row of Tab. 7.30 show that the association between accumulating several of the socio-demographic characteristics listed above (at least five out of eight) and non-car ownership is decreasing over the period of interest. This can be interpreted as follows: while there is a strong association between belonging to marginal social groups and non car ownership in all survey years, this has decreased over the period of interest.

Variable	Odds ratio	95 /97	98 /00	2002	2003	2004	2005	2006	2007	2008	2009	2010
Household size	1 (vs. 2 or more)	6.3	6.9	6.4	6.1	5.8	6.5	6.1	6.3	6.0	5.9	5.3
No. of members under 16	0 (vs. 1 or more)	2.0	2.3	2.0	2.2	2.2	2.1	2.1	2.2	2.3	2.0	1.9
HRP: sex	female (vs. male)	7.1	6.0	4.0	4.2	4.0	3.8	3.8	3.6	3.4	3.0	3.1
HRP: age	60+ (vs. 16-59)	3.4	3.7	2.9	3.0	2.7	2.6	2.6	2.3	2.2	2.0	1.8
No. of employed members	0 (vs. 1 or more)	8.4	9.4	7.6	7.1	7.1	6.9	7.1	6.8	5.8	6.2	5.8
Members with mobility difficulties	1 or more (vs. 0)	-	-	2.6	2.7	3.0	2.9	2.7	2.5	2.3	2.4	2.5
HRP: ethnic group	non-white (vs. white)	-	-	1.5	1.9	1.8	1.9	1.5	1.9	1.8	1.9	1.7
Income quintile	Lowest + second (vs. third or higher)	-	-	6.5	5.9	5.6	5.1	5.4	6.0	5.4	5.3	5.1
Additive index	5 to 8 characteristics (vs. less than 5)	-	-	8.3	8.5	8.3	8.3	7.8	7.3	7.0	6.8	6.4

Tab. 7.30 – Odds ratios for the odds of not owning cars, rather than owning them, 1995-2010 Unit of analysis: households. Source: own elaboration on NTS 1995-2001 and NTS 2002-2010 data (interview sample).

In a nutshell, then, the fact that no odds ratio in Tab. 7.30 increases over the period 2002-2010 suggests that hypothesis H2.1 (increasing concentration of the carless among marginal social groups over time) is not confirmed for the British case study. However, further analysis disaggregated by type of area (not reported here in detail for the sake of brevity, suggest that in small cities and rural areas, the decline in the association between socio-demographic determinants and non-car ownership is less pronounced. For some indicators, stability or even an increasing association are observed in these areas. As a result, the difference in the values of the odds ratios between different types of area (see §7.1.2) is increasing over the period of interest and peaks for the last survey year (2010).

This is exemplified in Fig. 7.27, with reference to the additive index reported in Tab. 7.30: the figure shows that between 2002 and 2010 the odds ratio declines in London and other metropolitan areas, as well as in other urban areas over 25,000 inhabitants. In small towns and rural areas, by contrast, the trend is less clear and the value for 2010 is higher than in 2002. As a result, the difference between the odds ratio for the most central and the most peripheral types of area is approximately 4 in 2002, and more than 7 in 2010.

A possible explanation for this finding is the following: in large cities, where non-car ownership is not decreasing over the period 2002-2010 (see Tab. 7.27), the association between non-car ownership and its socio-demographic determinants is decreasing, because of demographic trends such as increasing motorisation among new cohorts of older people, etc. In the most peripheral areas, where non-car ownership is still decreasing over the period 2002-2010 (see Tab. 7.27), this demographic trend is offset by the increasing association between socio-demographic variables and non-car ownership that is brought about by increasing car dependence (as suggested in hypothesis H2.1). This would explain why the value of the odds ratio does not decrease for small towns and rural areas. This explanation, however, falls short of explaining why in intermediate types of area (urban areas over 25,000 inhabitants) the association between socio-demographics and non-car ownership decreases over the period of interest, even though the percentage of carless households decreases significantly (-12%) between 2002 and 2010 (see Tab. 7.27).

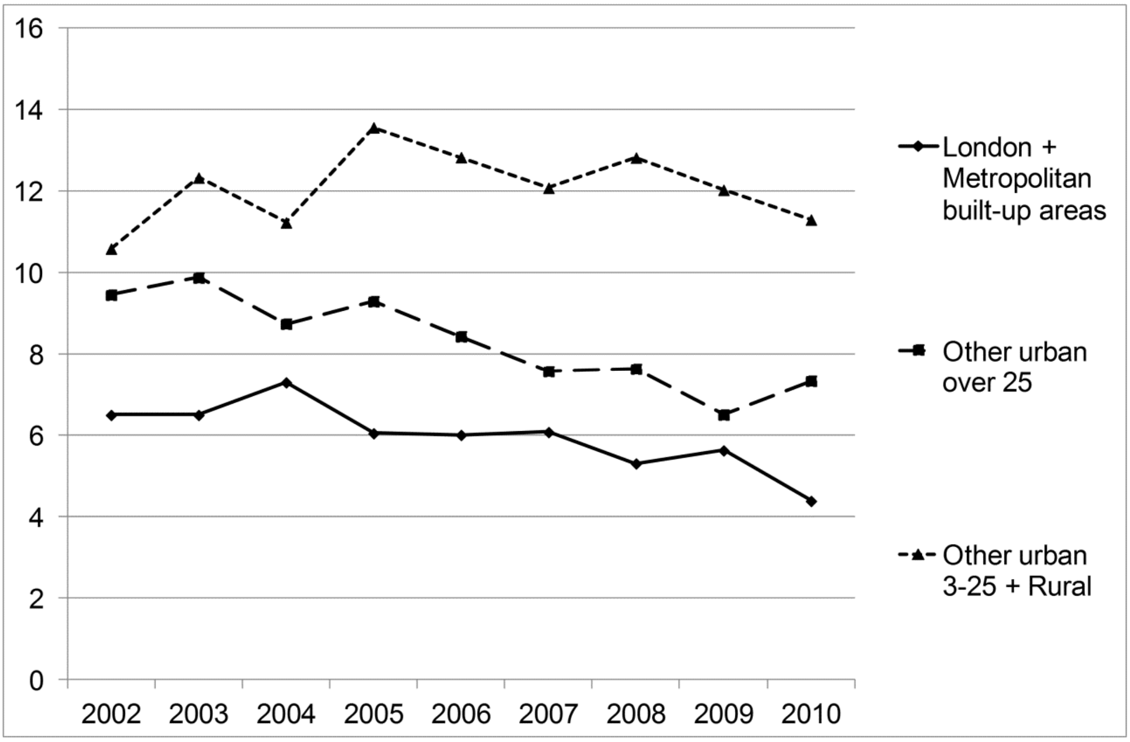

Fig. 7.27 – Odds ratios for the odds of not owning cars, rather than owning them, for households with five of more of the eight socio-demographic characteristics listed in Tab. 7.30 (as opposed to households with four or less characteristics), by type of area (thousands of inhabitants) and survey year. Unit of analysis: households. Source: own elaboration on NTS 2002-2010 data (interview sample).

Another way to explore whether the concentration of the carless households group among marginal social groups has decreased over the period of interest is to consider the goodness of fit of logistic regression models (outcome: non car-ownership) including only socio-demographic variables, as done previously in §7.1.2. Tab. 7.28 shows the values of McFadden's pseudo-R^2 for logistic regression models fitted separately for the nine survey waves. All models include the same socio-demographic variables, and are thus comparable[271]. Detailed results for the models are not reported here for the sake of brevity.

The graph shows that the goodness of the models declines steadily from 0.31 (2002) to 0.26 (2010). This result can be interpreted as follows: predicting non-car ownership on the basis of socio-demographic variables is less easy in 2010 than it was in 2002. This suggests that, when all relevant socio-demographic characteristics are considered, the carless households group is becoming *less* (rather than more) concentrated among marginal social groups over the period of interest. Further analysis of the pseudo-R^2 disaggregated by type of area provide some support to the hypothesis (discussed above), that the declining association between socio-demographic variables and non-car ownership does not apply to small towns and rural areas (detailed results not reported here for the sake of brevity).

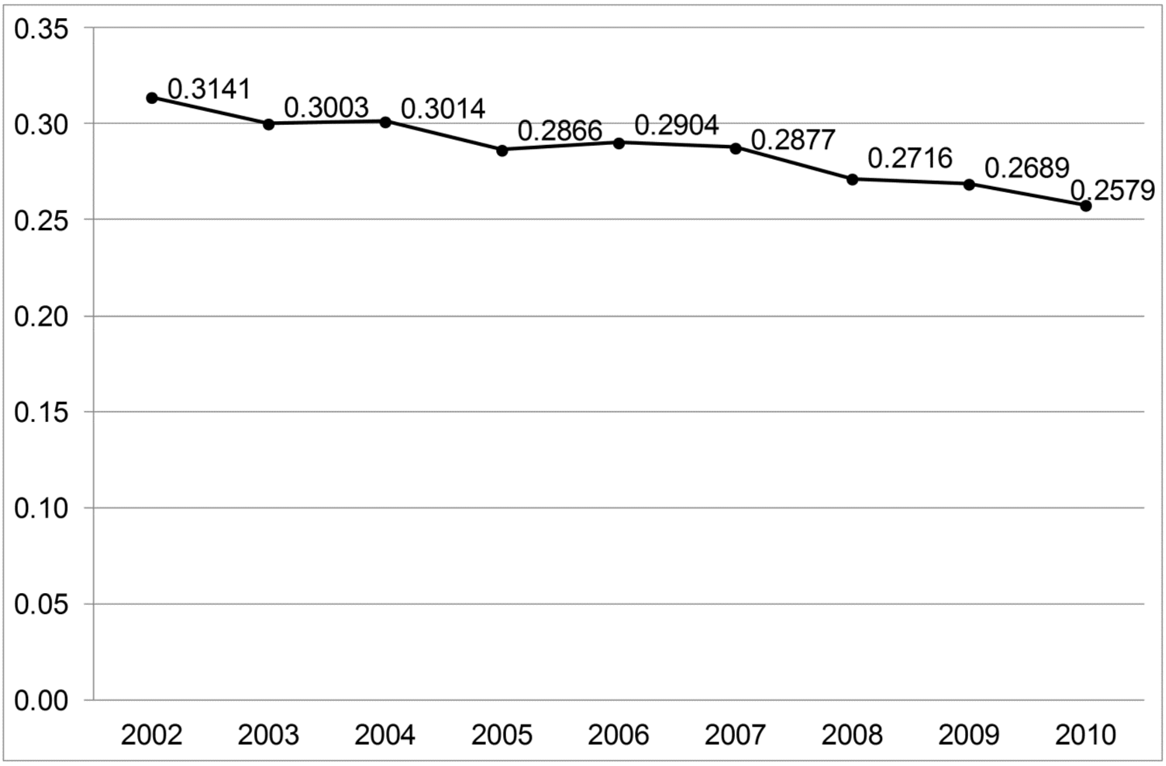

Fig. 7.28 – Values of McFadden's pseudo-R^2 for logistic regression models including only socio-demographic predictors, fitted separately for the different survey waves. Unit of analysis: households. Source: own elaboration on NTS 2002-2010 data.

7.2.2. Conclusions

In §3.3.3, two alternative hypothesis were put forward. According to the first (H.2.1), the ongoing process of car dependence would determine a greater concentration of the carless households group among marginal social groups. According to the second (H2.2), the sheer force of demographic change (increasing motorisation among older people, opposite trend for young adults) would change the composition of the carless households group accordingly. The result of the analysis illustrated in the previous section (§7.2.1) provide no support for the first hypothesis, while they corroborate the second.

Indeed, despite evidence that the size of the carless group has decreased between 2002 and 2010 (notably in peripheral and rural areas), for most socio-demographic determinants of non-car ownership the association has *decreased* (rather than increasing) over the period of interest. This happens because non-

[271] In detail, the predictors included are the same of the models reported in Tab. 7.14, except survey year.

car ownership is decreasing faster among less motorised social groups (older people, singles, female-headed households): as a result, in 2010 the carless group is *less* (rather than more) concentrated among marginal social groups than in 2002.

Why does this happen? Much of it is likely to be related to the process of demographic change described by hypothesis H2.2: the higher propensity to own cars of new cohorts of older people (past the age of retirement) combines with the stable (or slightly) decreasing propensity of younger age groups. At a descriptive level, this results in an increase in the relative weight of younger age groups among the carless. However, changes in the propensity to own cars result only partially in changes in the composition of the carless group, because of the general ageing of the population (whereby the increasing propensity of older households to own cars is balanced by the increasing weight of old cohorts in the population, while the opposite happens for other age groups). As old age is associated with most other socio-demographic predictors of non-car ownership (small household size, absence of young children, non-employment, mobility difficulties and low income), this might explain why the association between these variables and non-car ownership is becoming weaker over time. However, increasing motorisation of older people is unlikely to be the sole driver of these trends: in fact, further analysis disaggregated by age (not reported in §6.2.1 for the sake of brevity) shows that the association between non-car ownership and its socio-demographic determinants is decreasing in all age groups. This suggests that other drivers must be at work.

The overall conclusion is that in Great Britain motorisation, despite being low by international standards, seems to have reached saturation among most social groups in recent years. The proportion of carless households, however, continues to decline among the groups where it has traditionally been higher (older people, low-income females). As a result, the gap between different sectors of the population in terms of car ownership seems to be slowly closing down in the last decade. Clearly, this scenario contradicts the hypothesis of an increasing concentration of carless households among marginal social groups, as motorisation and car dependence increase.

However, there is some evidence to suggest that the association between socio-demographic determinants and non-car ownership is not decreasing (or is decreasing slower) in small towns and rural areas. Since these are the areas where non-car ownership is decreasing faster, this could be interpreted as providing support for hypothesis H2.1. With the available data, however, it is not possible to reach a definitive conclusion on this question.

PART IV – CONCLUSIONS

8. Conclusions

In this last chapter, I make the connections between the empirical results illustrated in Part III, my research questions and hypotheses and broader theoretical and policy debates. The chapter is structured as follows: in §8.1, I bring together empirical evidence for the two case studies, and discuss it in light of the research questions and hypotheses outlined in chapter 3. In the second section (§8.2), I discuss the empirical results in light of the theoretical and policy debates outlined in Part I and II of this thesis.

8.1. Bringing together the evidence

8.1.1. Question 1

As illustrated in §3.3.2, Question 1 focused on the varying composition of the carless group across different types of area. Notably, four specific research hypotheses were put forward. These are illustrated in Tab. 8.1, along with the empirical results for the two case studies. The rightmost column reports an overall assessment for each hypothesis.

With regard to H1.1 (socio-demographic composition), the results for both case studies strongly support the hypothesis that carless households are more concentrated among marginal social groups in car dependent areas. This is apparent from descriptive statistics, showing that households who accumulate several characteristics generally associated with non-car ownership account for a larger share of carless households in rural areas and small municipalities. This share decreases as the degree of urbanity increases. More formally stated, the *strength of the association* between the socio-demographic determinants of non-car ownership (as measured by odds ratios and goodness-of-fit statistics for logistic regression models) is highest in low-density, peripheral areas and lowest in the densely built areas of large cities.

Further analysis also suggests that this phenomenon is the result of the interweaving of socio-demographic and geographical determinants of non-car ownership. Indeed, the results of logistic regression models for both case study suggest that there are socio-demographic conditions (such as being a household with two working adults and children) that result in a very low probability of non-car ownership. The same applies to geographical conditions such as living in very low density areas with minimum levels of public transport service. This explains why the carless households group is more diverse in large cities (where the bar of non-car ownership is set lower), as well as why most carless households in rural areas cumulate several socio-demographic determinants of non-car ownership.

In its broad formulation, the hypothesis is strongly supported by the data for both case studies. However, the empirical analysis also shows that there are differences between the two countries. In Germany the odds ratios (Tab. 6.11) suggest that the strength of the association between indicators of social status (income and level of education) does not vary significantly with the degree of urbanity. In the British case, however, the strength of the association between belonging to the two lowest income quintiles and not owning cars increases strongly as one moves from London to rural areas (Tab. 7.13), thus confirming expectations, while the association with education level is not tested because of limitations in the available data. On the other hand, however, the values of the odds ratios for Great Britain (Tab. 7.13) suggest that the strength of the association between the lack of minor children and non-car ownership is not significantly stronger in car dependent areas. The opposite is true for Germany (Tab. 6.11) where it increases strongly as one moves away from large cities. Also, it appears that in Great Britain, the strength of the association between belonging to a non-white ethnic group and non-car ownership does not vary significantly across different types of area; given the lack of this variable in MiD 2008, there is no evidence on this point for the German case.

There are two possible explanations for the observed differences between the two countries. Firstly, these might be the by-product of differences in variable definitions between the surveys. For example, income levels are defined differently in MiD (five economic status classes that vary significantly in size) and NTS (income quintiles). The same is true for the lack of minor children, defined as household members aged 17 or less in German case, but 15 or less for the British case. However, more in-depth analysis (not reported in the thesis for the sake of brevity), suggest that definition differences between the surveys are not likely to be the main source of the observed differences.

Hypothesis		Germany	Great Britain	Overall
H1.1 (socio-demographics and economic status)	*Carless more concentrated among marginal social groups in car dependent areas*	Corroborated, but less true for indicators of social status (income, education level)	Corroborated, but less true for the lack of children and not true for ethnic group	Corroborated, differences between countries to be explored in future research
H1.2 (reasons for not owning cars)	*Carless more likely to mention constraints in car dependent areas*	Corroborated to a certain extent: the results for affordability problems defy expectations	Not tested	Reformulated and put forward hypothesis for future research (see §8.2.6 below)
H1.3 (travel behaviour)	*Non-car ownership more likely to correspond to low mobility levels in car dependent areas*	Corroborated Developed link with H1.1	Corroborated Developed link with H1.1 Emerging hypothesis of a systematic variation of modal split across different types of area (see H1.6 in Tab. 8.2 below)	Corroborated Developed link with H1.1 Emerging hypothesis of a systematic variation of modal split across different types of area (see H1.6 in Tab. 8.2 below)
H1.4 (accessibility to services and opportunities)	*Carless more concentrated among groups with a greater 'accessibility gap' in car dependent areas*	Corroborated Developed link with H1.1	Corroborated Developed link with H1.1	Corroborated Developed link with H1.1

Tab. 8.1 – Research hypotheses for Question 1 and empirical results for the two case studies. Source: own elaboration.

The second possible explanation is that the broad phenomenon (varying strength of the association between non-car ownership and its socio-demographic determinants across different types of area) interacts with characteristics of the countries. For example, the low level of income inequality in Germany (Wilkinson & Pickett, 2010) might explain why the strength of the association between income and non-car ownership does not vary across different types of area. Conversely, comparatively high levels of income inequality in Britain (*ibidem*) might explain why this phenomenon is observed there. Similarly, differences in the way children are brought up in the two countries might explain why the strength of the association between lack of children and non-car ownership varies significantly across areas in Germany, but not in Great Britain.

However, existing research does not support this hypothesis, as strong reliance on the car was observed both for German (Heine et al., 2001) and the British families (Davis, Hirsch et al., 2012).

As this thesis is not comparative in the strict sense of the word, these hypotheses were not explored. However, future research might shed light on these questions. Different approaches can be thought of: first, extending the scope of the analysis to other European countries (such as France, where a good national travel survey exists, see §3.4.2), might help distinguish socio-demographic variables that have a varying strength of association with non-car ownership across areas in *all* countries from those that do not. A second option is to draw on surveys that are homogenised at the European level (such as the European Community Household Panel used by Dargay et al., 2008) and include car ownership, socio-demographic variables and a 'type of area' variable, to explore the question on a larger number of countries. In this case, however, sample size might be an issue. Finally, qualitative studies might be able to explore in-depth if and how non-car ownership is experienced differently by low income households and households with children in Germany and Great Britain.

With regard to H1.2 (reasons for not owning cars), the hypothesis was tested only for the German case study. As argued in §6.1.5 the empirical results provide only limited support for the original hypothesis: while 'constraints' related to old age and disability are mentioned more frequently in car dependent areas, and both choice and lack of need are mentioned more frequently in large cities, the findings for affordability problems defy expectations. In fact, affordability problems are more frequently associated with choice and lack of need than with other constraints such as age and disability; also, the clusters that are most associated with affordability problems ('economically car deprived' and, to a lesser extent, 'car abstinence') do not account for a larger share of carless households in car dependent areas – quite the contrary.

While the NTS dataset does not allow me to test this hypothesis for the British case, it is important to observe that findings for Great Britain do not seem to contradict German results. While clusters characterised by old age and low use of modal alternatives ('car reliant' and 'immobile') account for approximately the same share of the population in all types of area, the size of the poorest cluster ('slow and local', 48% in the lowest income quintile) varies considerably across areas.

The implications of this unexpected result are discussed more in detail in §8.2.6 below, in light of the relevant literature, and hypotheses for future research are put forward.

With regard to H1.3 (travel behaviour), the findings for both countries confirm that non-car ownership in car dependent areas corresponds to a wider 'mobility gap' (as compared to car-owners) than in large cities. Notably, the evidence is more robust for the British case, because NTS data, including a one-week travel diary, are better suited to the analysis of travel behaviour. Therefore, the hypothesis is corroborated. However, the empirical results also suggest that this is to some extent the by-product of the varying socio-demographic composition of the carless group across different types of area. This shows that there is a link between the results for different hypotheses related to Question 1: this point is developed further below in this section. Also, initial findings for the British case have led me to develop a new 'emerging' hypothesis about how the modal split of carless individuals varies across different types of area (H1.6, see Tab. 8.2). This is also discussed further below in this section.

With regard to H1.4 (accessibility), the hypothesis is corroborated by empirical findings for both case studies. The evidence is more robust for the German case, because MiD data include a set of variables measuring (self-assessed) accessibility to services, thus allowing me to compute accessibility indexes (§B.2.3). In the British case, by contrast, this conclusion is based on a small set of items measuring 'travel difficulties'. Overall, the hypothesis is corroborated by the data. However, the empirical results also suggest that the wider 'accessibility gap' of carless households in car dependent areas is also the by-product of the varying socio-demographic composition of the carless group across different types of area. This second link between H1.1 and other hypothesis is also discussed further below in this section.

As argued above, the data analysis has led to the formulation of new hypotheses concerning the varying composition of the carless group across different types of area. Notably, two 'emerging' hypotheses have been tested (Tab. 8.2).

Emerging hypothesis		Germany	Great Britain	Overall
H.1.5	*Put in its simplest way, the structure of the carless group can be summarised as a mixture of scatters and clusters*	Corroborated *scatters*: old-age related reasons *clusters*: non old-age related reasons	Corroborated *scatters*: alternative modes non-users *clusters*: alternative modes users	Corroborated, but different hypotheses for the two case studies An integrated hypothesis is put forward for future research
H1.6	*Carless more reliant on cars, taxis and other private motorised modes of transport in car dependent areas*	Not tested	Corroborated Developed link with H1.1	Corroborated Developed link with H1.1

Tab. 8.2 – Emerging hypotheses related to Question 1 and results for the two case studies. Source: own elaboration

The first (H1.5) argues that *the simplest way* to describe how the composition of the carless group varies across different types of area is to distinguish a 'clustered' from a 'scattered' form of non-car ownership. 'Clustered' non-car ownership is strongly affected by the built environment characteristics of the local area, and is thus much more likely to be found in large and compact cities. By contrast, 'scattered' non-car ownership accounts for approximately the same share of total population in all types of area, because it is mostly associated with socio-demographic (rather than geographical) determinants of non-car ownership. In that sense, it constitutes the 'hard-core' of non-car ownership. This emerging hypothesis is corroborated by the results of multinomial logistic regression models for both case studies.

However, there are significant differences in how I have defined 'clustered' and 'scattered' carless groups in the two case studies. In the German case, 'scattered' non-car ownership corresponds to 'age-related' clusters (AR clusters), i.e. those (old) carless households who reported age, health and lack of car ownership as reasons for not owning cars. Conversely 'clustered' non-car ownership is defined by 'non-age related' reasons (NAR clusters) such as affordability problems, deliberate abstinence and lack of need. In the British case, 'scattered' non-car ownership corresponds to those individuals who, despite being carless, are quite unlikely to use transport modes alternative to the car (NAM clusters), while 'clustered' non-car ownership refers to individuals who reported a significant use of alternative modes (AM clusters).

Given limitations in the available data, it is not possible to test the same hypothesis for both case studies: indeed, NTS does not include a question about the reasons for not owning cars, while MiD data are not suitable to classify individuals based on their reported travel behaviour. However, it is tempting to suggest that the two hypotheses might be integrated in a single hypothesis for future research. This means positing that the structure of the carless group, in its simplest way, can be summarised as a mixture of: 'scatters', i.e. older people who do not own cars for age-related reasons and report lower use of modal alternatives, accounting for the same share of the total population in all types of area; and 'clusters', i.e. a group of both young adults and older people, who do not own cars because of reasons such as affordability problems, lack of need and choice, rely on the use of modal alternatives to the car and are much more likely to be found in dense urban areas. The evidence reported in this thesis provides limited support for this integrated hypothesis. With regard to the German case, AR clusters are more likely to report car passenger use, but also walking, while NAR clusters are not characterised by a single type of modal behaviour. Overall, modal split differences between 'clustered' and 'scattered' groups are not so pronounced in Germany. With regard to Great Britain, NAM clusters are strongly concentrated among old age groups, while the AM macro-cluster includes both the poorest (SL) and the richest (PTC) groups of carless, thus suggesting that their reasons for not owning cars include both affordability problems and choice. While this integrated hypothesis cannot be tested here, it is put forward for future research. Testing it would require a travel survey including both 'reasons for not owning cars' questions and a one-week travel diary.

The second emerging hypothesis (H1.6) is a 'spin-off' of H1.3: initial evidence about the variation of the carless' travel behaviour across different types of area in Great Britain suggested that carless individuals in car dependent areas are much more reliant on cars, taxis and other motorised modes of transport. This hypothesis was tested by means of cluster analysis for the British case, and corroborated. It was not possible to test it on the German case study, because of limitations in the travel survey (one-day travel diary). However, the fact that non-car ownership in German car dependent areas is more concentrated among AR clusters, who are also on average more reliant on car lifts, suggests that this might be the case. Also, findings for the British case suggest that the changing modal split across types of area is in part the by-product of the varying socio-demographic composition of the carless group. This constitutes the third link between H1.1 and other hypotheses.

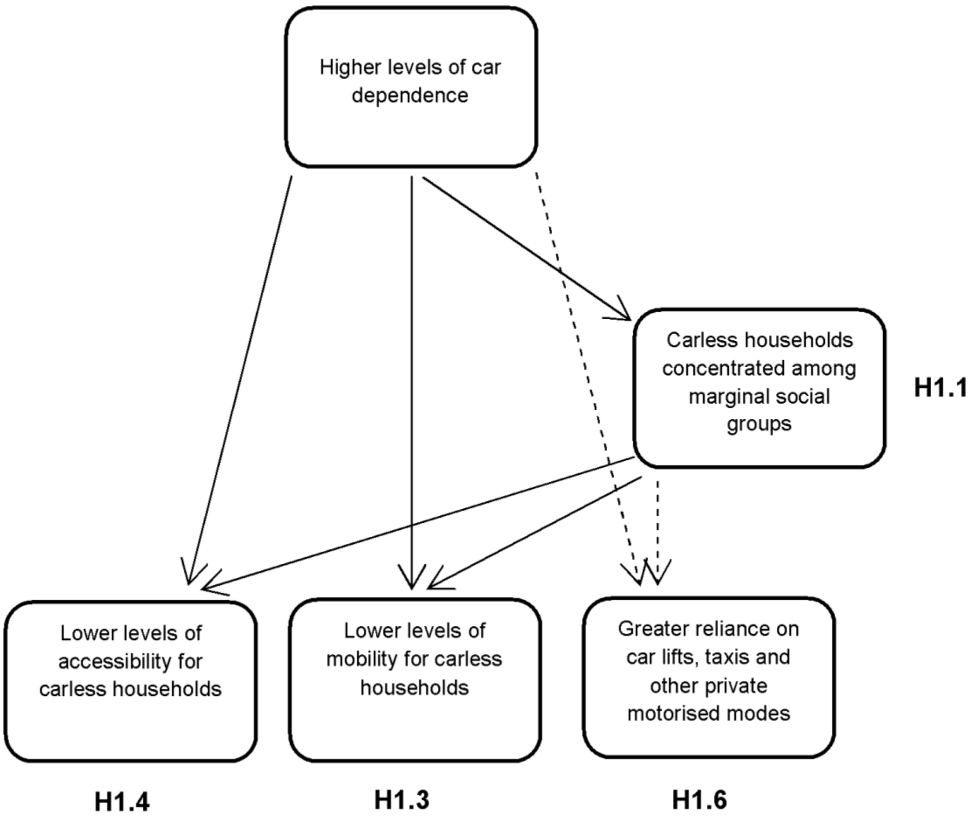

Fig. 8.1 – Diagrammatical representation of the relationships between empirical results related to Question 1. Source: own elaboration.

The causal linkages between different empirical results related to Question 1 are illustrated in Fig. 8.1. The diagram shows that a higher level of car dependence (in the local area) corresponds to a greater 'accessibility gap' (H1.4) and 'mobility gap' (H1.3) for carless households, and these hypotheses are corroborated for both case studies. On the other hand, however, higher levels of car dependence result in a higher concentration of the carless group in marginal social groups (H1.1) and this also contributes to the observed accessibility and mobility gaps. This has also been demonstrated for both case studies.

In that sense, the varying socio-demographic composition of the carless households group across different types of area is a *key mediating factor* between the level of car dependence of the local area and the observed differences between car-owning and carless households in terms of travel behaviour and accessibility to services and opportunities. As I argue in more detail in §8.2.5 below, this fact must be taken into account when interpreting differences in descriptive statistics between car-owning and carless households/individuals.

Similar considerations apply to H1.6 (changing modal behaviour of carless individuals across different types of area). This emerging hypothesis, however, was tested only for the British case, as indicated by the dashed arrows in Fig. 8.1. For this reason, it is assessed with less certainty.

8.1.2. Question 2

As illustrated in §3.3.3, Question 2 focused on the changing composition of the carless group over time. Notably, two alternative hypotheses were put forward. These are illustrated in Tab. 8.3, along with the empirical results for the two case studies. The rightmost column reports an overall assessment for each hypothesis.

Hypothesis		**Germany**	**Great Britain**	**Overall**
H.2.1	*Over time, non car ownership increasingly concentrated among marginal social groups, notably in car dependent areas*	Partially corroborated, but non-car ownership is *decreasingly* concentrated among retired people, and the overall strength of the relationship between non-car ownership and socio-demographic determinants is stable between 2002 and 2008	Refuted: decreasing concentration among marginal social groups	Refuted
H2.2	*Increasing proportion of younger adults offsetting a decreasing share of older households*	Partially corroborated (not apparent from descriptive statistics, but decreasing association between old age and non-car ownership)	Corroborated	Corroborated

Tab. 8.3 - Research hypotheses for Question 2 and empirical results for the two case studies. Source: own elaboration.

With regard to H2.1, the empirical findings are contradictory. In the German case, the decreasing share of carless households between 2002 and 2008 coincides with a slight increase in the strength of the association (as measured by odds ratios) between non-car ownership and most of its socio-demographic determinants (household size, lack of children, etc.) and a strong increase for income. There is also limited evidence to suggest that this increase was stronger in car dependent areas. However, there is also a marked decrease in the strength of the association between old age and presence of employed members on one hand and non-car ownership on the other – and this too is more pronounced in peripheral and rural areas.

This is consistent with the trend towards increasing motorisation of older people past the age of retirement. Overall, predicting non-car ownership based on socio-demographic variables is not easier in 2008 than it was in 2002, and there is no clear trend across types of area. There is limited evidence to suggest that this is the result of two contrasting trends: decreasing association between non-car ownership and retirement (old age and employment), and increasing association with other socio-demographic determinants (including income).

The empirical results for the British case are more straightforward to interpret. In this case, the strength of the association between non-car ownership and its socio-demographic determinants (as assessed by odds ratios) has decreased in most cases between 2002 and 2010, and remained stable for others. A comparison with figures for the mid-1990s suggests that the association was considerably stronger then. Descriptive statistics suggest that this is the result of non-car ownership decreasing faster for groups generally characterized by lower motorisation levels (low-income households, female-headed households, singles, etc.), as compared to other social groups. While increasing motorisation among the elderly explains part of this trend, it does not account for all of it. Clearly, these results contradict the hypothesis of an increasing concentration of carless households among marginal social groups.

As argued in §3.4.4, continuous NTS data are better suited than MiD for the analysis of trends over time. For this reason, I conclude that H2.1, although partially corroborated by the German data, is refuted.

With regard to H2.2, the empirical findings corroborate the hypothesis. Both in the German and the British case the share of households without cars is decreasing among older people and decreasing (or stable) for young adults. In terms of composition of the carless group, this does not result in a decreasing share of older households in Germany, because of broader ageing trends. In Great Britain, where population ageing is slower, it is clearer that a decreasing share of carless 'over 60' is offset by an increasing share of 'under 60s' (notably 'under 30'), resulting in a stable size of the carless group as a whole between 2002 and 2010. In both countries, the association between old age and non-car ownership (as measured by odds ratios) is decreasing over the period of interest.

8.1.3. Conclusions: car dependence and the socio-demographic composition of the carless group

To conclude this section, it is important to discuss what might appear as a contradiction between the empirical results obtained for Question 1 and Question 2. Admittedly, both H1.1 and H2.1 assumed the existence of a direct relationship between *increasing motorisation and car dependence*, on one hand, and *increasing concentration of the carless among marginal social groups*, on the other. With H1.1, in a *synchronic* perspective, I assumed that the concentration among marginal social groups would be higher in areas characterized by higher levels of motorisation and car dependence. With H2.1, in a *diachronic* perspective, I assumed that the concentration among marginal social groups would be higher at a later moment in time, as a consequence of increasing motorisation and car dependence. The empirical results summarised in §8.1.1 and §8.1.2 show that, while H1.1 is strongly supported by the data for both case studies, H2.1 is refuted. Therefore, what conclusion should be drawn for the 'latent' hypothesis of a direct relationship between increasing motorisation and car dependence, on one hand, and increasing concentration among marginal social groups on the other?

I argue that the *synchronic* approach adopted in H1.1 is a more effective way to test the hypothesis: by comparing areas with very different levels of motorisation, I was able to show how these correspond to different composition of the carless group, and to differences in the strength of the association between car ownership and its socio-demographic determinants. By contrast the *diachronic* approach adopted in H2.1 is, with hindsight, less suitable to detect this relationship, for at least two reasons. Firstly, the period of time considered (2002-2008 and 2002-2010) is arguably too short to correspond to a significant increase in the levels of car dependence of the German and British society. Notably, as I have shown in §4.2.1 and §5.2.1, the trend towards increasing motorisation (and decreasing share of carless households) has slowed down over time, and virtually stagnated since the turn of the millennium. In other words: one of the possible reasons why non-car ownership is not more concentrated among marginal social groups in 2008/2010 than it was in 2002 is that there has been only a slight decrease in the percentage of households without cars over the period of interest. Secondly, this is further complicated by the fact that a powerful demographic trend running in the opposite direction (increasing motorisation among older people) is at work over the period. This tends to obscure any change in the composition of the carless that might be attributed to the (slight) increase in the levels of motorisation over the period.

Therefore, although I refute H2.1, the corroboration of H1.1 provides sufficient support for the thesis that there is a direct relationship between the degree of motorisation and car dependence of a (local) society and the concentration of non-car ownership among marginal social groups. With the benefit of hindsight it is clear that, in order to test the hypothesis with a diachronic perspective, the empirical approach should be improved in two ways. Firstly, a much longer time series (spanning several decades) should be used, in order have enough variation in levels of motorisation. However, many socio-demographic variables (such as income) are not available (or not comparable) for older waves of national travel surveys in Germany and Great Britain. Secondly, methodological solutions (such as following cohorts over time) should be applied in order to control for the confounding effect of powerful demographic trends. These recommendations might be useful for future research in this direction.

8.2. Theoretical relevance and hypotheses for future research

In this section, I discuss the empirical results summarised in §8.1 in light of theoretical, policy and methodological debates. The aim is to show how the findings of this thesis might contribute to these debates. Also, some hypotheses for future research are formulated. Accordingly, this section is structured by topic.

8.2.1. Car dependence

At the theoretical level, the aim of this thesis was to bring together two different strands of research: studies focused on increasing motorisation and its negative environmental consequences and studies in the transport and social exclusion research field. This was accomplished by drawing on the concept of 'car dependence'. This notion was introduced in chapter 1 (§1.4), and then developed in chapter 2 (§2.3) and 3 (§3.1, §3.2). Notably, I have put forward an integrated framework to conceptualise the consequences of the self-reinforcing cycle of car dependence on different forms of car-related transport disadvantage. The research questions and hypotheses for empirical research have been derived from this framework. Fig. 8.2 depicts the empirical findings of this thesis in the context of the theoretical framework. It shows that the findings for several hypotheses can be interpreted as signs of an increasing intensity of car deprivation in areas where the degree of density and urbanity is lower. At the same time, the analysis has also shown that the concentration of carless households in marginal social groups (itself a result of increasing intensity of car deprivation) is a key mediating variable in this process.

Overall, the evidence presented in this thesis supports the proposition that, as land use and the built environment adapt to increasing motorisation, this results in an *increasing* intensity of car deprivation for a *decreasing* proportion of the population – that however is increasingly concentrated among marginal social groups. Therefore, empirical results also show that the composition of the carless group (in terms of socio-demographics, reasons for not owning cars, travel behaviour and accessibility) is a *good indicator for the level of car dependence of a local area*. In that sense, the study provides a practical illustration of how, as Lucas and Le Vine (2009) argue, "one of the most effective and immediate ways in which to identify the benefits of transport in general and car ownership in particular, is to look (at) what happens when people in predominantly car-based societies do not have regular access to a private motor vehicle" (Lucas & Le Vine, 2009, p. 8-9).

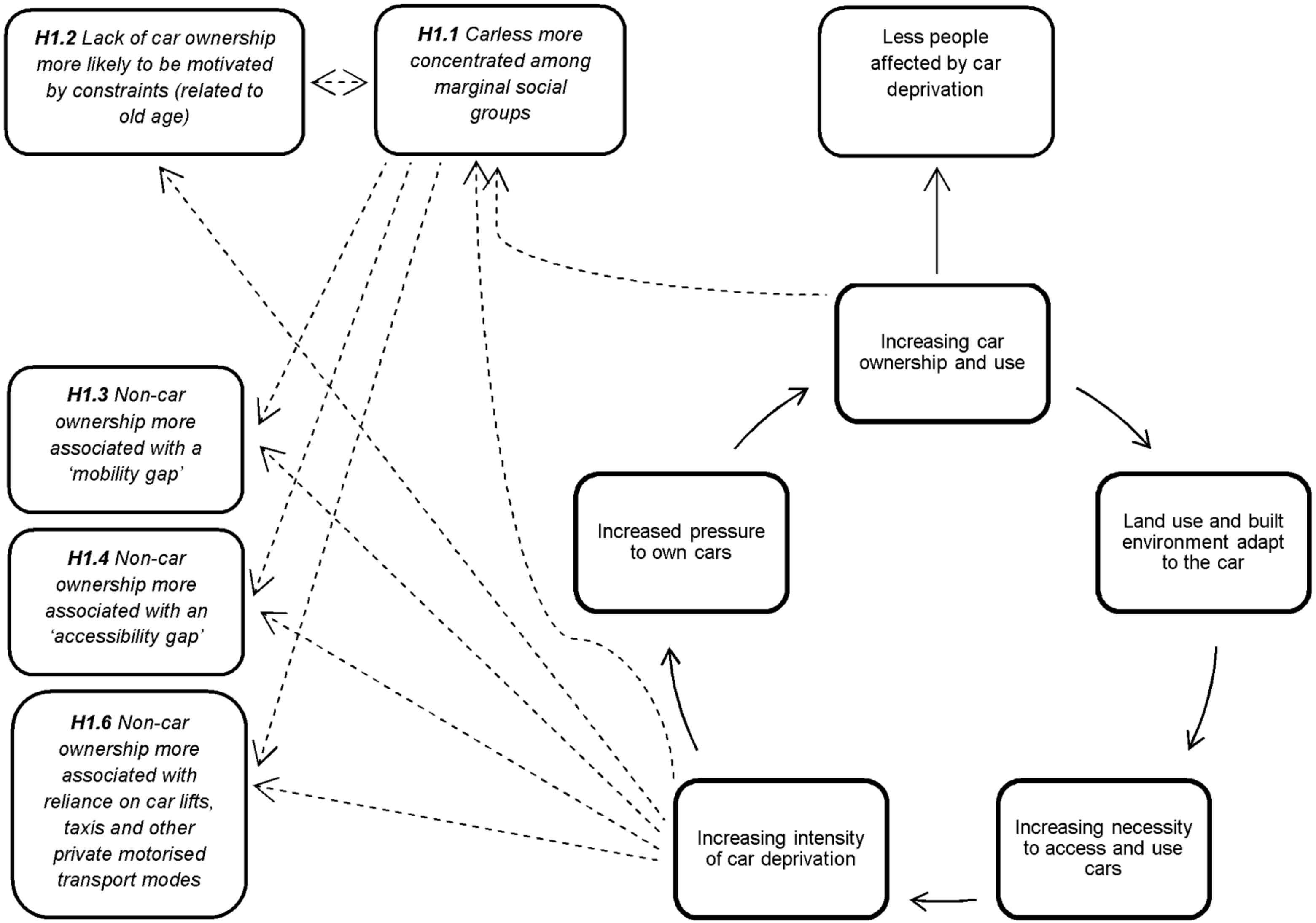

Fig. 8.2 – The cycle of car dependence and empirical results for Question 1. Source: own elaboration.

			High density historic city centre	Low-density suburban / rural areas
Existing research	*Car dependence*		Min.	Max.
	Intensity of car deprivation		Min.	Max.
	Non-car ownership		Max.	Min.
	Dargay (2002)		Highest income and cost elasticity of car ownership	Lowest income and cost elasticity of car ownership
	Smith et al. (2012)		Car not considered part of a minimum acceptable living standard	Car considered part of a minimum acceptable living standard
Empirical results of this thesis	*Households without cars*	*socio-demographics (H1.1)*	Min. concentration among marginal social groups	Max. concentration among marginal social groups
		reasons for not owning cars (H1.2)	Most likely to mention affordability problems, abstinence and lack of need	Most likely to mention constraints related to old age
		travel behaviour (H1.3, H1.6)	Min. 'mobility gap' as compared to car-owners	Max. 'mobility gap' as compared to car-owners
			Min. reliance on car lifts, taxis and other private motorised modes	Max. reliance on car lifts, taxis and other private motorised modes
		accessibility to services and opportunities (H1.4)	Min. 'accessibility gap' as compared to car-owners	Max. 'accessibility gap' as compared to car-owners
Future research	*Car deprivation in low-car ownership households*		?	?

Tab. 8.4 – Evidence from existing research, empirical results of this thesis and directions for future research, with reference to different types of area in the European urban structure. Source: own elaboration.

Also, the empirical findings of this thesis fill the evidence gap on the composition of the carless group, as illustrated in Tab. 8.4 (updating Tab. 3.1). By supporting the thesis that the car is more of a necessity in low density suburban / rural areas, they complement the findings of other studies that have adopted different methodological approaches (listed in the table), shedding light on how this impacts on the composition of the group of carless households.

However, given the definition of ‘carless’ adopted in this thesis (§3.2.1), nothing is said about what are the consequences of higher intensity of car deprivation for members of low-car ownership households who have limited or no access to the household’s car. Admittedly, this is a major blind spot of the approach adopted in this thesis. While several existing studies (reviewed in §2.2.1 and §3.2.1) have focused on this topic, to the knowledge of this author none has yet tried to show how the size and the composition of this group varies across different types of area. This is a possible direction for future research, that would complement the empirical results presented here (as illustrated in the last row of Tab. 8.4).

In this thesis, two typologies of carless households (and individuals) have been put forward. In this context, arguing that the composition of the carless group is a good indicator of the level of car dependence of a local area takes a second meaning. Indeed, transport studies concerned with environmental consequences of increasing car dependence have shown the variety of situations associated with car ownership, both in terms of socio-demographic conditions and preferences. This reflects the policy goal of encouraging modal shift and multimodal travel behaviour among car users. The variety of situations associated with non-car ownership has received comparatively less attention, perhaps reflecting the assumption that the travel behaviour of the carless is less problematic from an environmental perspective.

I argue by contrast that, by showing the variety of situations associated with non-car ownership, the findings reported in this thesis contribute to reveal the structural constraints sustaining car ownership and use. In other words, looking at who non-car owning households are and how they travel sheds light on why many others are reluctant to make do without cars in that area. In the following, I provide some examples of this, based on findings for the British case study. First of all, the fact that the ‘public transport commuters’ cluster is only of a significant size in the largest urban areas, for example, could be taken to indicate that it is only in that type of area that accessing employment and education with public transport is possible without excessive inconvenience. Similarly, the size of the ‘slow and local’ cluster might indicate the extent to which it is possible to access other essential services and opportunities with modal alternatives to the car. Finally, the results show that the ‘car reliant’ and ‘immobile’ clusters are best conceived as the hard core of the carless and represent approximately the same share of the total population across types of area: they are associated mainly with old age, mobility difficulties, low mobility levels and/or reliance on others for car lifts. When most of the carless group is composed of this kind of household, it suggests that powerful structural constraints stand in the way of more environmentally sustainable travel patterns in that area.

8.2.2. The tension between environmental and social goals in the field of transport

As illustrated in §8.1.1., the empirical results of this thesis strengthen previous evidence suggesting that car ownership is more of a necessity as one moves away from compact large cities. 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. This is part of the latent tension between the environmental and the social agenda in the field of transport that I have illustrated in §2.4.7.

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 have a more car-oriented travel behaviour (as illustrated for the British case). On the other hand, social exclusion concerns are also serious:

not only is car deprivation here worse, but there is arguably also a considerable amount of people who experience other forms of car-related transport disadvantage (car-related economic stress, oil vulnerability and car-related time poverty). 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 (as illustrated for the British case), 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. Moreover, the results for the German case suggest that many low income households, who in other areas find car ownership 'too expensive', are here 'forced' into car ownership (see §8.2.6): since they already struggle with car-related economic stress, they would probably be the most vehement opponents of pricing measures (such as national road pricing). 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 more oriented towards modal alternatives (as illustrated for the British case). 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 car-related economic stress, 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.

8.2.3. Transport and the built environment

A major finding of this thesis is the existence of a significant relationship between the type of area, the composition of the carless households group and the main reasons for the lack of a car. While the evidence supporting this conclusion is robust, interpreting it involves additional complexities. While it is tempting to conclude that a less car-oriented built environment is the *cause* of the observed differences, this does not take into account the possibility of residential self-selection (see §1.5.3). In fact, the empirical analysis has used cross-sectional national travel survey data, and none of the strategies usually employed to investigate the issue of self-selection (analysis of travel-related attitudinal variables, retrospective questions, path analysis, complementary qualitative interviews, panel data, etc., see §1.5.3) has been used. As a result, it is open to interpretation to what extent the relationship between the type of area and the composition of the carless households group might (also) be the product of residential self-selection.

In this context, a prudent position, based on the literature review conducted in §1.5.3 and §1.5.4 is to assume that both effects exist: on one hand, the built environment influences the size and the composition of the carless households group; on the other hand, residential self-selection processes are also at work. However, it is also reasonable to assume that the first mechanism is predominant.

In this section, because of limitations in the available data, I am not able to demonstrate what is the relative weight of the two mechanisms. However, I am able to illustrate how my research findings add on to existing knowledge on car ownership and the built environment, and suggest some directions for future research.

Firstly, with regard to the influence of the built environment on car ownership it is important to recall that, as illustrated in §1.5.2, the effects of different spatial features of the local areas (such as density, diversity, location in the urban hierarchy, etc.) are multicollinear; as a result, their effects are extremely difficult to disentangle. Therefore, it is not possible to draw from this study clues on how urban planners should design neighbourhoods that encourage as many households as possible to live without cars. However, the empirical results of this thesis highlight that the composition of the carless households group varies across types of area (defined by municipality size), but also with micro-level characteristics such as population density in the 1*1km pixel around the residence (for Germany) and in postal code zone (for Great Britain). In most cases, the figures for these micro-level variables were not reported in the main text for the sake of brevity. This does not necessarily imply that higher population densities at the micro-level *per se* lead to a lower concentration of non-car ownership among marginal social groups. However, it suggests that this is an hypothesis worth exploring in future research.

With regard to the residential self-selection debate, Scheiner has argued that, as car dependence increased during the last decades, large cities have become “the last areas where one can still live without a car and where car-less households are gathering, regardless of whether their car-less life is voluntarily chosen or caused by a lack of resources” (Scheiner, 2010, p. 83). As Scheiner argues, this was not the case just two or three decades ago (2009a, p. 94), and should thus be considered as the result of the widening gap between areas in the process of motorisation and the increasing importance of the area of residence as a determinant of travel behaviour (see §4.2.1, §5.2.1). On the other hand, the work conducted by Motte-Baumvol et al. (2010) on the metropolitan area of Paris has shown that, over the decade 1990-1999, carless households and (to a lesser extent) low-income households have shown a higher-than-average propensity to migrate away from car dependent suburban municipalities and towards less car dependent areas (such as inner city locations). In the words of the authors, “the inner city (has become) a haven for households burdened by car dependence” (p. 614) and “residential mobility provides a way to escape car dependence in periurban areas” (p. 607). To adopt the terminology put forward in this thesis, this happens because households migrate towards locations where the intensity of car deprivation and car-related economic stress is lower. Furthermore, Motte et al. (2010) show that these residential migration patterns have contributed significantly to the reduction in the proportion of carless households in car dependent periurban areas, “clearly transforming the social composition of certain areas in the outer suburbs” (p. 617).

The empirical findings of this thesis add on to this research debate by showing that the composition of the carless group is radically different in different types of area. Notably, I have shown that the carless households group is strongly concentrated among marginal social groups (especially older people) in car dependent areas. In this context, it would be interesting to investigate, from a diachronic perspective, if and to what extent this is a by-product of the residential migration of other types of carless households towards less car dependent areas. Conversely, my research findings show that the group of carless households is considerably more diverse in inner cities: notably certain types of carless (such as households with children or people in employment or education) are found virtually only in large urban areas. In this context, it would be interesting to investigate how many of these households have actually been attracted to urban areas by the chance to live without car that it offers.

In this context, another hypothesis is inspired by Melia, Barton and Parkhurst (2011) who, based on a small survey on potential residents in car-free areas in Britain, show that many of the young and comparatively wealthier ‘car choosers’ found in inner cities are determined to migrate ‘near the countryside’ at a later stage in life (p.9). This suggests an alternative way to explain the greater variety of carless households in inner cities. Indeed, the results of this thesis show that younger and student households without cars are significantly more likely to be found in inner cities (see the ‘public transport commuters’ cluster for the British case and the ‘economically car deprived’ cluster for the German case). On one hand, this can be taken to confirm that built environment configurations are less car dependent in inner cities, thus allowing a greater variety of households (including also those who are in education) to live without cars. An alternative explanation, however, would suggest that students in their 20s tend to migrate to urban areas (from the more car dependent areas where they grew up) in order to pursue higher education. During this phase, for other reasons, unrelated to the built environment (lower income, single living, etc.), they are also less likely to own cars. After this life stage, former students are more likely to ‘move back’ to the more car dependent areas where they grew up. If this was true, it would explain at least part of the greater socio-demographic diversity of the carless households group in urban areas.

Clearly, investigating these research questions would require the use of longitudinal data, including information about residential location and car ownership levels of households (before and after moving to urban areas), or at least retrospective questions. Notably, the hypothesis of a temporary 'urban and carless' life stage for young adults would be best explored with a 'mobility biography approach' (Scheiner, 2009a).

Overall, the possibility that residential self-selection processes explain part of the observed differences in the composition of the carless group across different types of area should not be taken to suggest that the built environment has no relevance, or to disprove the hypothesis that the composition of the carless group is a good indicator of the level of car dependence of a local area. In fact, as illustrated in a review of existing research on residential self-selection (§1.5.3, §1.5.4), it is reasonable to assume that, while both mechanisms are at work, the built environment effect is predominant. Therefore, the empirical results of this thesis tend to support the conclusion reached by Preisendörfer and Rinn (2003), who have argued that:

> "in large cities there is undoubtedly a considerable potential for living without car ownership without this resulting in important limitations. In light of this circumstance, the argument (prevailing in urban transport planning and policy) that non-car ownership as an alternative is out of the question, appears mistaken and defeatist" (Preisendörfer & Rinn, 2003, p. 175, own translation)

8.2.4. A variety of forms of car deprivation

In this and the following two sections, I focus on the implications of the empirical findings for the debate on transport and social exclusion. Notably in this section, I focus on what the findings reveal about the variety of forms of transport disadvantage that, in this thesis, have been subsumed under the label of 'car deprivation' (§2.2.1).

Of course, it must be remembered that car deprivation is defined in this thesis as the transport disadvantage that might derive from not having access to cars – rather than ownership. Therefore, as acknowledged above, a major blind spot of the approach adopted in this thesis is that, by defining the 'carless' as 'individuals in households without cars' it overlooks the transport disadvantage that affects some members of 'low car ownership' households. This is arguably yet another form of car deprivation – although one that is not taken into consideration in this section.

One of the main results of this thesis is to show the variety of conditions that are associated with non-car ownership. However, as argued in §3.3.2, it is important to stress that the goal of the study was not to identify those carless households who are transport disadvantaged, distinguishing them from those who are not. Indeed, the data used are unsuitable to achieve this goal, as they provide only limited information about access to services, opportunities and networks. It is possible however to discuss the typologies of carless households put forward in this thesis (§6.1.3, §7.1.3) in light of existing evidence on transport disadvantage (§2), and to draw from this clues about which forms of transport disadvantage *might* affect the different groups. In this context, the main goal is to elaborate hypotheses for future research, that ideally should be based on ad-hoc surveys, adopting a qualitative approach or conducting a more in-depth analysis of the datasets used here.

Arguably, an approach that deliberately acknowledges the variety of conditions associated with non-car ownership provides a welcome antidote to the tendency to assume that lack of car ownership is *per se* conducive to serious transport disadvantage, as it is sometimes the case in transport and social exclusion research. In fact, while studies in this field have devoted considerable attention to the issue of car deprivation, they have often (and understandably) focused on the most marginal and immediately policy-relevant types of carless households. An inadvertent outcome of this situation is that the overall view of the sheer variety of forms of transport disadvantage associated with lack of car access is lost.

In the remainder of this section, I do not review all the types of carless households / individuals identified by the classification analysis illustrated in §6.1.3, §7.1.3. Instead, I focus on two extreme types: the goal is to provide a clear illustration of how non-car ownership might result in very different forms of transport disadvantage.

Firstly, the analysis has shown that a considerable proportion of carless households, in all types of area, consists of old and very old people. In Germany, '(old) age-related' clusters include those households who put forward old age, health and lack of driving licence as the main reasons for not owning a car. The analysis of their self-assessed accessibility levels suggests that they experience great difficulties in accessing even the most basic services and opportunities (such as shops for the daily shopping). Notably, they report low levels of walking accessibility, something that is probably related to the high incidence of health-related mobility difficulties. Also in the British case, there is a 'hard-core' of older carless individuals in all types of area, including two groups, both characterised by their low use of modal alternatives to the car. The low to non-existent mobility levels of the 'immobile' cluster can be interpreted as the consequence of other forms of disadvantage (such as illness). In any case, this is likely to result in poor access to essential services and opportunities and/or in extreme dependence on others. The 'car reliant' cluster is interesting in that it shows how older non-drivers (a great majority of cluster members do not have a driving licence) can also be very dependent on the automobile for their daily activities: when this is the case, they are very much dependent on others for travel. Existing literature in the transport and social exclusion research field suggests that such reliance on car lifts, while it can partially offset their transport disadvantage (Gray et al., 2006), can be a burden for those who offer lifts (Rosenbloom, 2010) and challenge the sense of independence of the elderly (Davey, 2007), with potential knock-on effects on their well-being (Currie, 2011a). In short, existing research suggests that a strong reliance on car lifts can also be considered as a form of transport disadvantage for the elderly.

Overall, the empirical results suggest that there might be serious forms of transport disadvantage for *some* (though by no means all) of the elderly households who live without cars. There are hints that this might result in difficulty of access to basic services and opportunities, strong dependence on family and friends and drastic reductions in mobility. Interestingly, the findings suggest that this constitutes a 'scattered' form of non-car ownership, accounting for approximately the same share of the total population in all types of area. While the analysis shows that problems of access are more severe in low-density, car dependent areas, they also suggest that they might be serious also in inner cities. The reason for this is that accessibility problems here arise mostly from individual characteristics (e.g. disability), rather than from attributes of the transport systems and the built environment (even though these can of course aggravate these problems).

What do these empirical results tell us about possible policies to tackle the transport disadvantage of this group of people? Without trying to be exhaustive, in the following I elaborate on the implications of these findings for policy measures suggested in the transport and social exclusion research literature.

As illustrated in §2.4.5, Hine and Mitchell (2003) have argued that 'scattered' transport disadvantaged "can be better served through new information technologies where reservation systems can be used for demand responsive transport" (p. 129). This provides an illlustration of how 'virtual mobility' policies (§2.4.5) may interact with the provision of 'flexible' public transport and 'community transport' (see §2.4.3). The empirical results of this thesis challenge this policy direction. Indeed, they suggest that older people without cars might constitute an important form of 'scattered' transport disadvantage. However, they are unlikely to be able to take advantage of the opportunities offered by ICTs. Indeed, as illustrated in §6.1.1 (Tab. 6.17), only a minority of German carless households in 'age-related clusters' has a home computer with internet access. This suggests that for a substantial proportion of carless households, the scope for implementing ICT-based policy measures is very limited. This demonstrates that there is a 'virtual mobility-related dimension' of social exclusion (Kenyon et al., 2002) and that there is an urgent need to study how "transport poverty meets the digital divide" (Velaga, 2012), as acknowledged in the literature.

The same kind of objection could be raised against car-based solutions. Measures such as car clubs, car sharing and subsidies to car ownership and use are often proposed as a solution to the transport disadvantage of people without car access in low density areas, where they are arguably better suited than public transport to provide access to services and opportunities. The paradox is that, as illustrated in these thesis, a large proportion of carless households in these areas consists of older people who do not have a driving licence, and are extremely unlikely to get one. Accordingly, they are the least likely to benefit from these initiatives. Of course, such measures may be helpful for members of low-car ownership households who have only limited access to cars, as well for carless individuals who have a driving licence: however, the former are difficult to quantify, while the latter constitute a very small percentage of the population in these areas. If the goal is to help the bulk of carless households, other measures, such as flexible public transport and community transport services, are probably better suited to improve the living conditions of older people and of their car-owning relatives and friends in these areas.

More broadly speaking, the existence of a 'hard-core' of elderly among the carless shows the limits of measures aimed at promoting car ownership and use (§2.4.4). Indeed, it shows that even in the most car dependent areas there is a non negligeable share of households who – mostly for reasons of age and/or disability – are not able to use cars. Far from solving their accessibility problems, further increases in motorisation would only increase the intensity of car deprivation, thus worsening their situation.

Finally, the empirical results of this thesis help make sense of the results of previous research suggesting that there is a base-level of non-car ownership. For example, Lucas and Jones (2009), with reference to Great Britain, observe that there is a 10% of carless households in the top income quintiles (where income is no constraint on car ownership), a proportion similar to that observed in rural areas (where car dependence is strong) (p. 27). They conclude that 10% "may represent a base level of non-car ownership" (*ibidem*). The empirical results of this thesis strongly suggest that this base level consists mostly of older people, and that reasons related to lack of driving licence and health-related mobility difficulties are likely to be relevant.

The second type of carless that I consider in this section is the polar opposite of the former in several respects. As illustrated for both case studies, it is only in large cities that the carless group includes a substantial proportion of individuals who participate in employment or education. In the German case study, these are mostly found in the 'car abstinence' and the 'economically car deprived' clusters. In the British case study, they are gathered in the 'public transport commuters' cluster. In large cities, the values for these clusters on indicators of travel behaviour and accessibility are very close to those of car-owning individuals, suggesting that they are better off than other carless. However, it would be unwise to conclude that they do not experience any kind of disadvantage. In fact, this type of carless spends a great amount of time travelling. For example, 'public transport commuters' spend approximately one one hour more travelling per week than the average Briton, and they do not seem to travel much for reasons other than work or education. Similarly, 'non age related' clusters in Germany spend more time travelling than their motorised counterparts in most types of area, and notably in large cities. Such long travel times must be attributed to reliance on alternative modes (mostly public transport) that are slower than the car. This suggest that the lack of a household car might result in longer commuting times than would be otherwise, as observed in the literature (Farber & Páez, 2011). This in turn can result in 'time poverty', leading people to miss out activities that are essential for participation in society, and thus to social exclusion. Indeed, as argued in §2.2.1, time poverty is one of the possible ways in which car deprivation arises. While further research is certainly required to explore this question more in depth, the results of the analysis presented here suggest that this particular form of transport disadvantage – perhaps counter intuitively – might be more widespread in the *least* car dependent areas. This happens because it is only in such areas that a substantial proportion of people who participate in employment or education 'dare' to live without cars: while this might bring about several advantages (such as less expenditure for transport, see §8.2.6), the empirical results of this thesis suggests that it also entails the risk of travel-related time poverty.

To sum up, the empirical results of this thesis do not provide an answer to the question 'which carless do actually experience transport disadvantage?'. However, I put forward typologies of non-car owners (for both case studies) that might might serve as a blueprint for further studies based on ad-hoc surveys or adopting a qualitative approach. So for example, researchers interested in investigating car deprivation in large cities might do well to include time poverty among their objects of interest. Conversely, researchers investigating the transport disadvantage of carless households in rural areas will most likely have to deal with issues related to old age, health-related mobility difficulties and reliance on others for lifts.

8.2.5. A variety of carless households: methodological implications

As argued above, the main result of this thesis is to show the variety of conditions associated with non-car ownership. This has substantial implications for future research on car deprivation, as argued in the previous section (§8.2.4). However, it also has *methodological* implications for future research on non-car ownership, notably in the field of transport and social exclusion research.

As illustrated in §2.1.4, much research on transport and social exclusion has made use of what Delbosc and Currie (2011a, p.158) define 'anectodal evidence'. This term refers to the use of descriptive quantitative analysis to show patterns of inequality in travel behaviour and access, with a particular eye for social groups traditionally considered at risk of social exclusion, such as for example the carless. In practice what happens is that the average values for two or more groups (for example car-owning and carless households) on a given variable assumed to be a proxy for transport disadvantage (for example the time spent to access key services) are compared; the results are generally interpreted as indicative of a causal relationship between the sorting variable (in this example, car ownership) and transport disadvantage.

It is now acknowledged that this approach to the analysis of quantitative data has several limitations. As these have been discussed at length in §2.1.4, they are not repeated here. In this section, I aim to show how the particular characteristics of the carless households population greatly increase the risk of drawing misleading conclusions when applying the 'anecdotal evidence' approach. Overall, the data analysis illustrated in chapter 6 and 7 has shown that the carless households group is peculiar in several respects:

- firstly, in terms of *socio-demographics*, it is very different from the population average. Notably, as a whole, it is concentrated among marginal social groups
- secondly, in terms of *territorial distribution*, it is concentrated in large cities and high-density areas. This means that, in the carless households group, urban residents are strongly overrepresented and rural residents strongly underrepresented
- finally, again in terms of *socio-demographics*, the results of this thesis show that the composition of the carless households group varies considerably across different types of area. Notably, I have shown that the concentration of the carless households group among marginal social groups increases substantially as the degree of urbanity and density decreases. While the first two factors were known before, the third is a novel conclusion

Arguably, not taking into account all three factors might lead to wrong conclusions about the impact of non-car ownership on travel behaviour and/or access, and thus on transport disadvantage. In detail:

- with regard to the first factor, comparing the average of car-owning and carless households on a given indicator is potentially misleading, as the observed differences might be the by-product of socio-demographic differences between the groups. For example, the carless are on average less mobile (in terms of trips and travelled distance) than their motorised counterparts. However, this is also due to the fact that the carless group includes a substantial proportion of older people, who are generally less mobile. Therefore, not taking into account the different socio-demographic composition of the carless group might lead to overestimate the impact of non-car ownership on transport disadvantage
- with regard to the second factor, comparing the average of car-owning and carless households on a given indicator is potentially misleading, as the observed difference might be the by-product of the different territorial distribution of the two groups. For example, as illustrated in chapter 7 (Tab. 7.25), carless adults in Great Britain are more likely to report travel difficulties travelling to the doctor or the hospital than their motorised counterparts. However, this obscures the fact that, in most types of area, the difference between the two groups is much greater. The fact that most carless households are found in large cities and metropolitan areas (where the difference is smaller) tends to obscure this fact. Therefore, not taking into account the concentration of carless households in certain types of area might lead to overlook the transport disadvantage associated with non-car ownership
- a possible solution to this problem is to control for territorial differences, and compare carless and car-owning households only within the same type of area. For example, the analysis reported in

chapter 6 and 7 shows that the mobility and accessibility gap of carless households (as compared to motorised households) is lowest in large cities, and widens progressively as one moves towards small towns and rural areas. However, this does not take into account the varying socio-demographic composition of the carless group across different types of area: as I have illustrated, the widening mobility and accessibility gap is in part the by-product of this phenomenon.

To sum up, the particular features of the carless households group increase the risk of drawing wrong conclusions, or overlooking interesting phenomena, when analysing quantitative data. Notably, the simple comparison of average values for car-owning and carless households/individuals should be considered as particularly risky.

More broadly speaking, the results of the this thesis, emphasising the variety of conditions associated with non-car ownership, might be useful to interpret the results of previous research. In the remainder of this section, I provide one example of this. Obviously, the goal is not to criticize previous research, but rather to emphasise the added value of the approach adopted here.

Lucas and Jones devote a section of their report on "the car in British society" (2009) to "car use among non car-owning households" (p. 45-50). Based on NTS data, they observe that the modal share of the car is high also for carless households, and notably in rural areas and for food shopping trips. They interpret this result as yet another sign of the "dominance of the car in British society", whereby "people living in non-car owning households are placed at considerable disadvantage, as many activities essential to daily economic and social life are now less accessible to those who cannot travel by car" (p. 51). However, in another section, they illustrate a quite contradictory result, namely that "adults who are drivers in a non-car owning household are least common in rural areas and most common in the largest settlement category" (p. 60).

The results of the cluster analysis conducted for the British case shed new light on this evidence. Indeed, they show that, while it is true that some carless households make extensive use of cars (mostly as passengers), taxis and other private motorised modes of transport, these are strongly concentrated in a group (the 'car reliant' cluster) characterised by old age and high incidence of mobility difficulties. While this group accounts for a stable proportion of carless households across types of area, other forms of non-car ownership exist, and actually account for the majority of the carless households group. In these clusters ('slow and local' and 'public transport commuters') the car accounts for a marginal share of trips and travel distance (see Tab. 7.16). Interestingly, PTC is also the cluster with the highest driving licence ownership rate: the fact that they are strongly concentrated in urban areas explains the paradoxical finding mentioned above. Conversely, the stronger reliance of rural carless households on car lifts is (also) explained by their stronger concentration among older people ('car reliant' cluster).

Overall, the empirical findings of this thesis mitigate the conclusion of Lucas and Jones (2009) that, since even carless households rely on the car for travel, non-car ownership is conducive to transport disadvantage. Indeed, by showing the variety of forms of non-car ownership, I am able to show that for the majority of British carless individuals the modal share of the car is very low. This example provides an illustration of how, as argued above (§8.2.4), showing the variety of forms of non-car ownership counters the assumption that non-car ownership necessarily results in serious transport disadvantage.

8.2.6. The complementary relationship between car deprivation and car-related economic stress

As illustrated in §8.1.1, hypothesis H1.2 is not fully corroborated by the empirical results for Germany. In fact, the original hypothesis assumed that carless households in car dependent areas would be more likely to mention constraints (rather than choice and lack of need) as reasons for not owning cars. However, the empirical results show that carless households in small towns and rural areas are more likely to mention constraints such as age and health reasons and lack of driving licence, but actually less likely to report affordability problems. In fact, the size of the clusters defined by affordability problems ('economically car deprived' and, to a lesser extent, 'car abstinence') increases as the degree of urbanity increases. This goes against the expectations set by H1.2.

How to explain this result? In this section, I argue that this result is consistent with existing evidence on car-related economic stress (§2.2.2). In the following, I make the connections between my empirical results for this hypothesis, the 'car dependence' theoretical framework and the literature on car-related economic stress: this allows me to put forward a new hypothesis, to be tested in future research.

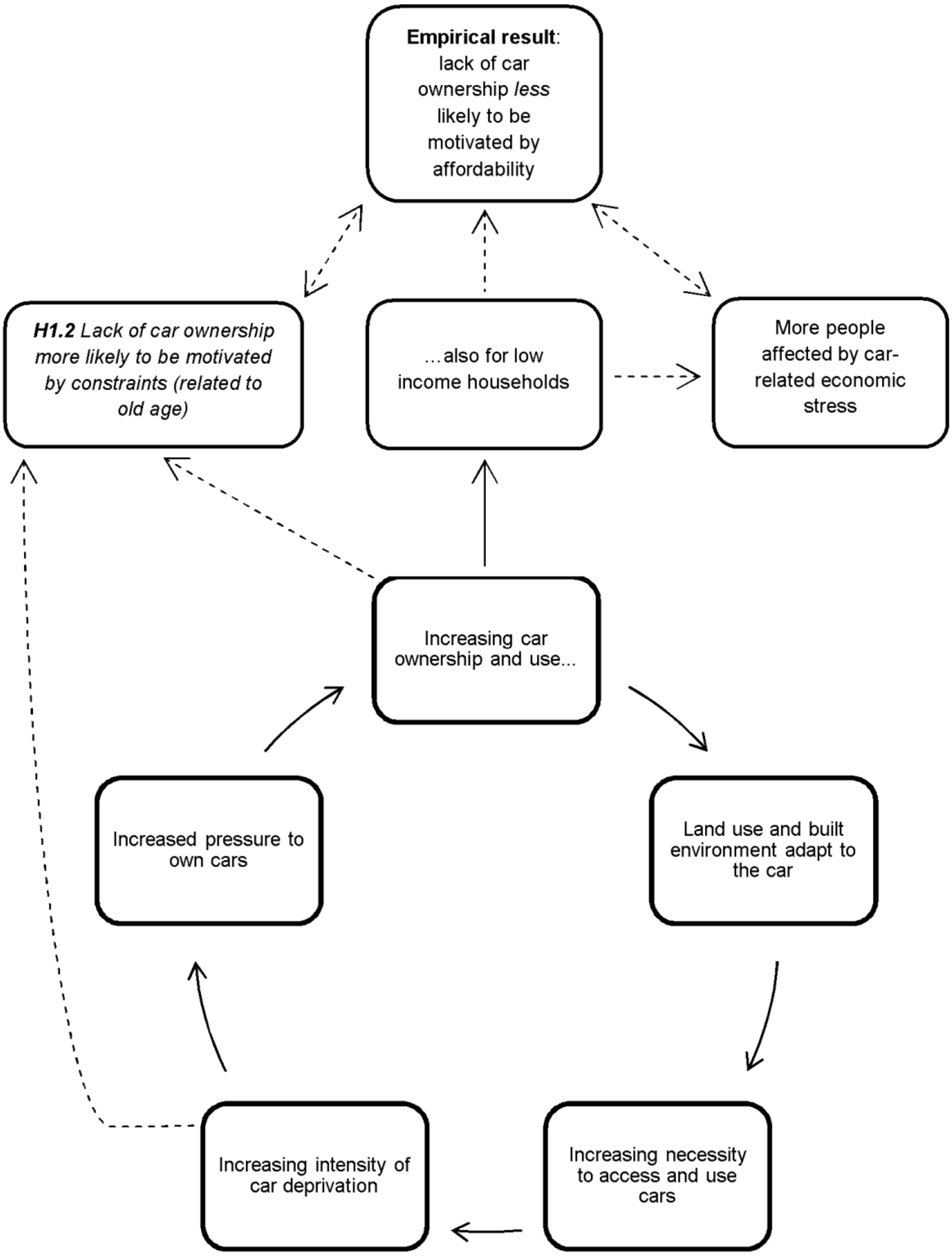

Fig. 8.3 – The cycle of car dependence, hypothesis H1.2 and empirical results. Source: own elaboration.

Fig. 8.3 shows the cycle of car dependence, along with the empirical results for hypothesis H1.2. It shows that, as expected, increasing levels of car dependence (implying increasing intensity of car deprivation) result in an increasing concentration of non-car ownership among households who put forward age reasons. As argued in §3.1.2, however, increasing motorisation means that an increasing proportion of low income households become car-owners: this in turn means that the number of people affected by car-related economic stress increases. Conversely, the fact that more low income households own cars, means that *less* low income households are part of the carless households group. This in turn explains why, as car dependence increases, the carless are less likely to mention affordabilty problems. In other words, the cycle of car dependence gradually transfers low-income households from non-car ownership (probably motivated by affordability problems and possibly associated with transport disadvantage) to car ownership (possibly associated with car-related economic stress).

But why does this happen for affordability problems, but not for other constraints (such as old age and health-related mobility difficulties)? The reason is arguably that low income is a *weaker* constraint to car ownership, as compared to others (such as age and health). This point is developed further in the next section (§8.2.7).

	High density historic city centre	**Low-density suburban / rural area**
Car deprivation	More people affected Minimum intensity	Less people affected Maximum intensity
Non-car ownership *(empirical results of this thesis)*	Less concentrated among marginal social groups Less likely to be motivated by constraints related to old age More likely to be motivated by economic reasons	More concentrated among marginal social groups More likely to be motivated by constraints related to old age Less likely to be motivated by economic reasons
Car-related economic stress	Less people affected Minimum intensity	More people affected Maximum intensity
Households in car related economic stress *(hypothesis for future research)*	More concentrated among groups defined by strong socio-demographic reasons for owning cars	Less concentrated among groups defined by strong socio-demographic reasons for owning cars

Tab. 8.5 – Forms of car-related transport disadvantage (across different types of area in the European urban structure), empirical results of this thesis and hypothesis for future research,. Source: own elaboration.

Overall, I argue that there is a complementary relationship between lack of car ownership motivated by economic reasons and car-related economic stress: more of the former means less of the latter, and vice-versa. This is arguably true also in a synchronic perspective, i.e. when different types of area are considered. This is illustrated in Tab. 8.5, updating Tab. 2.1 with the empirical results of this thesis and a new hypothesis for future research. The table suggests that in high density areas in large cities there are less households affected by car-related economic stress. At the same time, however, these households will probably be more concentrated among households who, for other reasons (such as the presence of children, participation in employment, etc.) are unable to give up the car, despite the financial burden associated with it. By contrast, I expect the group of households affected by car-related economic stress in low-density suburban and rural areas to be not only larger, but also less concentrated among particular social groups. In other words, I expect car-related economic stress to be more of a cross-cutting condition in car dependent areas. In more formal terms, I expect the association between the socio-demographic determinants of car ownership and being in car-related economic stress (as measured by odds ratios and goodness-of-fit statistics of logistic regression models) to increase with the degree of urbanity of the local area. In this context, income should probably not be included among the socio-demographic predictors, as low income is likely to be strongly associated with car-related economic stress in all areas (and possibly less so in car dependent areas, where the problem could affect even wealthier households). A way to get around this problem might be to limit the analysis only to low-income households.

This hypothesis for future research is the 'mirror image' of H1.1: indeed, it is reasonable to assume that, in the most car dependent areas, non-car ownership is concentrated among particular social groups, while car-related economic stress is widespread. The opposite goes for the least car dependent areas, where a greater range of households live without a car, while car-related economic stress is concentrated among particular social groups who, despite low income, are unable to give up the car.

Overall, the theoretical framework and the research hypothesis put forward in this section are driven by the belief that there is a *complementary relationship* between car deprivation and car-related economic stress. In the least car dependent areas, where non-car ownership is less concentrated among marginal social groups and many people are affected by (less serious forms of) car deprivation, car-related economic stress will affect less people, and will be more concentrated among particular social groups. Conversely, in the most car dependent areas, where non-car ownership is more concentrated among marginal social groups, and only a few people are affected by (more serious forms of) car deprivation, car-related economic stress will affect more people, and will be a more widespread condition, less concentrated among particular social groups. However, it is important to observe that this discussion implicitly assumes that only individuals living in households without cars experience car deprivation: however, as acknowledged above, this ignores the issue of car access in low-car ownership households. Taking into account this issue is likely to change the considerations made here considerably.

8.2.7. Choice and constraint in car ownership behaviour

The unexpected results for hypothesis H1.2 can be discussed also with reference to another theoretical debate, more closely related to the environmental sustainability debate. As illustrated in §4.2.2 and §5.2.2, previous studies on carless households both in Germany and in Great Britain have mostly tried to distinguish those households who 'choose' from those who are 'forced' to live without cars. This is consistent with what Shove (2010) has defined as the dominant 'ABC' paradigm of climate change policy and research, whereby the goal of public policy is to encourage people to 'choose' environmentally responsible behaviour by influencing their attitudes.

The original formulation of hypothesis H1.2 deliberately adhered to this approach. Indeed, it assumed that carless households in low density areas (where choice is constrained by a car-oriented built environment) would be more likely to mention constraints as reasons for not owning cars. Conversely, carless households in compact cities (where choice is less constrained by the built environment) were expected to mention 'choice' and 'lack of need' more frequently.

As discussed in §6.1.5 and §8.2.6, the empirical results for the German case strongly suggest that the opposition between 'choice' and 'constraint' that was implicit in hypothesis H1.2 was too rigid. In light of the findings, I argue that 'absolute' and 'weaker' constraints to car ownership should be distinguished. Impediments such as disability and lack of driving licence ownership among older people are apparently very hard to overcome: this is shown by the fact that a 'hard-core' of carless who mention old-age related reasons is found in all types of area. By contrast, the size of clusters that mention economic reasons is extremely variable depending on the type of area. This suggests that affordability problems are a weaker constraint to car ownership: in areas where car ownership behaviour is more constrained by the built environment, low income households 'choose' to acquire cars (thus possibly experiencing car-related economic stress); in areas where the built environment is less car oriented, they are more likely to 'choose' to live without cars, thus possibly experiencing car deprivation. This illustrates the complementary relationship between car deprivation and car-related economic stress described in the previous section (§8.2.6).

This picture suggests that the emphasis on 'choice' of existing research on non-car ownership is misplaced. At the least, the results of this thesis suggest that 'absolute' constraints to car ownership (such as disability) should be distinguished from 'weaker' constraints (such as low income). Notably the fact that low-income households often have to choose between 'two evils' (car deprivation and car-related economic stress) should be acknowledged. At the most, these results suggest that the radical criticism that Shove (2010) addresses to the 'ABC' paradigm is well deserved in the case of car ownership behaviour. In this thesis, I have tried to show that it is possible to investigate non-car ownership with an approach that does not (only) focus on questions of choice.

The distinction between weaker and absolute constraints to car ownership is not without consequences for future empirical research on non-car ownership. Much existing research seems to move from the assumption that low income is the strongest constraint to car ownership. For example Preisendörfer and Rinn (2003), commenting on a previous study on carless households, argue that "those who cannot afford a car constitute the core group of forced (*unfreiwillig*) carless households" (p. 38, own translation). A similar assumption underpins the 'priority' variable in the MiD 2008 database, that summarizes in five categories the 64 possible patterns of response for the 'reasons for not owning a car' items. Indeed, as illustrated in §6.1.3, the variable assumes the following order of priority: 'too expensive', 'health reasons' or 'age reasons', 'not necessary', 'deliberate abstinence', 'other reasons'. In light of the results of this thesis, this order of priority is highly questionable. Notably, while it makes sense to assume that 'constraints' have a higher priority than other factors, my analysis suggests that age and health-related reasons should have higher priority than 'too expensive' (rather than the other way around). Moreover, the fact that, as illustrated by the typology put forward in §6.1.3, many of those who chose 'other reasons' are older people without a driving licence (another 'absolute' constraint according to my interpretation) suggests that assigning the lowest priority to this answer category is not appropriate. To sum up, with regard to the 'reasons for not owning a car' questions in the MiD 2008 database, the results of this thesis suggest that, at the least, the assumptions about the order of priority should be modified. At the most, they show that a typology based on latent class analysis allows researchers to summarize the 64 possible patterns of response in a few categories, without having to make arbitrary assumptions about the order of priority.

Finally, it is worth pointing out what are the substantive implications of using the 'priority' item in MiD 2008. Assuming *a priori* that economic reasons are the most important constraint to car ownership obscures the fact that affordability is a weaker constraint as compared to age and health, and leads to overlook evidence suggesting that there is a complementary relationship between car deprivation and car-related economic stress (see §8.2.6).

8.2.8. Reasons for decreasing car ownership among young adults

As illustrated in §1.1.5, a decrease in car ownership, use and driving licence ownership has been observed in recent years in some developed countries, including Germany (§4.2.2) and Great Britain (§5.2.2). As illustrated previously in this thesis, different explanations have been put forward for this trend, but the debate is still very open.

The results for hypothesis H1.2 (§6.1.3) allow me to contribute to this debate, albeit only with reference to the German case and to car ownership. Indeed, the results depicted in Fig. 6.18 suggest that the 'economically car deprived' cluster (including mostly people who mention only economic reasons for not owning cars) constitutes the relative majority of carless households in the age group 18-29. Moreover, the combined size of 'economically car deprived' and 'car abstinence' (the two clusters characterised by higher than average likelihood of mentioning economic reasons), is much higher for young adults than for any other age group. While this result does not allow to conclude that economic reasons are the main determinant of the recent increase in non-car ownership among young adults, it strongly suggests that economic reasons were a very important reason for not owning cars for German young adults in 2008.

PART V – APPENDIX

Appendix A. Data analysis techniques

In chapters 6 and 7, different multivariate data analysis techniques are used. In this chapter, these techniques are described in detail.

A.1. Logistic regression models

In chapters 6 and 7, the results of various logistic regression models are presented and discussed in detail. In this section, further information about logistic regression is provided. All analyses reported in chapters 6 and 7, as well as in Appendix B and Appendix C were conducted using Stata version 11.1.

A.1.1. Multiple regression

Logistic regression models belong to the broader family of Multiple regression/correlation analysis (MRC). (Cohen, et al. 2003). In the words of Cohen et al., MRC is

> "a highly general and therefore very flexible data analytic system (that) may be used whenever a (..) dependent variable (Y), is to be studied as a function of, or in relationship to, any factors of interest, the independent variables (IVs)" (Cohen, et al. 2003, p.1)

The most general form of multiple regression equation is the following formula (Cohen, et al. 2003, p.9):

(A.1.1.) $$Y = a + bU + cV + dW + eX + \dots$$

Where a, b, c, d and e are constants, and U, V, W and X are the independent variables or predictors (Cohen, et al. 2003, p.9). This is *multiple* regression because there is more than one predictor. While this is a linear formula (on a graph it would be depicted by a straight line), it is important to note that multiple regression models are very flexible and can be used to describe more complex relationship, in at least two respects (Cohen, et al. 2003, p.6-9).

Firstly, with only slight adjustments to eq. *(A.1.1.)* (or to the independent variables) multiple regression models can be used "to represent any degree or type of shape (of the relationship)" (Cohen, et al. 2003, p.9). A typical example is when the researcher assumes that the relationship between two variables is not linear, but rather *curvilinear* (Miles & Shevlin, 2001, p. 137-150). In this case, the researcher has to use a *quadratic equation* to represent the relationship, as in the following formula (Miles & Shevlin, 2001, p. 140):

(A.1.2.) $$Y = a + bU + cU^2$$

In the new equation, the addition of quadratic term allows the line describing the relationship between Y and U to change direction once, and the model to represent the curvilinear relationship between the two (Miles & Shevlin, 2001, p. 140). Adding further elements (cubic term, fourth-power term, etc.) allows the researcher to model relationships where the line changes direction more than once (*ibidem*).

Secondly, as Cohen et al. (2003) argue, in MRC:

> "the nature of the dependent variable is (..) not constrained. Although MRC was originally developed for scaled dependent variables, extensions of the basic model now permit appropriate analysis of the full range of dependent variables, including those that are of the form of categories (e.g. ill vs. not ill) or ordered categories" (Cohen, et al. 2003, p.1)

In the case of a dichotomous dependent variable, researchers often use logistic regression (Pampel, 2000; Long & Freese, 2001; Cohen et al., 2003, p. 482-518; Miles & Shevlin, 2001, p. 136-164; Pisati, 2003, p. 233-260). This is the object of the next sections.

A.1.2. Logistic regression

As argued by Pampel (2000, p. v), when the dependent variable is dichotomous (rather than continuous) “ordinary regression confronts multiple problems – nonlinearity, nonsense prediction, nonnormality, heteroskedasticity – which lead to inefficient estimation”. For this reason, it is necessary to transform eq. *(A.1.1.).* The dependent variable in a logistic regression model is a dummy variable (where 0 stands for the absence of property and 1 for the presence of property): when the dependent variable is defined in this way, the mean value for a group can be interpreted as the probability of occurrence (Pampel, 2000, p. 1-2). In order to analyse a dummy variable in a meaningful way, however, it is necessary to transform the dependent variable prior to the use in regression, as illustrated in the following formula (p. 15):

(A.1.3) $$ln(P_i/1 - P_i) = b_0 + b_1X_i$$

The right side of the equation is the traditional regression equation including a constant (b_0) and a series of predictors (X_i). On the left side of the equation, however, instead of the probability of having the characteristic we find the natural logarithm of the odds. The odds are defined as the probability of having the characteristic divided by the probability of not having it ($P_i/1 - P_i$). The natural logarithm (*ln*) of the odds is also referred to as *logit* (Pampel, 2000, p. 15).

This transformation has two goals: firstly, it allows to convert a measure that is bounded between zero and one (the probability of having the characteristic) into a measure that is not bounded, i.e. it varies between plus and minus infinity (the left term of the regression equation) (Miles & Shevlin, 2001, p. 156). Secondly, it takes into account the fact that, when the dependent variable is the probability (bounded between zero and one), “the effect of a unit change in the independent variable on the predicted probability would be smaller near the floor or ceiling” (Pampel, 2000, p. 5), i.e. when the probability is close to zero or one. This is described by the S-shaped logistic curve depicted in Fig. A.1.

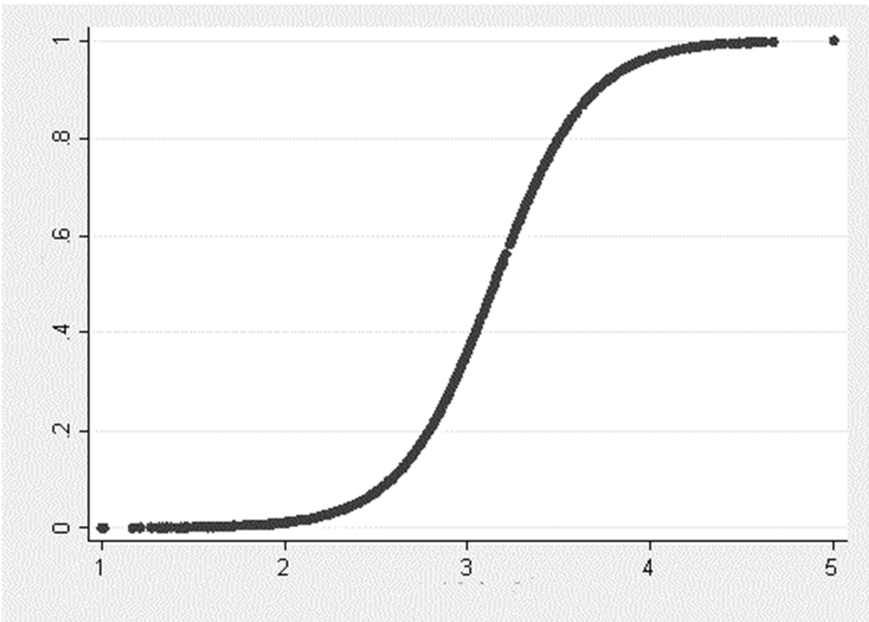

Fig. A.1 – A logistic curve. Source: own elaboration.

It is important to note that, for this reason, in logistic regression the effect of the independent variables is “inherently nonadditive and interactive” (Pampel, 2000, p. 8). As Pampel explains:

"if the value of one independent variable reaches a sufficiently high level to push the probability of the dependent variable to near 1 (or to near 0), then the effects of other variables cannot have much influence" (Pampel, 2000, p. 8)

A.1.3. Interpreting the results

While logistic regression has several advantages over using ordinary linear regression with a dichotomous dependent variable, it has one major drawback: the difficulty of interpreting the results. This is strictly related to the transformations made on the equation. As Pampel argues, the logit transformation can be viewed as "linearizing the inherent non linear relationship between X and the probability Y" (2000, p. 14); as a result, however:

"the linear relationship between X and the logit implies a nonlinear relationship between X and the original probabilities. A unit change in the logit results in smaller differences in probabilities at high and low levels than at levels at the middle" (Pampel, 2000, p. 14)

As illustrated by Cohen et al. (2003, p. 490-491), there are "three forms of predicted score" in logistic regression: logits, odds and predicted probabilities. Because of the logit transformation, the interpretation of all of them involves significant complexities. Moreover, as noted by Pampel "the interpretations of each effect have both advantages and disadvantages" (2000, p. 18, see Tab. A.1). As a result, interpreting the results of a logistic regression model is considerably more complicated than for ordinary, linear regression.

	Effects of the X variable	**Intuitive meaning**	**Expressed in a single coefficient**
Logits	Linear and additive	Low	Yes
Odds	Multiplicative	Medium	Yes
Predicted probabilities	Nonlinear and nonadditive	High	No

Tab. A.1 - Problems in the interpretation of logistic regression coefficients. Source: adapted from Pampel (2000, p. 19).

When interpreting *logits* (logistic regression coefficients), the researcher should keep in mind that they show "the change in the predicted logged odds of (..) having a characteristic for a one-unit-change in the independent variable" (2000, p. 19). Admittedly, logits have little intuitive meaning: while they have the merit of summarizing in a single coefficient the effect of X on Y (regardless of levels of independent variables), their interpretation is challenging. However, unlike the magnitude, the sign of logit coefficients can be more easily interpreted: a positive logit corresponds to an increase in the probability of having the characteristic in question, while a negative logit to a reduction (Cohen et al., 2003, p.489).

When interpreting odds associated with a predictor (they can be easily obtained by taking the antilogarithm of the logit), the researcher should keep in mind that the coefficients obtained "refer to multiplicative changes in the odds rather than probabilities" (Pampel, 2000, p. 23), and that odds are asymmetric: coefficients between zero and one decrease the odds, while coefficients between one and infinity increase it (p. 22). Moreover, as Pampel observes (2000, p. 72):

"because of the multiplicative nature of its effects, the actual change in odds depends on the starting point for the odds. The higher the starting odds, the greater the change from the same multiplicative coefficient. (..) Further, the same multiplicative change in odds will translate into different changes in probabilities depending on the starting point (Pampel, 2000, p. 72)

For these reasons, the interpretation of exponentiated coefficients is not necessarily more straightforward than that of the logits. A third possibility is to transform the logits into odds and then the odds into predicted probabilities. However, as illustrated by Pampel:

> "since the relationship between the independent variables and probabilities are nonlinear and nonadditive, they cannot be fully represented by a single coefficient. The effect on the probabilities has to be identified at a particular value or set of values. The choice of values to use in evaluating the effect of variables on the probabilities depends on the concerns of the researcher and the nature of the data, but an initial strategy has the advantage of simplicity: examine the effect on the probability for a typical case" (Pampel, 2000, p. 24)

In other words, instead of commenting the values of single coefficients, the researcher can tables and/or graphs to illustrate how changes in one (or more) independent variables affect the value of the predicted probability of having the characteristic. In doing that, however, the researcher has to hold the value of other independent variables constant at a predefined value. Therefore, the substantive conclusions drawn from these tables and graphs are not necessarily valid for other combinations of values.

Overall, Long and Freese argue that

> "no single approach to interpretation can fully describe the relationship between a variable and the outcome. We suggest that you try a variety of methods, with the goal of finding an elegant way to present the results that does justice to the complexities of the nonlinear model (Long & Freese, 2001, p. 119)

A.1.4. Standard errors and tests of significance

When regression is conducted on a sample of a larger population the values of the standard errors associated with the coefficients must be taken into account. When the regression model takes into account survey design and the fact that the sample is clustered in primary sampling units and strata, *robust standard errors* are reported instead of standard errors. These constitute the basis for the tests of significance in logistic regression (Pampel, 2000, p. 30). The results of the tests of significance should be taken into consideration when interpreting the results. As Pampel argues:

> "coefficients should exceed standard levels of significance before applying the interpretations. Because statistical significance depends so strongly on sample size, however, *p* values provide little information on the strength, importance or intuitive meaning of the relationship. Large samples, in particular, can produce significant p values for otherwise small and unimportant effects. (..) *p* values should serve only as an initial hurdle to overcome before interpreting the coefficient in other ways" (Pampel, 2000, p. 30-31)

A.1.5. Maximum likelihood estimation

Unlike for ordinary least square (OLS) regression, in logistic regression it is not possible to use closed equations to estimate the model parameters (Miles & Shevlin, 2001, p. 156-157). For this reason, logistic regression models use *maximum likelihood estimation* to find "estimates of the parameters that are most likely to give rise to the pattern of observations in the sample data" (Pampel, 2000, p. 40). They do so by finding "the model parameters that give the maximum value for the likelihood function" (p. 41), defined as (*ibidem*):

(A.1.4) $$LF = \prod\{{P_i}^{Y_i} * (1 - P_i)^{1-Y_i}\}$$

In eq. *(A.1.4.)* Y_i is the "observed value of the dichotomous dependent variable for case *i*" and P_i is the "predicted probability for case *i*" (Pampel, 2000, p. 40). In practice, an additive log-likelihood function is used instead of the multiplicative likelihood function reported above. The formula is the following (Pampel, 2000, p. 43):

(A.1.5) $$\ln LF = \sum\{[Y_i * \ln P_i] + [(1 - Y_i) * \ln(1 - P_i)]\}$$

The log-likelihood value can be interpreted as follows: "the closer the (..) values is to 0, and the more likely it is that the parameters could produce the observed data" (Pampel, 2000, p. 44). In practice, maximum likelihood estimation is an iterative procedure that proceeds in the following way:

> "(the) program usually begins with a model in which all *b* coefficients equal the least squares estimates. It then uses an algorithm to successively choose new sets of coefficients that produce larger log likelihoods and better fit with the observed data. It continues through iterations or cycles of this process until the increase in the log likelihood function from choosing new parameters becomes so small (and the coefficients change so little) that little benefits comes from continuing any further" (Pampel, 2000, p. 45)

A.1.6. Evaluating model fit

Most model fit measures for logistic regression models are based on the values of the likelihood function illustrated in the previous section (Pampel, 2000, p. 48). The logic behind the various *pseudo-R^2* measures proposed in the literature is "to compare a model knowing the independent variables to a model not knowing them" (*ibidem*). McFadden's R^2 (1979) for example, is defined by the following formula (Long & Freese, 2001, p. 84):

(A.1.6.) $${R^2}_{McF} = 1 - \frac{\ln \hat{L}(M_{full})}{\ln \hat{L}(M_{intercept})}$$

Where M_{full} stands for the current model while $M_{intercept}$ stands for the model with just the intercept (Long & Freese, 2001, p. 84). McFadden's R^2 ranges between zero and one, with larger values indicating a better model fit, although it never equals one (*ibidem*).

Since the addition of a new predictor always results in an increase in McFadden's Pseudo R^2 (Long & Freese, 2001, p. 84), this can lead the researcher to retain models that are overfitted to the data and not parsimonious. Since the goal of every model is to provide a *simplified* and *useful* representation of the observed data, information measures have been developed that take into account both model fit and parsimony, penalizing models that include more parameters (Long & Freese, 2001, p. 86-87). The two most common examples are AIC and BIC.

Akaike's Information Criteria (AIC) (1973) is defined as (Long & Freese, 2001, p. 86):

(A.1.7.) $$AIC = \frac{-2 \ln \hat{L}\,(M_k) + 2P}{N}$$

In the formula, both likelihood of the model ($\hat{L}(M_k)$) and the number of parameters (P) are taken into consideration, as well as sample size (N) (Long & Freese, 2001, p. 86). AIC can be used "to compare models across different samples or to compare non-nested models", according to the criterion that "all else being equal, the model with the smaller AIC is considered the better fitting model (*ibidem*).

A similar information criteria is BIC (Baesyan Information Criterion), defined as (Long & Freese, 2001, p. 86):

(A.1.8.) $$BIC_k = D(M_K) - df_k \ln N$$

In the formula, $D(M_K)$ is the deviance of the model and df_k is the number of degrees of freedom associated with the deviance (Long & Freese, 2001, p. 86). The rule when comparing the BIC of two models is "the more negative the BIC_k, the better the fit" (*ibidem*). Moreover, the largest the difference on the BIC between the models, the strongest the evidence in favour of one of the two models (*ibidem*).

A.2. Multinomial logistic regression

In chapters 6 and 7, the results of two multinomial logistic regression models are presented and discussed in detail. In this section, further information about multinomial logistic regression is provided. All analyses reported in chapters 6 and 7, as well as in Appendix B and Appendix C were conducted using Stata 11.1.

A.2.1. Generalizing the logistic regression model

As illustrated in the previous section, logistic regression is the suitable technique for dichotomous dependent variables. When the dependent variable is a nominal (unordered) variable with more than two categories, an extension of logistic regression, known as *multinomial logistic regression* (Long & Freese, 2001; Pisati, 2003) or *polytomous logistic regression* (Cohen et al., 2003) is used.

A multinomial logistic regression model can be conceived as the combination of *g* logistic regression models, where *g* is the number of categories of the nominal dependent variable (with *g*>2) (Pisati, 2003, p. 239). In the case of a dependent variable with three outcomes (*A, B, C*) and a single predictor (*X*), the model is defined by the following three formulae (Long & Freese, 2001, p. 172):

(A.2.1.) $$\ln\left[\frac{\Pr(C|x)}{\Pr(A|x)}\right] = \beta_{0,C|A} + \beta_{1,C|A}X$$

(A.2.2.) $$\ln\left[\frac{\Pr(B|x)}{\Pr(A|x)}\right] = \beta_{0,B|A} + \beta_{1,B|A}X$$

(A.2.3.) $$\ln\left[\frac{\Pr(C|x)}{\Pr(B|x)}\right] = \beta_{0,C|B} + \beta_{1,C|B}X$$

Equations *(A.2.1.)* to *(A.2.3.)* refer to three different comparisons between outcomes of the dependent variables, as indicated by the subscripts to the β's (Long & Freese, 2001, p. 172). However, as demonstrated by Long and Freese (2001, p. 172) and Pisati (2003, p. 240-241), one of the three equations is redundant and, in general, "with J outcomes, only J – 1 binary logits need to be estimated (because) estimates for the remaining coefficients can be computed using equalities" (Long & Freese, 2001, p. 172). Still, the equations are estimated simultaneously, as explained by Cohen et al. (2003, p. 519):

> "the logistic regression functions are combined into one overall polytomous regression equation that includes the intercepts from the (g-1) logistic regression functions plus the (g-1)k regression coefficients for the k predictors in the (g-1) regression functions" (Cohen et al., 2003, p. 519)

As a result, the estimates produced by a multinomial logistic regression model differ from those that would be obtained by estimating (g-1) logistic regression models based on different samples (each excluding the categories of the dependent variable not included in the comparison) (Long & Freese, 2001, p. 174). This happens because the multinomial logistic regression model imposes "constraints among coefficients that are implicit in the definition of the model" (*ibidem*).

The formal statement of the multinomial logistic regression model is the following formula (Long & Freese, 2001, p. 175)

(A.2.4.) $$\ln \Omega_{m|b}(\boldsymbol{x}) = \ln\frac{\Pr(y=m|\boldsymbol{x})}{\Pr(y=b|\boldsymbol{x})} = \boldsymbol{x}\beta_{m|b} \text{ for } m = 1 \text{ } to \text{ } J$$

Where b is the 'base category', i.e. the outcome for which no logistic regression model is estimated (Long & Freese, 2001, p. 175). In practice, the researcher has to choose the base category, based on substantive considerations; it is often recommended to set the base category to the outcome with the most observations (p. 178), as this reduces the standard errors and therefore the uncertainty around the estimates. It must be observed that, while the logit coefficients for the multinomial model differ according to the base category, predicted probabilities are not affected by this choice (p. 175).

In terms of interpretation of results, standard errors and tests of significance, estimation and testing of model fit the same considerations illustrated for logistic regression models (§A.1.3 to §A.1.6) apply to multinomial logistic regression models. Notably, the complexities involved in the interpretation of results are magnified for multinomial models, as argued by Long and Freese (2001, p. 171):

> "the biggest challenge in using the (multinomial logit model) is that (it) includes a lot of parameters, and it is easy to be overwhelmed by the complexity of the results. This complexity is compounded by the nonlinearity of the model, which leads to the same difficulties of interpretation found for models in prior chapters. While estimation of the model is straight-forward, interpretation involves many challenges" (Long & Freese, 2001, p. 171)

A.2.2. The assumption of independence of irrelevant alternatives

While the multinomial logistic regression model resembles the logistic regression model in several respects, it involves an additional assumption, known as the independence of irrelevant alternatives (IIA) (Long & Freese, 2001, p. 188-191; Pisati, 2003, p. 258-259). Consider the following formula, with respect to the outcomes *m* and *n* of a nominal dependent variable (Long & Freese, 2001, p. 188):

(A.2.5.)
$$\frac{\Pr(y=m|x)}{\Pr(y=n|x)} = \exp\left(x\,[\beta_{m|b} - \beta_{n|b}]\right)$$

With reference to the formula, the IIA assumption states that the odds on the right side of the equation (Long & Freese, 2001, p. 188)

> "do not depend on other outcomes that are available. In this sense these alternative outcomes are "irrelevant". What this means is that adding or delecting outcomes does not affect the odds among the remaining outcomes" (Long & Freese, 2001, p. 188)

The IIA assumption needs to be tested when performing multinomial logistic regression. A test of the assumption has been suggested by Small and Hsiao (1985). The formula of the Small-Hsiao statistic is the following[272] (Long & Freese, 2001, p. 189):

(A.2.6.)
$$SH = -2\left[L(\hat{\beta}_u^{S_1S_2}) - L(\hat{\beta}_r^{S_2})\,\right]$$

The Small-Hsiao statistic is distributed as a chi-squared with associated *p*-value. It tests the null hypothesis (H_0) that for the outcome omitted, the odds between the other outcomes are independent of other alternatives (Long & Freese, 2001, p. 189). The test must be repeated for each omitted outcome.

It must be noted, however, that the results of the test might be misleading. As noted by Long and Freese (2001, p. 191), tests of IIA:

> "often give inconsistent results and provide little guidance to violations of the IIA assumption. (..) Care in specifying the model to involve distinct outcomes that are not substitute for one another seems to be reasonable, albeit unfortunately ambiguous, advice" (Long & Freese, 2001, p. 191)

A.3. Cluster analysis

A.3.1. Classification and cluster analysis

In chapters 6 and 7, two data analysis techniques are used to classify carless households (or individuals). While for the German case I use latent class analysis (see §A.4 below), for the NTS database I use cluster analysis (described in this section[273]). Broadly speaking, a 'classification scheme' can be defined as

[272] Details about how the terms in eq. *(A.2.6.)* are computed are provided in Long and Freese (2001, p. 189-190).

"a convenient method for organizing a large data set so that it can be understood more easily and information retrieved more efficiently. If the data can validly be summarized by a small number of groups of objects, then the group labels may provide a very concise description of patterns of similarities and differences in the data" (Everitt et al., 2011, p.3)

While there are many techniques for deriving classifications (including graphical inspection of data, see Everitt et al., 2011, chapter 2), the term 'cluster analysis' is usually employed to refer to *numerical* methods of classification

"concerned with exploring data sets to assess whether or not they can be summarized meaningfully in terms of a relatively small number of groups or clusters of objects or individuals which resemble each other and which are different in some respects from individuals in other clusters" (Everitt et al., 2011)

In cluster analysis, the similarity between observations is measured on a number of variables, in the following defined as 'input variables'. The selection of input variables is an important step of cluster analysis in its own right: Gordon (1999, p. 33) stresses the "importance of giving careful consideration to the choice of variables that are used to describe objects and of including only those that are relevant for the purpose at hand".

While cluster analysis techniques are capable of handling both continuous and categorical input variables (as well as combinations thereof) (see Everitt et al., 2011, pp. 46-56), in this section I refer exclusively to cluster analysis applied to continuous variables. A classification technique developed precisely for categorical data, latent class analysis, is discussed in detail in the following section (§A.4).

Everitt et al. (2011, p.261-262), suggest nine steps for using clustering techniques in practice including (among others) the following points that are addressed in the following sections:

- variable weighting and standardization
- choosing the proximity measure
- choosing the clustering method
- choosing the number of clusters (model selection)

A.3.2. Weighting and standardization

When applying cluster analysis, if often makes sense to standardize the input variables before clustering. Standardizing is recommended notably when input variables are not measured in the same units and/or do not have the same range of variation (Everitt et al., 2011, p. 67-68; Gordon, 1999, p. 34-35). In these circumstances, using unstandardized variables as input variables is not sensible, as it means assuming that the score on each of the variables is "equivalent in any sense in determining a measure of similarity or distance" (Everitt et al., 2011, p.67). In practice, this would mean attributing more weight to variables with a greater variance. The solution to this problem is "to standardize each variable to unit variance before analysis" (ibidem). The most frequently used standardization technique is *z-scoring*, described by the following formula (Corbetta et al., 2001, p.84):

(A.3.1.)

$$Z_i = (X_i - \overline{X})/S$$

Where X is the original variable, Z is the new variable and S is the standard deviation for the original variable (Corbetta et al., 2001, p.84).

As argued by Everitt et al. (2011, p.67), standardization with z-scoring is a "special case of weighting" where the weight is the reciprocal of standard deviations and "the investigator assumes that the importance of a variable decreases with increasing variability" (*ibidem*). However, it should be noted that standardizing the

[273] Cluster analysis was conducted using Stata 11.1.

input variables is not without risks: as noted by Everitt et al. (2011, p. 64), the variability of the input variables is what ultimately allows the investigator to identify meaningful clusters. Therefore, z-scoring standardization "can have the serious disadvantage of diluting differences between groups on the variables which are the best discriminators" (*ibidem*). For this reason "standardization is not necessarily always indicated and can sometimes be misleading" (p. 261). When this is the case, alternative to z-scoring (such as standardization using the range and using a cluster methods that is invariant under scaling) are recommended (*ibidem*). Moreover, as discussed by Romesburg (1984, Chapter 2) "standardizing the data matrix and choosing a resemblance coefficients are interrelated decisions that must be made in consideration with each other" (p. 93).

A.3.3. Proximity measures

Most clustering methods use as basic information a measure of "how 'close' individuals are to each other, or how far apart they are" (Everitt et al., 2011, p. 44), with respect to the input variables. Different terms are used to identify these measures: dissimilarity or similarity measures (Gordon, 1999), resemblance coefficients (Romesburg, 1984) and distance measures (Everitt et al., 2011). Everitt et al. use 'proximity measures' as a general term in this context (2011, p. 43). Proximity measures are generally used to derive a 'dissimilarity matrix' from the original data set.

A wide variety of proximity measures are mentioned in the literature on cluster analysis (Everitt et al., 2011; Gordon, 1999; Romesburg, 1984). The most common measure used for continuous data (Everitt et al., 2011, p. 49-56) is the Euclidean distance, defined by the following formula (Everitt et al., 2011, p. 49):

(A.3.2.) $$d_{ij} = \left[\sum_{k=1}^{p}\left(x_{ik} - x_{jk}\right)^2\right]^{1/2}$$

Where "x_{ik} and x_{jk} are, respectively, the *k*th variable value of the *p*-dimensional observations for individuals *i* and *j*" (Everitt et al., 2011, p. 49). As the name suggests, this measure can be interpreted as the geometrical distance between two points (*ibidem*). As observed by Gordon (1999, p. 38), proximity measures such Euclidean distance are appropriate when the investigator is interested in "differences between the actual values taken by the variables", rather than "in the relative magnitude of the set of variables describing the two objects". When the researcher wants to take into account the second phenomenon, also called 'size displacement' the use of other proximity measures, such as correlation, is recommended (Gordon, 1999; Romesburg, 1984; Everitt et al., 2011, p. 50-51).

A.3.4. Clustering methods

There are two main families of methods in cluster analysis: hierarchical clustering and optimization clustering techniques (Everitt et al., 2011). The former can be defined as a technique whereby

> "the data are not partitioned into a particular number of classes or clusters at a single step. Instead the classification consists of a series of partitions, which may run from a single cluster containing all individuals, to *n* clusters each containing a single individual. Hierarchical clustering techniques may be subdivided into *agglomerative* methods, which proceed by a series of successive fusions of the *n* individuals into groups, and *divisive* methods, which separate the *n* individuals successively into finer groupings" (Everitt et al., 2011, p. 71)

While hierarchical clustering has some advantages, it also has several limitations: it is ill-suited for very large data sets (Everitt et al., 2011, p. 97) and different hierarchical clustering methods "may give very different results on the same data" (Everitt et al., 2011, p. 83).

Optimization clustering techniques, by contrast, do not proceed hierarchically, but rather

> "produce a partition of the individuals into a specified number of groups, by either minimizing or maximizing some numerical criterion. (..) Differences between the methods in this class arise both

because of the variety of clustering criteria that might be used and the various optimization algorithms that might be used" (Everitt et al., 2011, p. 111)

A particular type of optimization algorithms, known as hill-climbing algorithms, have been developed to "search for the optimum value of a clustering criterion by rearranging existing partitions and keeping the new one only if it provides improvement" (Everitt et al., 2011, p. 121). It is important to observe that, when using optimization clustering techniques and hill-climbing algorithms the investigator has to specify a priori the number of groups *n* and the initial partition of the objects into the *n* groups (*ibidem*). When using Euclidean distance as a proximity measures, a common method of obtaining an initial partition is to choose *n* points at random that will act as cluster centers (Everitt et al., 2011, p. 122).

K-means algorithms proceed by "iteratively updating a partition by simultaneously relocating each object to the group to whose mean it was closest and then recalculating the group means" (Everitt et al., 2011, p. 122). Everitt et al. argue that this is equivalent to minimizing the sum of the within group sum of squares, over all input variables, thus maximizing the homogeneity and the cohesiveness of the clusters (Everitt et al., 2011, p. 112, 114, 122). This is equivalent to state that the algorithm minimizes trace($\boldsymbol{W}$), where $\boldsymbol{W}$ is the within-group dispersion matrix, defined by the following formula (Everitt et al., 2011, p. 114):

(A.3.3.) $$\boldsymbol{W} = \sum_{m=1}^{g} \sum_{l=1}^{n_m} (\boldsymbol{x}_{ml} - \overline{\boldsymbol{x}}_m)(\boldsymbol{x}_{ml} - \overline{\boldsymbol{x}}_m)'$$

The terms in the formula are interpreted as follows (Everitt et al., 2011, p. 114):

- g is the number of groups (identified by m)
- n_m is the number of observations in group m, with l identifying each single observation
- $\boldsymbol{x}_{ml}$ is "the p-dimensional vector of observations of the *l*th object in group *m*" (*p* is the number of input variables) (Everitt et al., 2011, p. 114)
- $\overline{\boldsymbol{x}}$ is "the p-dimensional vector of the overall sample means for each variable" (Everitt et al., 2011, p. 114)

A.3.5. Model selection

As illustrated above, optimization clustering techniques require the investigator to set a priori the number of clusters. K-means algorithms, for example, minimize the within-group dispersion *among different clustering solutions with the same number of clusters*. For this reason, the researcher using k-means often has to decide between competing solutions, each optimal if compared to other solutions with the same number of clusters, but each including a different number of clusters.

To assist the investigator in this decision, different criteria have been developed (Everitt et al., 2011, p. 126-130). The technique proposed by Caliński and Harabasz (1974) aims at maximizing $\boldsymbol{C}(g)$, as defined in the following formula (Everitt et al., 2011, p. 127):

(A.3.4) $$\boldsymbol{C}(g) = \frac{trace(\boldsymbol{B})}{(g-1)} / \frac{trace(\boldsymbol{W})}{(n-g)}$$

According to this technique, the solution retained is that which includes the number of groups g associated with the maximum value of $\boldsymbol{C}(g)$ (Everitt et al., 2011, p. 127). In the formula, *n* is the number of observations and *B* is the between-group dispersion matrix, defined by the following formula (Everitt et al., 2011, p. 114)

(A.3.5.) $$\boldsymbol{B} = \sum_{m=1}^{g} n_m (\boldsymbol{x}_m - \overline{\boldsymbol{x}}_m)(\boldsymbol{x}_m - \overline{\boldsymbol{x}}_m)'$$

Overall, then, the rule suggested by Caliński and Harabasz aims at maximizing between group variation and at minimizing within-group variation. However, as ilustrated in *(A.3.4)* it penalizes solutions including more clusters, thus taking into account parsimony. In the Stata software package, it is possible to compute a 'Caliński and Harabasz pseudo-F index': large values on this index are considered to indicate distinct clustering (StataCorp., 2009, p. 159-166).

A.4. Latent class analysis

In chapter 6, the results of latent class analysis performed on a sample of carless households are presented and discussed. In this section, further information about latent class analysis is provided. All analyses reported in chapter 6, as well as in Appendix B were conducted using Latent Gold™ 4.5.

A.4.1. Latent class analysis as a clustering tool

According to the terminology used in the previous section (§A.3.1) , latent class analysis (LCA) is a numerical method of classification developed for the analysis of categorical data[274] (McCutcheon, 1987; McCutcheon & Hagenaars, 2002; Collins & Lanza, 2010).

There are two more differences between LCA and the clustering methods reviewed in the previous section (§A.3). Firstly, LCA is a *model-based technique*: this means that a model (i.e. a simplified representation of the data), is estimated based on the observed data. In a subsequent step, the results predicted by the model are compared with the observed data, in order to evaluate model fit. This logic is similar to that of logistic and multinomial logistic regression models (§A.1 and §A.2). However, it distinguishes LCA from clustering techniques such as k-means clustering, where cases are grouped into clusters so as to maximize within-group homogeneity and minimize between-group homogeneity, but it is not possible to define a measure of model fit. As argued by Magidson and Vermunt (2002a), LCA:

> "is a model-based clustering approach. This means that a statistical model is postulated for the population from which the sample under study is taken. More precisely, it is assumed that the data are generated by a mixture of underlying probability distributions. (..) An advantage (over standard non-hierarchical cluster techniques) is (..) that the choice of the cluster criterion is less arbitrary" (Magidson & Vermunt, 2002a, p. 89)

Secondly, LCA is *latent variable* model. As Collins and Lanza explain (2010, p. 4):

> "the term *latent* means that an error-free latent variable is postulated. The latent variable is not measured directly. Instead, it is measured indirectly by means of two or more observed variables. Unlike the latent variables, the observed variables are subject to error. Most statistical analysis approaches are based on latent variable models attempt to separate the latent variable and measurement error" (Collins & Lanza, 2010, p. 4)

As argued by Collins and Lanza (2010, p. 6-7), the defining feature of latent class analysis is that it treats the indicators as categorical (whereas other clustering techniques are often incapable of treating categorical variables as such) *and* it assumes that the latent variable is categorical. This distinguishes it from other latent variables models such as factor analysis, where indicators are treated as continuous and a continuous latent variable is postulated (Collins & Lanza, 2010, p. 6-7).

The categorical latent variable in LCA can be interpreted as a latent classification, whereby the categories of the latent variables are equivalent to groups or clusters. As argued by Magidson and Vermunt (2002a, p. 89), in LCA:

> "objects are assumed to belong to one of a set of *K* latent classes, with the number of classes and their size not known a priori. In addition, objects belonging to the same class are similar with respect to the observed variables in the sense that their observed scores are assumed to come from the same probability distributions, whose parameters are, however, unknown quantities to be estimated.

[274] Recently techniques that allow LCA to handle continuous variables have been developed, thus offering "a model-based alternative to more traditional clustering approaches such as K-means" (Magidson & Vermunt, 2002b, p. 37).

Because of similarity between cluster and exploratory (latent class) analysis, it is not surprising that the latter method is becoming a more popular clustering tool" (Magidson & Vermunt, 2002a, p. 89)

In other words, as argued by Goodman (2002, p. 22):

> "when the responses on the observed variables (..) are viewed as providing some information about the respondent's latent class membership (..), the model can be used to classify (in a probabilistic manner) each respondent as being in one of the latent classes on the basis of the respondent's response on one or more of the observed variables" (Goodman, 2002, p. 22)

A.4.2. Parameters and assumptions

The basic elements of LCA are illustrated in Fig. A.2.

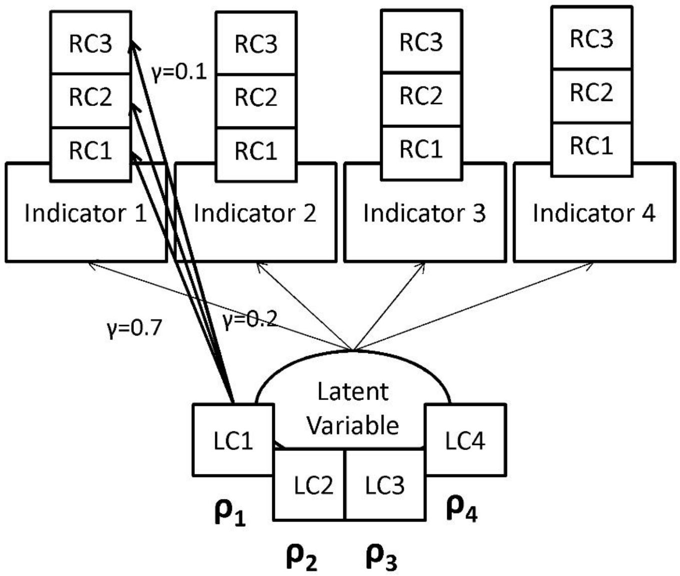

Fig. A.2 – Basic elements of latent class analysis. Source: own elaboration.

The graph shows the relationships between a latent variable and four indicators (observed variables). The indicators are categorical variables with three response categories (*RC*). Also the latent variable is categorical, and includes four latent classes (*LC*). As illustrated in Fig. A.2, two kinds of parameters are estimated when latent class analysis is performed:

- *latent class probabilities* (also referred to as 'latent class prevalences', see Collins & Lanza, 2010) are the ρ's in the graph. They represent "the probability of membership in each latent class" (Collins & Lanza, 2010, p. 11). As illustrated by McCutcheon (1987, p. 18-19), the number of classes (T) should be considered as the second important aspect of the latent class probabilities. Accordingly, "the sum of the latent class probabilities over all T latent classes of the latent variable (..) must equal one" (*ibidem*)
- *conditional probabilities* (also referred to as 'item-response probabilities', see Collins & Lanza, 2010) are the γ's in the graph. They represent "the probability of each response (..) to each observed variable for each latent class", as illustrated by the arrows in Fig. A.2 and they "form the basis for interpretation and labelling of the latent classes" (Collins & Lanza, 2010, p. 12). Intuitively, "within each of the T latent classes the conditional probabilities for each of the observed variables sum to 1.00" (McCutcheon, 1987, p. 20)

The number of parameters included in the model depend on the number of latent classes, the number of indicators and the number of response categories. As illustrated by the density of overlapping arrows in Fig. A.3, this number can be very high even for a quite simple model: for a model including four indicators, each including three response categories, and four latent classes, the number of conditional probabilities that have to be estimated is 4 x 3 x 4 = 48 parameters. With the addition of four latent class probabilities, this makes for a total of 52 parameters for a four-class typology.

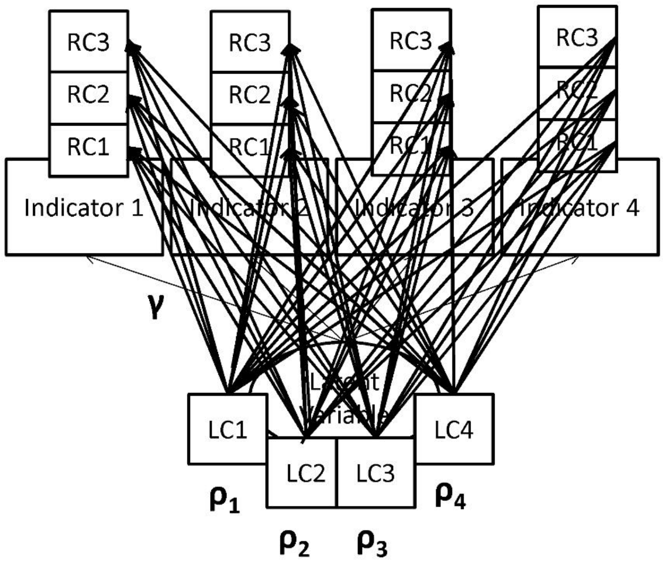

Fig. A.3 – Conditional probabilities for a fictional latent class model. Source: own elaboration.

LCA estimates these parameters moving from the basic assumption of *local independence*. This is explained by McCutcheon (1987, p. 5-6) in the following way:

> "the basic premise of the study of latent variables is that the covariation actually observed among the manifest (observed) variables is due to each manifest variable's relationship to the latent variable – that the latent variable "explains" the relationships between the observed variables. If such a variable exists, then controlling for this latent variable will result in diminishing the covariation between all of the observed variables to the level of chance covariation. Consequently, the latent variable is said to be the "true" source of the originally observed covariations" (McCutcheon, 1987, p. 5-6)

For this reason, Mc Cutcheon (2002, p. 56, 84) argues that LCA

> "is most appropriately used when the observed indicator variables are associated because of some underlying unobserved factor rather than being causally related. (..) In (..) instances (where) it is plausible that the observed associations reflect cause-effect relationships (..) latent class analysis is inappropriate" (McCutcheon, 2002, p. 56, 84)

As illustrated by Collins and Lanza (2010, p. 44-46), this is equivalent to assuming that observed variables should be related to each other only through the latent variable (as in Fig. A.4a) and not through their error components (as it happens in Fig. A.4b).

The formula for a latent class cluster model that assumes local independence and that does not include covariates is the following[275] (Vermunt & Magidson, 2005b, p. 8):

[275] Details about the meaning of the terms in eq. *(A.4.1.)* are provided in Vermunt and Magidson (2005b, p. 7-8).

(A.4.1.) $$f(\boldsymbol{y_i}|\boldsymbol{z_i}) = \sum_{x=1}^{K} P(x) f(\boldsymbol{y_i}|x, \boldsymbol{z_i}) = \sum_{x=1}^{K} P(x) \prod_{t=1}^{T} f(y_{it}|x)$$

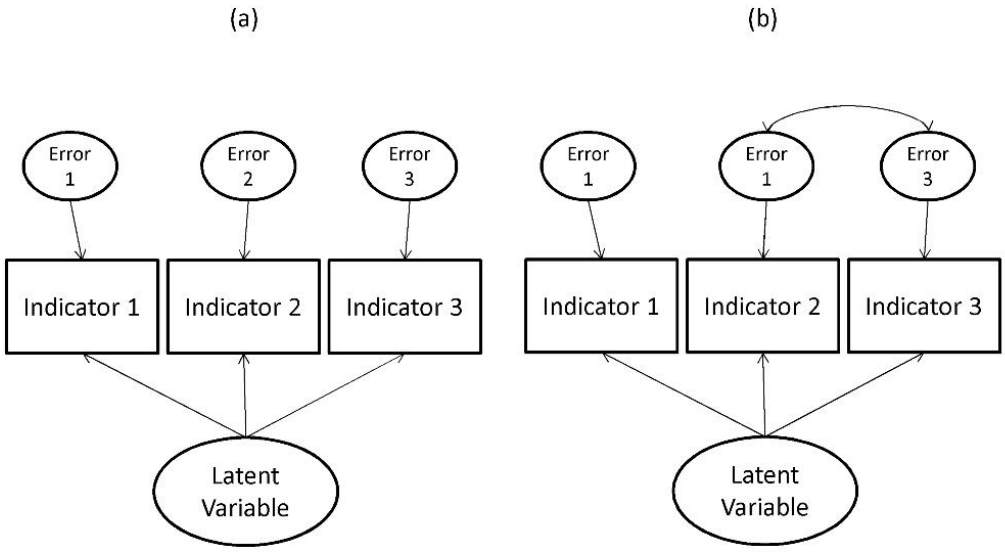

Fig. A.4 – Latent class models and the assumption of local independence. Source: adapted from Collins and Lanza (2010, p. 44-45).

A.4.3. Estimation and survey design

Before estimating a latent class model, the researcher has to decide the number of latent classes to identify (T>=2) (McCutcheon, 1987, p. 29). Once this parameter is set, the software is able to estimate the latent class model based on eq. *(9.4.1.)*. To do this, two iterative, maximum-likelihood estimation approaches exist: the EM algorithm and the Newton-Raphson (NR) method (McCutcheon, 2002, p. 64-66). As McCutcheon (2002, p. 64) explains:

> "both algorithms begin with a set of "start values" and proceed with a series of steps of parameter estimation and reestimation iterations until some designated criterion is reached. Usually, the "stop" criteria focus on convergence – each additional iteration in the parameter reestimation procedure finally approaches some predesignated "small" change, and the procedure stops" (McCutcheon, 2002, p. 64)

In the Latent GOLD software, ML estimation involves finding the estimates that maximize a log-likelihood function (Vermunt & Magidson, 2005b, p. 43). When complex survey sampling has to be taken into account, *pseudo-likelihood estimates* (Patterson et al., 2002) are provided instead of regular maximum likelihood estimates (Vermunt & Magidson, 2005b, p. 43). This involves maximising the following log-likelihood function (p. 99)

(A.4.2.) $$\log \mathcal{L}_{pseudo} = \sum_{o=1}^{O} \sum_{c=1}^{C_o} \sum_{i=1}^{I_{oc}} sw_{oci} \log f(\boldsymbol{y_{oic}}|\boldsymbol{z_{oic}}, \vartheta)$$

Where:

- $\boldsymbol{\vartheta}$ denotes "the vector containing the unknown (..) parameters" (Vermunt & Magidson, 2005b, p. 43)
- $\boldsymbol{y_{oic}}$ and $\boldsymbol{z_{oic}}$ denote "the vectors of dependent and explanatory variables for case *i*" (*ibidem*)
- sw_{oci} is "the sample weight corresponding to case *i* belonging to PSU *c* of stratum *o*" (Vermunt & Magidson, 2005b, p. 98)

In Latent GOLD, the estimation procedure uses both the EM and the NR algorithm[276]. In practice, this means that (Vermunt & Magidson, 2005b, p. 49):

> "the estimation process starts with a number of EM iterations. When close enough to the final solution, the program switches to Newton-Ralphson. This is a way to exploit the advantages of both algorithms; that is, the stability of EM even when it is far away from the optimum and the speed of Newton-Ralphson when it is close to the optimum" (Vermunt & Magidson, 2005b, p. 49)

An issue when estimating a latent class model is the problem of identification (McCutcheon, 2002, p. 64-66; Collins & Lanza, 2010, p. 89-94): since likelihood approaches such as the EM and NR algorithms can incur in local optima (estimates corresponding to points that *appear to*, but actually do not maximize the likelihood function), different starting values for the estimation procedure can result in different estimates for the model (McCutcheon, 2002, p. 64-66). This is referred to as the issue of *model identification*, i.e. "whether there is sufficient information in the observed cross-tabulation to estimate the parameters of the proposed model" (p. 66). McCutcheon argues that (2002, p. 66):

> "one practical approach to exploring whether the model is identified is to begin with quite different start values for each of the model parameters and estimate the same model several times. If the final estimates of the model parameters are quite different for the several analyses but the estimated frequencies and the chi square are the same for each of the analyses, it is a sure sign that the model is not identified" (McCutcheon, 2002, p. 66)

A.4.4. Model evaluation

Once input variables and other settings for latent class analysis are defined and one or more models have been obtained, it is necessary to select the model that fits best to the observed data. A crucial choice in this context is deciding how many classes to include in the latent class model. To this end, there are several standard evaluations criteria (Vermunt & Magidson, 2005a, p. 111-112, 124-125), and all of them are "evaluations of how well the expected cell counts under the model hypothesis replicate the originally observed cell counts" [277] (McCutcheon, 2002, p. 66).

Absolute model fit is assessed by the likelihood-ratio goodness-of-fit value L-squared (L^2) and relative *p*-value. The formula for L-squared is the following (Vermunt & Magidson, 2005b, p. 59):

(A.4.3.) $$L^2 = 2 \sum_{i^*=1}^{I^*} n_i * \log \frac{n_{i^*}}{\hat{m}_{i^*}}$$

Where *i** denotes a "particular data pattern" (Vermunt & Magidson, 2005b, p. 58), and n_i denotes the weighted frequency counts for the same data pattern (*ibidem*). The term $\hat{m}_{i^*}$ by contrast denotes "the estimated cell count for data pattern *i**" (p. 59).

The degrees of freedom associated with the L^2 statistic are defined as following (Vermunt & Magidson, 2005b, p. 59):

(A.4.4.) $$df = \sum_{u=1}^{U} \left(\prod_{t=1}^{T^*u} M_{ut}^* - 1 \right) - npar$$

Where T^*_u denotes "the total number of observed indicators (replications) in "covariance" pattern *u*" and M_{ut}^* "the number of categories of the *t*th observed indicator (replication) corresponding to "covariate" pattern *u*" (Vermunt & Magidson, 2005b, p. 59) and *npar* is the number of parameters estimated in the model.

When using L^2, the criterion is to select the model with the L^2 value closest to zero, and a non-significant *p*-value (higher than 0.05).

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276 Given the complexities of the formulae that describe the EM and the NR algorithms, they are not reported here for the sake of brevity: however, they can be found in detailed form in Vermunt and Magidson (2005b, p. 53).

277 In this context, the reference is to cell counts in the contingency table defined by *all* input variables used in the LCA.

Besides L^2, there are information criteria such as the Akaike Information Criterion (AIC), the Bayesian Information Criterion (BIC) and the Consistent Akaike Information Criterion (CAIC) that take into account both model fit and parsimony. They are based on L^2, as illustrated by the following formulae (Vermunt & Magidson, 2005b, p. 60):

(A.4.5.) $$AIC = L^2 - 2df$$

(A.4.6.) $$BIC = L^2 - \log(N)df$$

(A.4.7.) $$AIC = L^2 - [\log(N) + 1]\, df$$

When using these information criteria, the criterion is to retain the model associated with the lowest and most negative value.

The Average Weight of Evidence (AWE) statistic takes into consideration also the performance of classification, besides absolute model fit and parsimony (Vermunt & Magidson, 2005b, p. 63). This is useful when a 'classify-analyze' approach to the analysis of clusters is adopted (see §A.4.5). The formula is the following (*ibidem*):

(A.4.8.) $$\mathrm{AWE} = -2\log \mathcal{L}^c + 2\left(\frac{3}{2} + \log N\right) npar$$

Where $\log \mathcal{L}^c$ is the "classification log-likelihood (..) equivalent to the complete data log-likelihood" (Vermunt & Magidson, 2005b, p. 63), defined as (*ibidem*):

(A.4.9.) $$\log \mathcal{L}^c = \sum_{i=1}^{I} \sum_{x=1}^{K} \widehat{w}_{xi} \log \hat{P}(x|\boldsymbol{z_i}) \hat{f}(y_i|x.\boldsymbol{z_i})$$

Another criterion to evaluate the goodness of fit of a latent class model is to look at the table showing the bivariate residuals between each possible pair of input variables. This provides "direct checks" of the local independence assumption, because the residuals "indicate how similar the estimated and observed bivariate associations are" (Vermunt & Magidson, 2005b, p. 72). In Latent GOLD, bivariate residuals are similar to Lagrange-type residuals, defined as follows[278] (p. 73):

(A.4.10.) $$BR = \frac{1}{P} \sum_{p=1}^{P} \left(\frac{\partial \log \mathrm{P}}{\partial \vartheta_p^{local}}\right)^2 \bigg/ \left(\frac{\partial^2 \log \mathrm{P}}{\partial^2 \vartheta_p^{local}}\right)$$

In practice, the number of bivariate residuals for the model whose value is over 3.84, indicates how many "correlations between the associated variable pairs (..) have not been adequately explained by the model" (Vermunt & Magidson, 2005a, p. 125). Therefore, the criterion is to select the model with the lowest number of bivariate residuals over 3.84

Finally, the *Bootstrap -2LL diff* option in Latent Gold™ 4.5 tests whether an additional class "provides a significant improvement in model fit" (Vermunt & Magidson, 2005a, p. 98-99). It does so by providing "the estimated bootstrap *p*-value (and the standard error) for the *-2LL* difference between a restricted and an unrestricted model" (Vermunt & Magidson, 2005b, p. 61), where *-2LL* stands for $-2\log \mathcal{L}$ and $\log \mathcal{L}$ is defined as (*ibidem*):

(A.4.11.) $$\log \mathcal{L} = \sum_{i=1}^{I} w_i \log \hat{f}(\boldsymbol{y_i}|\, \boldsymbol{z_i})$$

When using the conditional bootstrap, the criterion is to keep adding classes until the estimated conditional bootstrap p-value becomes significant ($p<0.05$) (Vermunt & Magidson, 2005a, p. 180-181).

278 Details about the meaning of the terms in eq. *(A.4.10.)* are provided in Vermunt and Magidson (2005b, p. 72-74).

A.4.5. Approaches to the analysis of the clusters

Once clusters have been obtained by means of LCA, the investigator usually wants to describe the clusters with respect to other variables, different from the indicators of the latent variable used as input variables in the LCA. To accomplish this, there are two different approaches: the 'classify-analyze' approach and including covariates into the analysis (Collins & Lanza, 2010, p. 67-68, 149-177).

With regard to the 'classify-analyze approach', it must be kept in mind that LCA generates *probabilistic* models. This means that, unlike other clustering methods reviewed in §A.3, the outcome of the analysis is *not* the assignment of observations to different classes, but rather the estimation of parameters, indicating the probability for each individual to belong to a certain latent class (*latent class probabilities*) or the probability for individuals belonging to a certain class to have a certain characteristic, as measured by the observed variables (*conditional probabilities*) (§A.4.2).

Of course, it is possible to use "posterior probabilities to assign individuals to classes, and then to follow this assignment with statistical analyses, such as logistic regression, to predict class membership using new variables" (Collins & Lanza, 2010, p. 67-68). This is the 'classify-analyze' approach. In Latent GOLD, "posterior or membership probabilities" are defined as (Vermunt & Magidson, 2005b, p. 62):

(A.4.12.) $$\hat{P}(x|\boldsymbol{z_i},\boldsymbol{y_i}) = \frac{\hat{P}\,(x|\boldsymbol{z_i})\hat{f}(\boldsymbol{y_i}|x,\boldsymbol{z_i})}{\hat{f}(\boldsymbol{y_i}|\,\boldsymbol{z_i})}$$

As argued by Collins and Lanza, however, there are dangers in the classify-analyze approach (2010, p. 68):

> "the difficulty with such analyses is that they generally do not take into account the uncertainty in classification that is present to some degree in every latent class analysis (and) this affects any inferences drawn from subsequent analyses (..). Classification uncertainty varies not only across latent class solutions, but also across individual subjects in a single data set for any particular latent class solution. For this reason we do not recommend using posterior classifications in subsequent analyses, except as a rough exploratory or heuristic device, *unless homogeneity and latent class separation are sufficient to assure a high degree of certainty in classification for all individuals*, or classification uncertainty is somehow modelled explicitly into the analysis" (Collins & Lanza, 2010, p. 68, emphasis added)

Classification statistics allow the investigator to evaluate the degree of classification uncertainty, by assessing "how well the model classifies into clusters" (Vermunt & Magidson, 2005a, p. 112). As illustrated by Vermunt and Magidson (2005b, p. 62), the proportion of classification errors (estimating the proportion of misclassified cases) is defined as:

(A.4.13.) $$E = \frac{\sum_{i=1}^{I} w_i[1-\max \hat{P}(x|\boldsymbol{z_i},\boldsymbol{y_i})]}{N}$$

Three pseudo-R_2 statistics ('reduction of errors', 'entropy R-squared' and 'standard R-squared') indicating "how well on can predict class memberships based on the observed variables" (Vermunt & Magidson, 2005a, p. 112) are provided by Latent GOLD. They are defined as follows (Vermunt & Magidson, 2005b, p. 62):

(A.4.14.) $$R^2_{x,errors} = \left\{\left[Error(x) - \frac{\sum_{i=1}^{I} w_i(1-\max \hat{P}(x|\boldsymbol{z_i},\boldsymbol{y_i}))}{N}\right]/Error(x)\right\}$$

(A.4.15.) $$R^2_{x,entropy} = \left\{\left[Error(x) - \frac{\sum_{i=1}^{I} w_i(\sum_{x=1}^{K} \; -\hat{P}(x|\boldsymbol{z_i},\boldsymbol{y_i})\log \hat{P}(x|\boldsymbol{z_i},\boldsymbol{y_i}))}{N}\right]/Error(x)\right\}$$

(A.4.16.) $$R^2_{x,variance} = \left\{\left[Error(x) - \frac{\sum_{i=1}^{I} w_i(1-\sum_{x=1}^{K}[\hat{P}(x|\boldsymbol{z_i},\boldsymbol{y_i})]^2)}{N}\right]/Error(x)\right\}$$

In the formulae (Vermunt & Magidson, 2005b, p. 62):

- $Error(x)$ is "the total error when predicting *x* without using information on *z* and *y*" (*ibidem*)
- the three pseudo-R^2 measures differ in the definition of case-specific errors, whose weighted average is used to measure the "prediction error if we use all observed information from the cases" (Vermunt & Magidson, 2005b, p. 62)

When using classification statistics, the criterion is to select the model with the best classification performance: this corresponds to the lowest value for the classification error, but the highest value for the pseudo-R^2 measures and the classification log-likelihood closest to zero. As illustrated above (§A.4.4), the Average Weight of Evidence (AWE) statistics "weighs fit, parsimony, and the performance of the classification" (Vermunt & Magidson, 2005a, p. 63), thus allowing the researcher to take into account classification performance during the process of model evaluation.

Collins and Lanza (2010) recommend that investigators include covariates in LCA, as an alternative to assigning observations to classes using posterior probabilities of latent class membership (p. 67-68). Indeed, it is possible to:

> "introduce variables into LCA as covariates that predict latent class membership (..). This is accomplished by means of ordinary logistic regression; the only difference is that the outcome is latent rather than directly observed" (Collins & Lanza, 2010, p. 149)

It is then possible to use hypothesis tests to test whether the effect of a set of covariates is statistically significant (Collins & Lanza, 2010, p. 155). However, including covariates in LCA in Latent GOLD results in the estimation of a very large number of parameters, that in turn leads to the problems of model identification, as illustrated above (§A.4.3).

Appendix B. Data analysis for MiD 2008 and MiD 2002

In chapter 6, the empirical results for the German case are illustrated. In this Appendix, further details about the secondary data analysis are presented. First of all (§B.1) I provide technical details about the datasets MiD 2008 and MiD 2002 (survey design, sampling design, weighting, dataset structure, key definitions, etc. In section §B.2, I provide details for variables that have been manipulated. In the following section (§B.3), I provide details about multivariate models, focusing notably on model selection.

B.1. "Mobilität in Deutschland": the datasets

B.1.1. Survey design

Following the reunification of Germany, no national travel survey was conducted for more than a decade, after KONTIV 1989 (Engelhardt, et al., 2005a, p. 144). For this reason, a "Pilot Study for the Survey Mobility in Germany" was conducted, in order "to explore different options for the next NTS" (ibidem). The result of the study led to changes in the survey mode (Engelhardt, et al., 2005b, p. 206): while previous KONTIV waves were based on self-administered questionnaires (SAQ) (Follmer, Kuner, & Smid, 2001, p. 3), MiD 2002 was based on a mix of computer-assisted telephone interview (CATI) and postal SAQ instruments (Engelhardt, et al., 2005b; Kunert & Follmer, 2005).

In detail, for MiD 2002, the following procedure was followed (Kunert & Follmer, 2005, p. 419). Potential interviewees were sampled from population registers (see §B.1.2): when the telephone number was traceable (approximately 60% of cases in 2002), they received a letter in advance, announcing that would be interviewed. All interviews (household and person interview and travel diary) were then done by CATI. When the telephone number of persons sampled from population registers was not traceable (approximately 40% of cases in 2002), they received a postal SAQ. However, most people who returned the household questionnaire by mail included their telephone number (85% in 2002), thus making it possible to conduct the person interviews via CATI (Engelhardt, et al., 2005b, p. 206). As a result, "a total of 95% of the information finally available for analysis was gathered via CATI" (Kunert & Follmer, 2005, p. 422). According to Kunert and Follmer, this "mixed-method approach" improved "the accuracy and scope of the data gathered" (2005, p. 427) and increased the response rate[279]. However, it has to be noted that some questions were only included in the CATI questionnaire: as a result, postal SAQ interviews include a higher proportion of missing data (Follmer & Kunert, 2003, p. 9; infas, 2010a, p. 7).

For MiD 2008, the survey method was slightly changed: while most interviews were conducted by CATI, and a few by postal SAQ, for the first time interviewees had the opportunity to answer the household interview online (computer assisted web interview, CAWI) (infas, 2010a, p. 3). However, all person and travel diary interviews were conducted by CATI (*ibidem*).

For both waves of *Mobilität in Deutschland*, all households members were interviewed, including children from the age of 0, as this allows for "household context analysis"[280] (Kunert & Follmer, 2005, p. 417). For respondents under the age of 14, a special questionnaire was developed; for children under the age of 10, however, all interviews were conducted by proxy; for children from 10 to 13 years, respondents could choose between regular and proxy interviews (Engelhardt, et al., 2005b, p. 206-207). In special occasions, also households members over the age of 14 were interviewed by proxy (12% in MiD 2002) (Kunert & Follmer, 2005, p. 422; infas, 2010a, p. 7). For both waves, only "complete households" (defined as those where 50% or more of the household members were interviewed) were included in the final data set (Kunert & Follmer, 2005, p. 422).

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279 The overall return rate for MiD 2002 was 42% (Kunert & Follmer, 2005, p. 422).

280 In previous KONTIV waves, by contrast, only children over the age of 6/10 years were eligible (Follmer, Kuner, & Smid, 2001, p. 3).

As most National Travel Surveys, the sample is representative for the whole calendar year: this means that the travel diary days are spread over twelve months (infas, 2010a, p. 5). The use of fixed diary-dates allows to "capture seasonal variations in travel" (Kunert & Follmer, 2005, p. 417). In detail, the fieldwork for MiD 2002 was conducted from November 2001 to December 2002 (Engelhardt, et al., 2005a), while MiD 2008 was conducted from end of January 2008 to mid-February 2009 (infas, 2010a, p. 3).

The MiD interviews consist essentially of two phases (infas, 2010b, p. 9). First, a household interview is conducted, to assess household characteristics, availability of transport means, etc. Only household members over the age of 14 are allowed to answer the household interview (infas, 2010b, p. 16). In a second phase, all household members are requested to answer a person-level interview and a travel diary (infas, 2010b, p. 9), if necessary by proxy (see above). The travel diary covers a single day, in order to "avoid recall and fatigue effects" (Kunert & Follmer, 2005, p. 417).

MiD surveys are representative for Germany as a whole. However, cities and region are allowed to request so-called "regional add-ons" to expand the range of analysis that it is possible to carry out at a regional level (DLR and infas, 2007, p. 16). Regional add-ons are available upon request to the regional authorities that commissioned them. All analyses reported in chapter 6 are based on the baseline sample only, and do not take into account regional add-ons. Also, all analyses have been carried out on the "public-use file" (PUF) (infas, 2010a, p. 12).

B.1.2. Sampling design

Both MiD waves are representative at the national level. The reference population is the population living in Germany, regardless of age, nationality or ethnic background (Kunert & Follmer, 2005, p. 419). The sample is drawn from official person registers: this allows for the inclusion of foreigners and institutionalized persons and "to control the process of sample loss on the basic variables supplied by the registers (gender, age, nationality)"[281] (Kunert & Follmer, 2005, p. 416-417). This in turn contributes to the computation of sampling weights (see below). Only persons aged 14 years and above were drawn from the official person registers (Kunert & Follmer, 2005, p. 419): all persons living in the same household as the extracted person were then included in the sample (Engelhardt, et al., 2005b, p. 206). To draw the individuals from the registers, random numbers were used (infas, 2010a, p. 33).

In detail, households have been sampled using a two-tier system, so the data are clustered in municipalities (infas, 2010a, p. 33). This means that, in a first step, approximately 300 municipalities have been sampled (primary sampling units[282]) (infas, 2010a, p. 39). In a second step, persons over 14 have been sampled from the official person registers of those municipalities[283] (Engelhardt, et al., 2005b).

The sampling of municipalities was stratified by State (*Bundesländer*) and type of region, as described by infas (2010a, p. 31-32). This improves the territorial representativeness of the sample, and allows for analysis to be conducted at the State level (*ibidem*). For each German State, a sample of at least 750 households was included in MiD 2008 (infas, 2010b, p. 12). This, combined with large sample size, allows to compute the values of key mobility indicators for each German State (Engelhardt, et al., 2005b, p. 206; infas, 2010a, p. 38).

In a nutshell, the sampling design can be described as stratified random sampling from official person registers (Engelhardt, et al., 2005b). These sampling design characteristics have been taken into account in the data analysis reported in chapter 6, notably when computing standard errors for significance tests and multivariate models (see below).

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281 For Turkish-speaking residents a questionnaire in Turkish was available in 2002. However, in some cases interviews with foreigners could not be completed because of language problems (Engelhardt, et al., 2005b, p. 206).

282 For MiD 2008, 341 sample-points in 270 municipalities (infas, 2010a, p. 31).

283 More detailed information about the sampling design is available in infas (2010a; 2010b).

In the MiD 2002 and MiD 2008 datasets, sampling weights are included for each type of unit of analysis (households, individuals, trips, etc.) (infas, 2010b, p. 34). These allow to compute values that are representative for the German population as a whole. In detail, sampling weights are computed so as to[284]:

- correct the biases resulting from unequal probability of selection (as a result of sampling design) (infas, 2010a, p. 25, 31) and/or differential non-response (p. 38)
- make the frequency distribution of the sample on key variables (e.g. household size, age, gender, type of region, day of the week, calendar month) as similar as possible to that of the reference population (infas, 2010b, p. 25, 33)

All analyses reported in chapter 6 are based on weighted data.

B.1.3. Dataset structure

As the MiD surveys gather information concerning different units of analysis, different datasets are available. For Mid 2008, five datasets are available, as illustrated in Fig. B.1 (infas, 2010a, p. 6, 14). The household datasets includes information about the household, gathered with the household and or the person-level interviews. The individual dataset includes information about all household members. The trips dataset includes information about up to twelve trips made on the travel diary day (infas, 2010a, p. 5). The 'long distance journey' dataset includes information about up to three overnight journeys made in the three months preceding the interview[285] (infas, 2010a, p. 6). The car dataset includes detailed information about up to three automobiles owned by the household (infas, 2010a, p. 6).

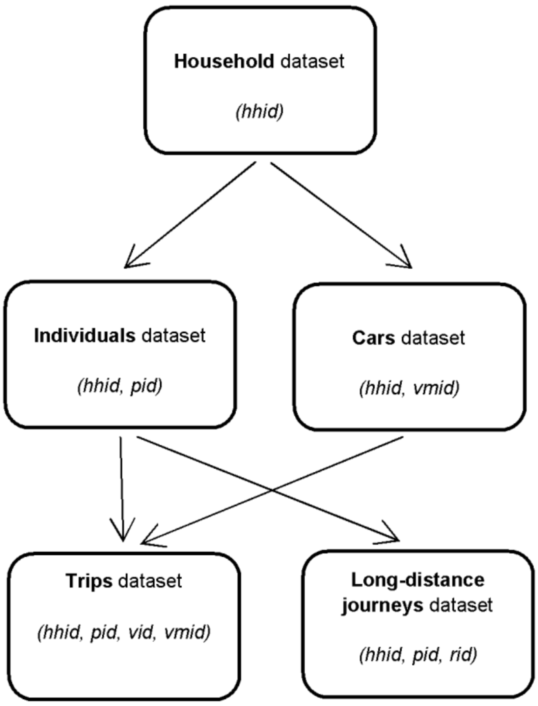


Fig. B.1 – Levels in the MiD 2008 database and identifier variables. Source: adapted from infas (2010a, p. 14)

[284] More details about how sampling weights are computed for MiD 2008 are found in infas (2010a; 2010b).

[285] In MiD 2002, no 'long distance journey' dataset is available.

As illustrated in Fig. B.1, it is easy to link the data from each level of the dataset hierarchy using the identifier variables (infas, 2010a, p. 13). The analysis reported in chapter 6 is based on data from the household, individual and trip datasets exclusively. For all analysis reported in chapter 6, I specify unambiguously which dataset and unit of analysis is considered.

B.1.4. Additional geographical variables

Both the MiD 2002 and MiD 2008 datasets include basic geographical variables (municipality size, type of region, etc.). For MiD 2008, further geographical variables are available separately upon request to the German German Federal Ministry of Transport, Building and Urban Development (infas, 2010a, p. 11). These include (among others):

- a classification of municipalities in 17 categories (*Siedlungsstrukturelle Gemeindetypen*), depending on the nature of their region (agglomeration, urban space or rural space) and their degree of density, urbanity and centrality inside the regional space
- population and job density, as measured both on the whole surface of the municipality and only on its urbanised surface
- weighted number of people potentially accessible within a 100km radius around the municipality
- population density in the proximity area (1x1km)[286]
- percentage of flats in one or two-family houses in the municipality
- motorisation rate at the district (*Kreis*) level
- accessibility to the closest important city from the municipality of residence (measured in minutes of travel by car)

In chapter 6, I have used the variables ‘population density at the municipality level’ and ‘population density in the proximity area (1x1km)’ for some analysis.

B.1.5. Definition of trip

As illustrated in §3.4.2, even if travel surveys have been conducted in many countries over the world since at least 40 years, during that time no successful attempt has been made to standardize the process; in the European context, while Eurostat has successfully implemented an harmonisations of national surveys on time use, a similar process for travel surveys is still underway (De La Fuente Layos, 2005). As a result, “there are presently no agreed standards for conducting comparable and reliable surveys at an EU level” and thus “the methodological differences between countries’ surveys do not allow a full comparison of the results obtained” (p. 1-2). Notably, the definitions of key concepts such as ‘trip’ vary between surveys.

According to the definition of the German national travel surveys (KONTIV and MiD), a ‘trip’ takes place when a person moves from one place to another by foot or with other modes of transport (infas, 2010a, p. 17). A trip might be made with a combination of different modes of transport (*ibidem*). While the MiD 2008 travel diary recorded up to 12 trips on the day of survey, only up to eight trips were recorded in the MiD 2002 survey (2010a, p. 29).

B.2. Variable manipulation

In many cases, the variables used for the data analysis in chapter 6 are different from the original variables included in the MiD databases 2002 and 2008. While in some cases the variables have been recoded in a simple way, in other occasions more complex recoding and computation of indexes have been undertaken. In this section, the details of these operations are described.

[286] This variable has been introduced in the dataset explicitly in order to allow the analysis of the relations between density at the micro-scale and transport behaviour (such as modal choice).

B.2.1. Household type

In order to put forward a simple typology of family units, the variable ‘household type’ has been generated. Tab. B.1 shows the description of the variable categories.

Categories	Description
Retired single	Household consisting of one member who is also retired
Retired household	Household including at least one retired member where all other members are either retired, housewife / househusband or unemployed
Single	Household consisting of one member who is not retired
Other	All remaining households

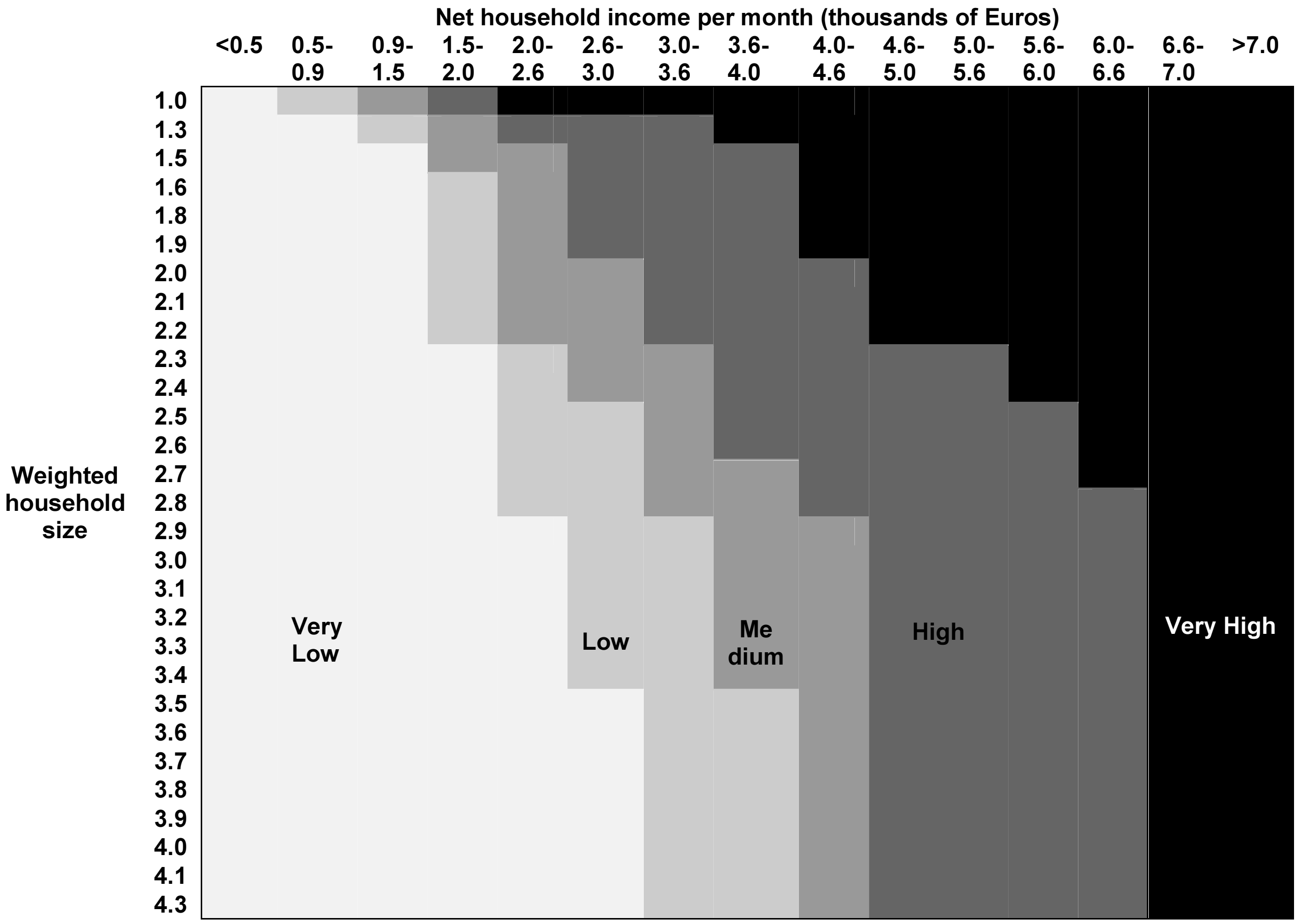
Tab. B.1 – Description of the categories of the recoded variable ‘household type’. Source: own elaboration.

B.2.2. Economic status

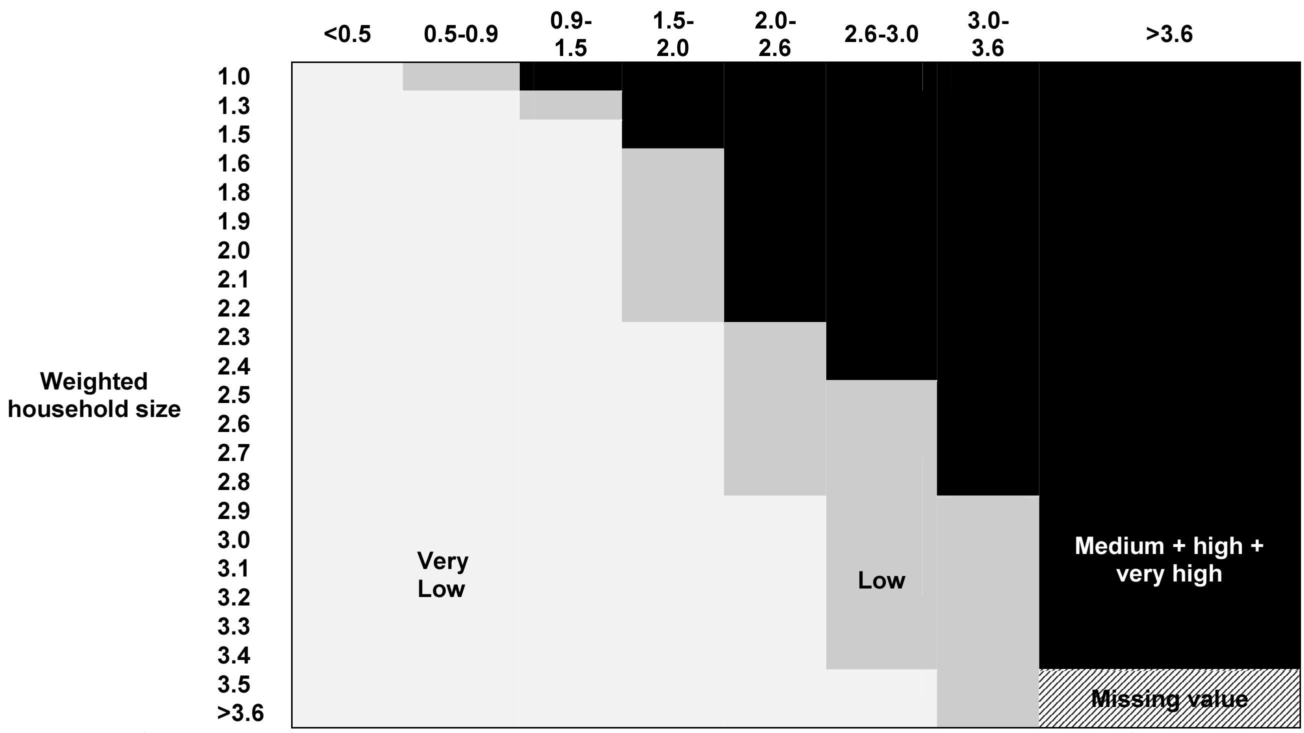
The variable ‘economic status’ (*ökonomischer Status des Hausalts*) is available in the MiD 2008 household database. A detailed description of how the variable is constructed is provided by infas (2010a, p. 5). In a nutshell, the variable is based on the principle of the ‘equivalent income’ adopted by the OECD. This takes into consideration the net household income as well as a ‘weighted household size’, computed assuming a different weight for household members over 15 (1 point for the first member, 0.5 for each additional member) and for members under the age of 15 (0.3). According to their values on these two variables, households have been assigned to the five economic status categories, as illustrated in Tab. B.2. However, the original variable ‘net household income per month’ included a high proportion of missing observations, due to non-response (13%). These cases have been assigned to an economic status category according to the auto model or (for carless households or when also this information was missing) according to type of neighbourhood (infas, 2010a, p. 5).

However, no ‘economic status’ variable is available in the MiD 2002 database. In order to allow comparison between the two waves, I have constructed a new variable, based on the available variables ‘net household income’, ‘household size’ and ‘age of households members’. The approach followed is illustrated in Tab. B.3. However, since the variable ‘net household income’ in MiD 2002 has only eight categories, a small number of households with large weighted household size could not be assigned to any categories, and have thus been recoded as missing. For all analysis illustrated in chapter 6, the variable ‘economic status’ for 2002 has been recoded in two categories: low and very low; medium, high and very high.

The variable ‘economic status’ for 2002 thus adopts the same criteria as the corresponding variable available in MiD 2008. While this is meant to allow comparison, it must be acknowledged that this method has some shortcomings. Firstly, it does not take into account changes in average per-capita income over time, nor inflation. Since both GDP growth and inflation were larger than zero between 2002 and 2008 in Germany, it logically follows that the variable ‘economic status’ might underestimate the economic condition of households. Given the relative short time span, however, this effect is likely to be negligible. Secondly, for the 2002 variable, missing cases for the variable ‘net household income’ have been coded as missing (unlike for the MiD 2008 variable): if the likelihood of not anwering is associated with levels of income, this might lead to bias when comparing between 2002 and 2008. Given these limitations, the results of the comparison between the waves for this variable should be considered with care.



Tab. B.2 – Economic status, net household income and weighted household size for MiD 2008. Source: adapted from infas (2010a, p. 5).



Tab. B.3 – Categories of the economic status variable, income and weighted household size for MiD 2002. Source: own elaboration, adapted from infas (2010a, p. 5).

B.2.3. Accessibility to services and opportunities

In chapter 6, several indexes of accessibility have been used in the data analysis. In this section, I illustrate how the indexes have been computed, and discuss the advantages and the limitations of each one of them.

All indexes are computed on the basis of 14 accessibility items included in the MiD 2008 database (but not in MiD 2002). The items measure accessibility levels for key destinations with different transport means. In a section of the individual questionnaire all respondents over 14 years old were asked to rate on a six-point scale (1: very good; 2: good; 3: to some extent; 4: bad; 5: very bad; 6: not at all) the accessibility of services and opportunities (school, place of formation, workplace, shops for daily shopping) with different modes of transport (walking, cycling, public transport, car). The details for all variables are illustrated in Tab. B.4.

With reference to Tab. B.4, two crucial observations need to be made:

- first, not all respondents answered the same questions. Indeed, while questions about shops were asked to all respondents, questions concerning other services and opportunities were filtered. For example, quite understandably, only employed respondents had to answer about the accessibility of the workplace; similarly, only not employed individuals under the age of 18 had to rate school accessibility. Finally, people who were in formation at the time of survey, also had to rate the accessibility of the place of apprenticeship. This implies that, while for many respondents information is available only for the accessibility of shops, others had to rate two destinations (but none had to rate three destinations or more)
- on the other hand, all respondents were asked to rate accessibility (to relevant destinations) by all transport modes listed in the table (walking, cycling, public transport and car) regardless if they had access to the transport mode or not. For example, individuals living in households without cars also had to rate the accessibility by car. The exception here is accessibility by foot to the workplace or the place of apprenticeship: for these combinations of transport mode and destination, no question was included in MiD 2008. This probably reflects the assumption that these opportunities are generally beyond walking distance. The point to stress here is however that, with reference to a specific destination, information is available about the self-rated accessibility with all transport modes (except of course in the case of missing values). As it will be illustrated below, this feature of the MiD 2008 database is very useful to compute overall accessibility indexes, and notably the index of car-related accessibility advantage

„How is the accessibility to (Y) by (X)?" *(1: very good – 6: not at all)*	**"..your workplace"**	**"..your place of apprenticeship"**	**"..your school"**	**"..the shops for your daily shopping"**
Filter:	*employed*	*in formation*	*not employed, under 18*	*(None)*
Walking	*no variable*	*no variable*	p0411_3	p0411_4
Cycling	p0412_1	p0412_2	p0412_3	p0412_4
Public Transport	p0413_1	p0413_2	p0413_3	p0413_4
Car	p0414_1	p0414_2	p0414_3	p0414_4

Tab. B.4 - Accessibility-related variables in MiD 2008 (individual database). Source: MiD 2008 database.

For use in the data analysis, I have summarised the variables listed in Tab. B.4 using different criteria, as illustrated below. While these variables provide precious information about accessibility, and allow the researcher to show interesting results, using these items entails several limitations, that need to be acknowledged:

- first, the variables provide information about the *subjective rating* respondents assign to the accessibility of destination Y with transport mode X. In that sense, they are very different from objective measures of accessibility (such as, for example, distance between the residence and the destination, travel time required, etc.). On one hand, this can be an asset, as it provides a measure of the perception of accessibility: this perception, in turn, it is likely to have an important impact on travel behavior and the effective access to services and opportunities of the individual. On the other hand, however, the existence of gaps between the real situation and the perceived situation in terms of accessibility can be problematic
- this problem is compounded by the fact that respondents were asked to rate accessibility with all transport modes, even if they actually did not use them to reach the destination, or even did not have access to them. On one hand this is an asset, as it allows the researcher to compute the difference in accessibility levels between different modes for all respondents. On the other hand, however, it may be problematic. Notably, lack of knowledge and first-hand experience can distort the estimates of accessibility. For example, a regular car commuter might have never tried to commute by other modes: accordingly, his rating of workplace accessibility by bike will be arbitrary at best. In these cases, processes of cognitive dissonance reduction (Festinger, 1957) might be at work. For example, a man who commutes by bike because (for whatever reason) there is no car in the household, might underestimate workplace accessibility by car, and overestimate accessibility by bike. Overall, both lack of knowledge and cognitive dissonance point at concerns about the *validity* of the indicators in Tab. B.4
- third, and most importantly, the number of activities and services that are taken into account is extremely limited. Notably, the battery of items does not include any public service, nor destinations for leisure activities. This is problematic since it might obscure differences in accessibility that have considerable impact on transport-related social exclusion. For example, for older people, access to health services (doctor, hospital, etc.) is often essential. As suggested in the literature (see Chapter 2), there are often great differences between accessibility to hospitals by car and by other modes. When this happens, older people in carless households are at considerable disadvantage, with respect to their motorized counterparts. However, insofar as retired people were only asked to rate accessibility to local shops in MiD 2008, these differences are completely obscured. Moreover, the filters applied to the questions have a similar effect. For example, a carless household where all members are unemployed might report excellent accessibility to local shops by foot, and at the same time be in desperate need of a car for access to potential workplaces. In fact, as discussed in the literature, lack of car access might be an important reason for unemployment (see §2.2.1). However, the question 'accessibility to the workplace' was asked only to individuals who *already have* a job. As a result, this important differential in accessibility is obscured. As these examples illustrate, a relevant consequence of the limited range of destinations considered by the accessibility items in MiD 2008 (as well of the filters applied to them) is that the differential in access between people with and without car access tends to be underestimated. In a nutshell then, using accessibility indexes based on the variables listed in Tab. B.4 implies a *normative assumption*, that should be made explicit: it is assumed that the basic needs of people can be satisfied by accessing to the services and opportunities that were asked to them. Indeed, this assumption is implausible: it implies, for example, that the access needs of a person who is neither in employment or formation are satisfied if access to shops for daily shopping is rated positively

To sum up, then, the accessibility indexes used in chapter 6 have several limitations. Notably, as discussed above, many of these limitations (cognitive dissonance reduction, limited range of destinations considered, filters applied) arguably result in an underestimation of the accessibility disadvantage for the carless. This should be taken into consideration when discussing the results illustrated in chapter 6: notably, all differentials in accessibility levels between individuals with and without cars should be considered as conservative estimates, as the differential is likely to be higher. Conversely, when no difference in accessibility is observed between car-owning and non-car owning individuals (or when there is even an advantage for the carless), the findings should be considered with great caution.

There is not a single way of constructing indexes of accessibility based on the items of Tab. B.4. Indeed, there are many possible approaches, each of them is likely to result in different findings and conclusions, and it is not immediately obvious which is the best way. The approach adopted in this thesis is the following: several indexes of accessibility have been constructed, using different methods. In chapter 6, results are presented for all of them: trends that are observed for all indexes are more likely to reflect real differences, while divergences are explained with reference to the different method of computation. In this section, for each index I illustrate the method used to compute it, its substantive interpretation and I point out the its possible biases.

For all indexes, a preliminary operation was the recoding of the variables listed in Tab. B.4 into new variables, with the reverse coding scheme (0: not at all; 1: very bad; 2: bad, 3: to some extent; 4: good; 5: very good). In the new variables, higher values mean more accessibility. Also it must be noted that computing continuous indexes on the basis of these items implies the assumption that the response categories are equally spaced.

Accessibility: walking

This index is computed as the average of the rating of walking, for access to all destinations that are relevant to the individual. The formula used is the following:

$$Index_1 = \frac{p0411_3 + p0411_4}{n}$$

Where *n* is the number of destinations for which questions were asked to the individual and the value is not missing. Given that walking accessibility was asked only for schools and shops, there are only two possible cases: people under the age of 18 who are not in employment (for whom $index_1$=(p0411_3 + p0411_4)/2) and others (for whom index=p0411_3). Therefore, it is important to note that for most respondents, the index considers only accessibility to shops. This is a limitation, and thus high values should be interpreted with great care. Conversely, low values should be considered as suggestive of accessibility problems that are likely to be even greater for other services and opportunities. Similar considerations apply to the following three indexes.

The index ranges between 0 (worst walking accessibility) and 5 (best walking accessibility). The maximum value is obtained when walking accessibility is rated ‘very good’ for all relevant destinations. The minimum value is obtained when walking accessibility is rated ‘not at all’ for all relevant destinations. The rating should be considered as positive if higher than 3 (‘somehow’) and negative if lower.

Accessibility: cycling

This index is computed as the average of the rating of cycling, for access to all destinations that are relevant to the individual. The formula used is the following:

$$Index_2 = \frac{p0412_1 + p0412_2 + p0412_3 + p0412_4}{n}$$

Where *n* is the number of destinations for which questions were asked to the individual and the value is not missing.

The index ranges between 0 (worst cycling accessibility) and 5 (best cycling accessibility). The maximum value is obtained when walking accessibility is rated ‘very good’ for all relevant destinations. The minimum value is obtained when walking accessibility is rated ‘not at all’ for all relevant destinations. The rating should be considered as positive if higher than 3 (‘somehow’) and negative if lower.

Accessibility: public transport

This index is computed as the average of the rating of public transport, for access to all destinations that are relevant to the individual. The formula used is the following:

$$Index_3 = \frac{p0413_1 + p0413_2 + p0413_3 + p0413_4}{n}$$

Where *n* is the number of destinations for which questions were asked to the individual and the value is not missing.

The index ranges between 0 (worst public transport accessibility) and 5 (best public transport accessibility). The maximum value is obtained when walking accessibility is rated ‘very good’ for all relevant destinations. The minimum value is obtained when walking accessibility is rated ‘not at all’ for all relevant destinations. The rating should be considered as positive if higher than 3 (‘somehow’) and negative if lower.

Accessibility: car

This index is computed as the average of the rating of the car, for access to all destinations that are relevant to the individual. The formula used is the following:

$$Index_4 = \frac{p0414_1 + p0414_2 + p0414_3 + p0414_4}{n}$$

Where *n* is the number of destinations for which questions were asked to the individual and the value is not missing.

The index ranges between 0 (worst car accessibility) and 5 (best car accessibility). The maximum value is obtained when walking accessibility is rated ‘very good’ for all relevant destinations. The minimum value is obtained when walking accessibility is rated ‘not at all’ for all relevant destinations. The rating should be considered as positive if higher than 3 (‘somehow’) and negative if lower.

All modes, maximum accessibility

This index takes into consideration, for each relevant destination, only the value associated with the transport mode providing the best accessibility. The index is then computed by averaging the values across all destinations that are relevant to the individual. The formula used is the following:

$$Index_5 = \frac{\begin{array}{c} max(p0412_1, p0413_1, p0414_1) + max(p0412_2, p0413_2, p0414_2) \\ + max(p0411_3, p0412_3, p0413_3, p0414_3) + max(p0411_4, p0412_4, p0413_4, p0414_4) \end{array}}{n}$$

Where *n* is the number of destinations for which questions were asked to the individual and the value is not missing.

The index ranges between 0 (worst accessibility) and 5 (best accessibility). The rating should be considered as positive if higher than 3 (‘somehow’) and negative if lower. It is important to observe that the maximum value is obtained when *at least one* transport mode for every relevant destination is rated as ‘very good’. When this condition is satisfied, the value of $index_5$ will be 5, regardless of the rating assigned to other modes of transport. By contrast, the minimum value is obtained only when *all* modes of transport provide ‘no’ access, for all relevant destinations. A score in the middle range of the index can be obtained when accessibility is high for one destination, but low for another, as well as when accessibility is average for all relevant destinations.

The index has two main characteristics. First, it takes into consideration all means of transport, regardless of their availability to the individual. For this reason, it is an accurate measure of experienced accessibility only for households who have both cars and bicycles available. Indeed, I expect lack of public transport services in the area and health-related mobility problems that make walking impossible to be reflected in the score assigned to these modes. By contrast, I expect people who do not have access to cars and bicycles to assign a score corresponding to the accessibility that they would experience if they had access to that mode[287]. Therefore, for these people $index_5$ is not an accurate measure of the accessibility that they experience, since the score for unavailable modes of transport should not be taken into account. However, for all individuals, it is arguably a good measure of the accessibility that they would experience, if they had access to all private means of transport.

Second, the index takes into account only the value of the transport mode that provides the best accessibility to the relevant destination. The assumption (with normative implications) here is that having good access with one mode is a sufficient condition to have good overall accessibility, regardless of what happens when other modes are considered. So for example, a person who enjoys ‘very good’ access to shops by car (but ‘very bad’ access with other means of transport) is assigned the same score than a person who reports ‘very good’ access with *all* means of transport. Notably, this assumption neglects the value of choice, whereby people who can choose between different modes of transport (providing high levels of accessibility) do not have a higher score than people who are forced into the use of one mode (because it is the only one providing good access).

All modes, mean accessibility

This index takes into consideration, for each relevant destination, the average of the values assigned to every transport mode. The index is then computed by averaging the values across all destinations that are relevant to the individual. The formula used is the following:

$$Index_6 = \frac{\begin{array}{c} mean(p0412_{1,}\, p0413_{1,}\, p0414_1) + mean(p0412_{2,}\ p0413_{2,}\, p0414_2) \\ + mean(p0411_{3,}\, p0412_{3,}\, p0413_{3,}\, p0414_3) + mean(p0411_{4,}\, p0412_{4,}\, p0413_{4,}\, p0414_4) \end{array}}{n}$$

For every destination, the mean is obtained by dividing the sum of the values for the number of non-missing values for the variables. In the formula, n is the number of destinations for which questions were asked to the individual and the value is not missing.

Like other indexes in this section, it ranges between 0 (worst accessibility) and 5 (best accessibility). The rating should be considered as positive if higher than 3 (‘somehow’) and negative if lower. It is important to observe that the maximum value is obtained when *all* means of transport for *every* relevant destination are rated as ‘very good’. This is a much more stringent condition than for $index_5$, as even a single sub-optimal value results in a lower score on $index_6$. By contrast, just like for $index_5$, the minimum value is obtained only when *all* modes of transport provide ‘no’ access, for all relevant destinations. A score in the middle range of the index can be obtained when accessibility is high for some modes, but not for others, or when it is average for all modes (the same applies to destinations).

Like $index_5$, this index takes into consideration all modes and therefore the same observations apply. However, it is based on mean, rather than maximum values, and this has important implications for its substantive interpretation. The assumption (with normative implications) here is that having good access with one mode is not a sufficient condition to have good overall accessibility: for example, a respondent reporting ‘very good’ accessibility by car, but ‘no accessibility’ by other modes for all relevant destinations would have a total score comprised between 1.25 and 1.67 (depending on the destinations involved), i.e. a score in the lower range of the index. By contrast, an individual reporting ‘average’ accessibility for all destinations would have a higher final score (3). Therefore, this index recognizes the importance of choice, by assigning a higher score to individuals who can choose between different modes for the same destination. While this is an asset, it must be observed that this assumption is not necessarily realistic: for example, people enjoying

[287] Of course, it is possible that some respondents rated car and bicycle accessibility worse, on the ground that they cannot travel by that mode. Most (but not all) indexes presented in this section, however, move from the assumption that respondents have *not* thought this way. This assumption cannot be demonstrated on the basis of MiD data: for example, as illustrated in Tab. 6.6, the average score for car accessibility is lower for carless than for car-owning households. However, this could be the result of cognitive dissonance reduction (as argued above) or of the fact that carless households tend to live in areas where accessibility by alternative modes is on average higher. Therefore, proving this assumption would require qualitative in-depth interviews.

good accessibility to shops by foot, might not agree low accessibility by public transport (perhaps because the destination is *too close*) puts them at disadvantage.

Alternative modes (car excluded), maximum accessibility

This index takes into account, for each relevant destination, only the value associated with the transport mode providing the best accessibility. The index is then computed by averaging the values across all destinations that are relevant to the individual. In this respect, the index is identical to $index_5$ (all modes, maximum accessibility). The crucial difference here is that the score assigned to the car is not taken into consideration. The formula used is the following:

$$Index_7 = \frac{max(p0412_1, p0413_1) + max(p0412_2, p0413_2) + max(p0411_3, p0412_3, p0413_3) + max(p0411_4, p0412_4, p0413_4)}{n}$$

Where *n* is the number of destinations for which questions were asked to the individual and the value is not missing.

The index ranges between 0 (worst accessibility) and 5 (best accessibility). The rating should be considered as positive if higher than 3 ('somehow') and negative if lower. The same considerations made for $index_5$ apply about the substantive implications of considering the maximum value (rather than the mean) apply here, except that car accessibility is not taken into account. Therefore, the index provides a measure of experienced accessibility only for individuals who do not have car access (but own a bicycle). For all other individuals, it provides a measure of the accessibility that they would experience, if they did not have a car available (but had a bike). For example, a car owning individual who assigned 'very good' to car accessibility but 'no access' to all other modes, for all relevant destinations, will have the minimum score (0), i.e. less than an individual who does not have car access, but assigned a rather low score (e.g. 2) to all modes.

Alternative modes (car excluded), mean accessibility

This index takes into account, for each relevant destination, the average of the values assigned to every transport mode. The index is then computed by averaging the values across all destinations that are relevant to the individual. In this respect, the index is identical to $index_6$ (all modes, mean accessibility). The crucial difference here is that the score assigned to the car is not taken into consideration. The formula used is the following:

$$Index_8 = \frac{mean(p0412_1, p0413_1) + mean(p0412_2, p0413_2) + mean(p0411_3, p0412_3, p0413_3) + mean(p0411_4, p0412_4, p0413_4)}{n}$$

For every destination, the mean is obtained by dividing the sum of the values for the number of non-missing values for the variables. In the formula, *n* is the number of destinations for which questions were asked to the individual and the value is not missing.

The index ranges between 0 (worst accessibility) and 5 (best accessibility). The rating should be considered as positive if higher than 3 ('somehow') and negative if lower. The same considerations made for $index_6$ about the substantive implications of calculating the mean (instead of the maximum value) apply here, except that car accessibility is not taken into account. Therefore, the index provides a measure of the experienced accessibility only for individuals who do not have car access (but own a bicycle). For all other individuals, it provides a measure of the accessibility that they would experience, if they did not have a car available (but had a bike).

Accessibility and mobility capital index

This index is different from all others in that by definition it assigns a higher score to individuals who have access to private modes of transport. This is obtained by replacing the score assigned to car or bicycle accessibility with 0, if the individual does not own a bike or the household does not own a vehicle[288]. The values for the different destinations are then as usual averaged across all destinations. Given the approach adopted here, the index has three different formulas, depending on the ownership of private vehicles.

For individuals in motorised households who own a functioning bicycle, the formula is the following:

$$Index_9 = \frac{mean(p0412_{1,} p0413_{1,} p0414_1) + mean(p0412_{2,}\ p0413_{2,} p0414_2) + mean(p0411_{3,} p0412_{3,} p0413_{3,} p0414_3) + mean(p0411_{4,} p0412_{4,} p0413_{4,} p0414_4)}{n}$$

Where *n* is as usual the number of destinations for which questions were asked to the individual. It must be noted that for these subjects, the computing method is the same as $index_6$. Therefore, the formula can also be written as:

$$Index_9 = Index_6$$

However, for individuals living in motorised households who do not own a functioning bicycle, the formula is the following:

$$Index_9 = \frac{mean(p0412_{1A,} p0413_{1,} p0414_1) + mean(p0412_{2A,}\ p0413_{2,} p0414_2) + mean(p0411_{3,} p0412_{3A,} p0413_{3,} p0414_3) + mean(p0411_{4,} p0412_{4A,} p0413_{4,} p0414_4)}{n}$$

Where $p0412_{1A}=p0412_{2A}=p0412_{3A}=p0412_{4A}=0$ by definition and *n* is as usual the number of destinations for which questions were asked to the individual.

The third possible case is that of an individual living in a carless household who does not own a functioning bicycle. In this case, the formula is

$$Index_9 = \frac{mean(p0412_{1A,} p0413_{1,} p0414_{1A}) + mean(p0412_{2A,}\ p0413_{2,} p0414_{2A}) + mean(p0411_{3,} p0412_{3A,} p0413_{3,} p0414_{3A}) + mean(p0411_{4,} p0412_{4A,} p0413_{4,} p0414_{4A})}{n}$$

Where $p0412_{1A}=p0412_{2A}=p0412_{3A}=p0412_{4A}=0$ and $p0414_{1A}=p0414_{2A}=p0414_{3A}=p0414_{4A}=0$ by definition, and *n* is as usual the number of destinations for which questions were asked to the individual.

The index ranges between 0 (minimum accessibility) and 5 (maximum accessibility). Unlike other indexes, the scale has no meaningful midpoint. The maximum value, by definition, can be obtained only by individuals in car-owning households who own a functioning bike and who have assigned the maximum score to all modes, for all destinations. Individuals who live in carless households and/or do not own a bicycle, by contrast, cannot reach the maximum value: for example, an individual who does not own any private transport mode cannot by definition be assigned a value higher than 2.5, and this only in the case that accessibility is optimal both by walking and by public transport, for all relevant destinations. The minimum value (0) by contrast, is obtained only by individuals who reported 'no accessibility' by walking, public transport and all private transport modes that they own. In practice, the peculiar feature of this index is to penalise individuals who do not own private modes of transport, by assigning them a lower score: so for example, in the case of an individual in a car owning household, who does not own bicycles and assigns 3 to all accessibility items for the destination 'shops', the final value is (3+0+3+3)/4=2.25 and not (3+3+3+3)/4=3 (as it would be the case for $index_6$) or (3+3+3)/3=3 (as it would be the case for $index_{11}$, see below). Therefore, the index takes into account both accessibility and mobility capital (see above, §6.1.1). It is thus to be expected that the index will stress the accessibility advantage of individuals living in car owning households, with respect to carless households.

[288] Here and for the following indexes, I use the variable 'household car ownership' as the criterion to assess car availability for individuals. This choice is justified in light of the limitations of alternative variables: the variable 'car available as driver' does not assess the availability of car as passenger; the variable 'car available on day of survey' refers to both, but is focused only on the day of survey (and not to habitual behaviour).

Available transport modes, maximum accessibility

This index is similar to $index_9$ in that it takes into consideration the ownership of private modes when computing the total value, but it is also similar to $index_7$ and $index_5$ because it is based on the principle of maximum accessibility. Given the approach adopted here, the index has three different formulas, depending on the ownership of private vehicles. For individuals in motorised households who own a functioning bicycle, the formula is the following:

$$Index_{10} = \frac{max(p0412_1, p0413_1, p0414_1) + max(p0412_2, p0413_2, p0414_2) + max(p0411_3, p0412_3, p0413_3, p0414_3) + max(p0411_4, p0412_4, p0413_4, p0414_4)}{n}$$

Where *n* is the number of destinations for which questions were asked to the individual. As this is exactly the same method as $index_5$, the formula can be rewritten as follows:

$$Index_9 = Index_5$$

For individuals living in motorised households who do not own a functioning bicycle, the formula is the following:

$$Index_{10} = \frac{max(p0413_1, p414_1) + max(p0413_2, p0414_2) + max(p0411_3, p0413_3, p0414_3) + max(p0411_4, p0413_4, p0414_4)}{n}$$

Where *n* is the number of destinations for which questions have been asked to the individual.

Finally, for individuals living in carless households who does not own a functioning bicycle, the formula is:

$$Index_{10} = \frac{max(p0413_1) + max(p0413_2) + max(p0411_3, p0413_3) + max(p0411_4, p0413_4)}{n}$$

Where *n* is the number of destinations for which questions were asked to the individual.

The indexes ranges between 0 (minimum accessibility) and 5 (maximum accessibility). The rating should be considered as positive if higher than 3 ('somehow') and negative if lower. Unlike for $index_9$, the maximum value can be reached by all individuals, provided that they have reported 'very good' accessibility by walking *or* public transport or a private mode of transport that they own, for all relevant destinations. It must be noted, however, that reaching the maximum value should be easier for individuals who own private modes (for whom the maximum value among all indicators is considered) than for others (for whom some or all private mode indicators are excluded from the formula). For example, the minimum value is reached by individuals who do not own private modes also in the case in which they report 'no accessibility' by walking and public transport, but 'very good' for other modes. With the same response pattern, individuals who own both private modes are assigned the highest value. This reflects the assumption that accessibility by private modes of transport only matters when the mode of transport is actually available to the individual or owned by the household.

Available transport modes, mean accessibility

This index is similar to the previous two in that it takes into consideration the ownership of private modes when computing the total value, but it is also similar to $index_8$ and $index_6$ in that it is based on the principle of mean accessibility. Given the approach adopted here, the index has three different formulas, depending on the ownership of private vehicles. For individuals in motorised households who own a functioning bicycle, the formula is the following:

$$Index_{11} = \frac{mean(p0412_1, p0413_1, p0414_1) + mean(p0412_2, p0413_2, p0414_2) + mean(p0411_3, p0412_3, p0413_3, p0414_3) + mean(p0411_4, p0412_4, p0413_4, p0414_4)}{n}$$

Where *n* is the number of destinations for which questions were asked to the individual. As this is exactly the same method as index$_6$, the formula can be rewritten as follows:

$$Index_{11} = Index_6$$

For individuals living in motorised households who do not own a functioning bicycle, the formula is the following:

$$Index_{11} = \frac{mean(p0413_1, p0414_1) + mean(p0413_2, p0414_2) + mean(p0411_3, p0413_3, p0414_3) + mean(p0411_4, p0413_4, p0414_4)}{n}$$

Where *n* is the number of destinations for which questions were asked to the individual.

Finally, for individuals living in carless households who does not own a functioning bicycle, the formula is:

$$Index_{11} = \frac{mean(p0413_1) + mean(p0413_2) + mean(p0411_3, p0413_3) + mean(p0411_4, p0413_4)}{n}$$

Where *n* is the number of destinations for which questions were asked to the individual.

The indexes ranges between 0 (minimum accessibility) and 5 (maximum accessibility). The rating should be considered as positive if higher than 3 ('somehow') and negative if lower. Unlike for index$_9$, the maximum value can be reached by all individuals, provided that they have reported 'very good' accessibility by walking, public transport *and* all private modes of transport that they own, for all relevant destinations. This reflects the assumption that accessibility by private modes of transport matters only when the mode of transport is actually available to the individual or owned by the household.

Car-related accessibility advantage (household index)

This last index has a different purpose than the others: instead of measuring overall accessibility, it measures the accessibility advantage that is (or would be) associated with the ownership of a car. In chapter 6, this index has not been used for descriptive statistics, but is included among the predictors in the logistic regression model for non-car ownership (see §6.1.1). Accordingly, unlike other indexes, it is computed at the household level.

For every household member, the index is computed as the average value (across all relevant destinations) of the difference between the rating of the accessibility by car and the mean value of the rating of other ('alternative') means, for every relevant destination. The formula used in the individual database is the following:

$$Index_{12} = \frac{[p0414_1 - mean(p0412_1, p0413_1)] + [p0414_2 - mean(p0412_2, p0413_2)] + [p0414_3 - mean(p0411_3, p0412_3, p0413_3)] + [p0414_4 - mean(p0411_4, p0412_4, p0413_4)]}{n}$$

Where *n* is the number of destinations for which questions were asked to the individual.

The index is equivalent to the difference between the accessibility by car and the mean accessibility by alternative modes, and can thus be rewritten as follows:

$$Index_{12} = Index_4 - Index_8$$

The household index is then computed as an average of the values for each household member for which the value is not missing. The obtained variable can be arguably interpreted as an estimate of the perceived car accessibility advantage that is (or would be) provided by a car for accessing a series of services and opportunities that are relevant for the daily life of the household, where values on the individual index represent different 'estimates' that are then averaged at the household level. Unlike previous indexes, index$_{12}$ ranges from -5 to +5. The maximum value is assigned if all household members, for all relevant destinations, rated car accessibility as ‘very good’ and reported ‘no accessibility’ by all other modes: it can be therefore interpreted as a situation of maximum accessibility advantage for the car, as compared to alternative modes. The minimum value is assigned if all household members, for all relevant destinations, reported ‘no accessibility’ by car and rated accessibility by all other modes as ‘very good’: it can therefore be interpreted as a situation of maximum accessibility advantage of alternative modes, as compared to the car. The scale midpoint (0) is obtained when all household members, for all destinations, assigned the same score to all modes of transport, or when values balance out across alternative modes, destinations and/or across household members. It can therefore be interpreted as a situation where, overall, the accessibility provided by the car is equivalent to that provided by the alternatives. It follows that negative values on this index indicate an accessibility advantage of alternatives over the car, and positive values the existence of a car-related accessibility advantage.

Of course, other methods for computing this index are conceivable, for example using maximum values instead of mean values (for accessibility by alternative modes) or by taking into consideration the ownership of bicycles. However, while descriptive statics for different indexes can be presented simultaneously, regression models require the inclusion of a single predictor to tap the same concept (to avoid the problem of multicollinearity). I prefer the formula presented here because it does not discard any information, and thus arguably provides the best assessment of car-related accessibility advantage.

B.2.4. Main travel mode

In the MiD 2008 questionnaire, for each trip respondents are asked to report a sequence of up to nine different modes of transport (see §B.1.5). The variable ‘main travel mode’ in the trip database was then generated by assuming the following order of priority for multi-mode trips: airplane, ship, train, coach, car, bicycle, others (including other public transport, walking, etc.). The assumption here is that modes higher in the priority order are more likely to correspond to the longest stretch of the trip (infas, 2010b, p. 3). In the analysis presented in chapter 6, I have recoded this variable, according to the criteria illustrated in Tab. B.5 (with German variable labels in the left column).

Main mode (original variable, MiD 2008)	Main mode (recode)
zu Fuß	Walking
Fahrrad	Cycling
Mofa | Moped	Motorbike
Motorrad	Motorbike
Pkw (Mitfahrer)	Car / van passenger
Pkw (Fahrer)	Car / van driver
Lkw	Car / van driver or Car / van passenger[289]
ÖPNV	Public transport
Taxi	Taxi / minicab
Schiff, Bahn, Bus, Flugzeug	Public transport
sonstiges	Public transport

Tab. B.5 – Criteria for recoding the variable ‘main mode’ in MiD 2008. Source: own elaboration.

The coding scheme adopted has two main goals: first, to reduce the number of categories; second, to allow comparison with the corresponding variable in the NTS database (see §B.2.4).

B.2.5. Distance residence – public transport stops

The MiD 2008 person-level interview includes questions about the distance between the residence and the closest bus stop and local train station. In order to use this information in the logistic regression model for

[289] Answers to the dedicated question “passenger or driver?” have been used to assign trips by Lkw (truck / van) to the ‘Car / van driver’ or to the ‘Car / van passenger’ category. When respondents answered ‘both’, the trip was recoded as missing.

non-car ownership at the household level, I have followed two steps: first, I have transformed the categorical variables into continuous variables, following the criteria illustrated in Tab. B.6.

Original coding (MiD 2008)	Recoding
Less than 100m	50
100 to 200m	150
200 to 400m	300
400 to 1,000m	700
1 to 2km	1,500
2 to 5km	3,500
5 to 10km	7,500
More than 10km	11,000

Tab. B.6 – Recoding scheme for the variables 'distance between residence and closest bus stop' and 'distance between residence and closest local train station'. Source: own elaboration.

For most categories, the value assigned to the continuous variable corresponds to the midpoint between the extremes identified by labels for the categorical variable. This reflects the assumption that, for each response category, the *real value* of the distance has a symmetrical distribution around the mean. The exception in this context is the last category, 'more than 10km': in this case, since only one threshold is provided, I assign the value of 11,000. While this is arbitrary, it reflects the assumption that, beyond the 10km threshold, the real value distribution is skewed to the left, i.e. the distribution ends with a long 'tail'.

In a second step, the household value is computed as the average of values for all household members (excluding observations with missing values). This reflect the assumption that the values reported by individuals are estimates of the real distance with the same error.

B.2.6. Number of employed adults in the household

Both the MiD 2002 and the MiD 2008 household database include variables assessing the employment status of the first eight members of the household. While the MiD 2008 report states that the variables are identical, except for the different variable label (infas, 2010a, p. 5), a comparison of their distribution in the two waves shows employment rates that are implausibly low in 2002. An in-depth examination of the database suggests that in MiD 2002 there are many false missing cases, that are identified as employed on other variables. I have therefore corrected the variable 'employment status' with reference to the variable 'type of employment', substituting missing values with 'employed' when the household member was coded as 'employed full time' or 'employed part time'. After this correction, the comparison of the variables between the two waves generates plausible results. However, given the arbitrariness of recoding, all results of comparisons between the two databases on this variable should be interpreted with care.

B.3. Multivariate models: details and model selection

B.3.1. Logistic regression models

In chapter 6, the results of several logistic regression models (§A.1) for non-car ownership are presented and discussed. In this section, I discuss the methodological details that have been omitted from the empirical findings chapter (in order not to burden the text), focusing notably on model selection.

All logistic regression models take into account sampling design in terms of weighting, clustering and stratification (see §B.1.2). Notably, for MiD 2008, the clustering of the sample into 342 stratified primary sampling units (16 strata corresponding to the German *Bundesländer*) has been taken into account and household weights have been applied. Similarly, for MiD 2002, the clustering of the sample into 297 stratified primary sampling units (16 strata corresponding to the German *Bundesländer*) has been taken into account and household weights have been applied. Accordingly, all logistic regression model tables in chapter 6 report robust standard errors (see §A.1.4).

As illustrated in §A.1.6, different measures of fit for logistic regression models exist. While in chapter 6 only the values for McFadden's pseudo R^2 have been reported, other goodness of fit statistics exist, such as the AIC and the BIC, that take into account also parsimony. Such statistics are useful when the goal is to present a model that is as simple as possible, without losing (too much) predictive power.

Indeed, the model presented in §6.1.1 (Tab. 6.7) does not include all variables that are relevant determinants (according to theory) of household car ownership: notably, territorial variables assessing municipality size, the type of region and the type of district are not included, while population density variables are included. Tab. B.7 shows the results for two logistic regression models: a 'complete' model, including all relevant predictors (according to theory), and a 'reduced' model, excluding some territorial variables. As suggested in the literature (Long & Freese, 2001, p. 66-67), both models refer to the same sample (n=24,442), including all observations without missing values on all predictors included in the 'complete' model. This allows to rule out that different result between the two models might be the by-product of differences in the sample.

A comparison of the models illustrated in Tab. B.7 indicates that:

- with regard to socio-demographic variables, the car-related accessibility advantage index, and the variables assessing the distance to public transport stops, there is no significant difference in terms of logit coefficients and statistical significance of the terms
- (almost) all coefficients associated with variables included in the complete model, but not in the reduced model (type of region, type of district and municipality size) are not statistically significant
- the logit coefficients for the two variables measuring population density are generally lower and less statistically significant in the 'complete' model
- the goodness of fit, as measured by McFadden's pseudo R^2, is only very slightly higher in the complete model (0.406) than in the reduced model (0.405)

These observations suggest that the exclusion of the predictors 'type of region', 'type of district' and 'municipality size' in the second model is justified, since it does not result in significant changes in the coefficients nor in the predictive power of the model. Substantively, this can be interpreted as follows: most of the effect of different types of area (in terms of region, district and municipality) is mediated by population density at the local level (municipality and proximity area). Therefore, when this is controlled for, the effect disappears.

Tab. B.8 compares goodness of fit statistics (see §A.1.6) for the models reported in Tab. B.7. It shows that, while the exclusion of three territorial variables in the reduced model results in a very slight reduction in McFadden's pseudo R^2, information measures taking into account not only the goodness of fit, but also the parsimony of the model, provide support for the reduced model. Notably, while there is no difference in the value of the AIC, the strong difference in BIC provides strong support for the reduced model (see Long & Freese, 2001, p. 86-87). Therefore, in §6.1.1, I present and discuss the reduced model, without making any reference to the complete model.

Other logistic regression models discussed in chapter 6 include only socio-demographic variables (those in the upper half of Tab. B.7). Since they are aimed at measuring the conjoint effect of *all* the socio-demographic determinants of non-car ownership, they have not undergone the process of model selection and will not be further elaborated upon here.

	Complete		Reduced	
	Coef.	**Robust Std. Error**	**Coef.**	**Robust Std. Error**
No. of HH members	-1.951***	(0.100)	-1.947***	(0.100)
No. of HH members (squared)	0.153***	(0.0132)	0.153***	(0.0132)
No. of minor children	0.719***	(0.110)	0.711***	(0.110)
No adult men in HH (dummy)	0.782***	(0.0884)	0.783***	(0.0884)
Mean age of adults	-0.137***	(0.0147)	-0.136***	(0.0146)
Mean age of adults (squared)	0.00136***	(0.000138)	0.00135***	(0.000137)
No. of employed HH members	-0.106	(0.0729)	-0.103	(0.0723)
At least one member with university degree (dummy)	-0.230**	(0.0870)	-0.218*	(0.0870)
Members with health-related mobility problems (ref.cat.: None) Some	0.477***	(0.112)	0.476***	(0.112)
All	0.983***	(0.122)	0.984***	(0.122)
Economic status (ref.cat.: Very low):				
Low	-0.444***	(0.120)	-0.441***	(0.120)
Medium	-1.511***	(0.0969)	-1.515***	(0.0982)
High	-2.042***	(0.121)	-2.037***	(0.121)
Very high	-2.780***	(0.193)	-2.787***	(0.194)
East Germany (dummy)	0.454***	(0.0735)	0.483***	(0.0699)
Type of region (ref.cat.: Agglomeration):				
Urbanised area	-0.0481	(0.0901)		
Rural area	0.112	(0.158)		
Type of district (ref.cat: Core city)				
Dense district	0.170	(0.184)		
Rural area	0.165	(0.220)		
Municipality size (ref.cat.: >500,000 in.)				
100,000-500,000	-0.297	(0.165)		
50,000-100,000	-0.501	(0.258)		
20,000-50,000	-0.379	(0.246)		
5,000-20,000	-0.538*	(0.261)		
<5,000	-0.569	(0.291)		
Population density (municipality)				
(ref.cat.: >2,000 in/km^2) 1,500-2,000	-0.0942	(0.147)	-0.246*	(0.114)
1,000-1,500	-0.139	(0.193)	-0.349*	(0.138)
500-1,000	-0.427*	(0.205)	-0.674***	(0.137)
200-500	-0.495*	(0.200)	-0.711***	(0.126)
<200	-0.544*	(0.237)	-0.818***	(0.148)
Population density (1x1km pixel)				
(ref.cat.: >10,000 in.): 5,000-10,000	-0.393**	(0.147)	-0.420**	(0.148)
2,000-5,000	-0.577***	(0.155)	-0.607***	(0.152)
1,000-2,000	-0.467**	(0.177)	-0.507**	(0.174)
500-1,000	-0.512*	(0.201)	-0.555**	(0.198)
250-500	-0.504*	(0.222)	-0.551*	(0.219)
100-250	-0.943**	(0.306)	-0.980**	(0.308)
1-100	-1.137**	(0.361)	-1.182**	(0.361)
0	-1.450*	(0.724)	-1.549*	(0.727)
Distance residence – closest bus stop (meters)	-0.0000711	(0.0000438)	-0.0000673	(0.0000435)
Distance residence – closest local train station (meters)	-0.0000400***	(0.0000119)	-0.0000421***	(0.0000119)
Car-related accessibility advantage	-0.445***	(0.0269)	-0.446***	(0.0267)
(constant)	6.466***	(0.382)	6.391***	(0.382)
N	24,442		24,442	
McFadden's pseudo R^2	0.406		0.405	

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Tab. B.7 - Logistic regression models for the probability of not owning a household car (complete and reduced version) (logit coefficients and robust standard errors). Unit of analysis: households. Source: own elaboration on MiD 2008 data.

Measure of fit	Complete model	Reduced model	Difference
McFadden's pseudo R^2	0.406	0.405	-0.001
AIC	0.523	0.523	0
BIC	-233,857.598	-233,928.673	-71.075

Tab. B.8 – Measures of fit for the logistic regression models reported in Tab. B.7. Source: own elaboration on MiD 2008 data.

B.3.2. Latent Class Analysis

Sections §6.1.3 and §6.1.4 present and discuss a typology of carless households. This was obtained by latent class analysis (§A.4) applied to items about the reasons for not owning cars. In this section, I present the methodological details that have been omitted from the empirical findings chapter (in order not burden the text), focusing notably on model selection. As illustrated in §A.4.4 this operation, in the case of latent class analysis, consists essentially of deciding the number of classes in the typology.

The seven variables used as input variables for LCA are listed in Tab. B.9, along with their distribution in the sample used for the analysis[290]. The analysis has focused on 2,952 households without cars: one household with missing values on all 'reasons for not owning cars' items was excluded, while seven cases who did not select any of the six items were included.

The analysis has taken into account sampling design in terms of weighting, clustering and stratification (see §B.1.2). Notably, the clustering of cases into 342 stratified primary sampling units (16 strata corresponding to the German *Bundesländer*) has been taken into account. Similarly, household weights have been applied, and thus the weighted analysis sample amounts to 4,590.1141 cases (no rescaling has been applied).

		Applicable		Not applicable		Total	
		%	**N**	**%**	**N**	**%**	**N**
Reason for not owning a car	**Not necessary**	44.9	1,325	55.1	1,627	100.0	2,952
	Deliberate abstinence	42.9	1,278	57.1	1,674	100.0	2,952
	Too expensive	49.7	1,495	50.3	1,457	100.0	2,952
	Health reasons	79.6	631	20.4	2,321	100.0	2,952
	Age reasons	78.9	608	21.1	2,344	100.0	2,952
	Other reasons	74.8	711	25.2	2,241	100.0	2,952
Household without licensed members		49.9	1,367	50.1	1,585	100.0	2,952

Tab. B.9 – Distribution of input variables in the estimation sample (percentage values and number of observations). Source: own elaboration on MiD 2008 data.

[290] In Tab. B.9, the percentage values do not correspond exactly to the number of observations, because weighting has been applied.

As illustrated in §A.4.4, there are different criteria to select the optimal latent class model, once input variables and other parameters have been set. Notably, I have used the following criteria (Vermunt & Magidson, 2005a, p. 111-112, 124-125):

- absolute model fit is assessed by the likelihood-ratio goodness-of-fit value L-squared (L^2) and relative p-value. The criterion here is to select the model with the L^2 value closest to 0, and a non-significant p-value (>0.05)
- information criteria such as AIC, BIC and CAIC (based on L^2), taking into account both model fit and parsimony. The criterion here is to select the model associated with the lowest and negative information criteria values
- the conditional bootstrap test in Latent Gold™ 4.5 (Vermunt & Magidson, 2005a, p. 97). This tests whether an additional class provides a significant improvement in model fit (*ibidem*). The criterion here is to keep adding classes until the estimated conditional bootstrap p-value becomes significant ($p<0.05$)
- the number of bivariate residuals for the model whose value is over 3.84, indicating how many "correlations between the associated variable pairs that have not been adequately explained by the model" (Vermunt & Magidson, 2005a, p. 125). The criterion here is to select the model with the lowest number of bivariate residuals over 3.84
- classification statistics "to assess how well the model classifies into clusters" (Vermunt & Magidson, 2005a, p. 112, see §A.4.5). These include classification errors (estimating the proportion of misclassified cases) and pseudo-R^2 statistics ('reduction of errors', 'entropy R-squared' and 'standard R-squared') indicating "how well on can predict class memberships based on the observed variables" (*ibidem*). The criterion here is to select the model with the best classification performance, i.e. the lowest classification error

Tab. B.10 and Tab. B.11 show the values of these parameters (alongside other essential information) for latent class models including up to eleven clusters. In the following, I discuss the implications of the values for model selection. The p-value associated with the chi-square test (L^2) does not reach the desired threshold ($p=0.05$) for any of the models in the table. This might suggest that the underlying latent class structure is too complex to be represented by a model with few classes. However, as suggested in the literature (MacCallum et al., 1996), chi-square is highly sensitive to sample size: accordingly, with a rather large sample like the one used here (2,952 cases, approximately 4,950 weighted cases) obtaining a significant value might be impossible. I thus turn my attention to information criteria: the value of the AIC declines with each additional cluster, and keeps declining even for models with more than eleven clusters (not reported here for the sake of brevity). This also suggests that the latent class structure is too complex to be represented by few clusters. However, both the BIC and the CAIC reach their minimum value for the 8-cluster model, and this is also the first model where no bivariate residual is higher than 3.84. While this would suggest the selection of the 8-cluster model, conditional bootstrap tests show that the last model associated with a significant improvement in model fit is the 10-cluster model.

Overall, the parameters reported in Tab. B.10 are contradictory, but would suggest the selection of the eight-cluster model. However, classification statistics also have to be taken into account. Indeed, as illustrated in §A.4.5 latent class models can be used as probabilistic models (without having to assign observations to clusters) and some authors even strongly recommend this research strategy (Collins & Lanza, 2010). However, this requires the inclusion of all variables of interest (for descriptive purposes) among the covariates, and this considerably complicates the analysis. Broadly speaking, the descriptive analysis of the clusters is central in the analysis carried out in chapter 6. For this reason, it is more practical to assign cases to the clusters, even if it means renouncing to the probabilistic properties of latent class models. This, however, always entails the risk of misclassification: therefore, it is necessary to take into account classification statistics, reported in Tab. B.11.

No. of clusters	***No. of parameters***	***L^2***	***BIC (L^2)***	***AIC (L^2)***	***CAIC (L^2)***	***Degrees of freedom***	***p-value***	***Significant improvement over model with one cluster less (conditional bootstrap)***	***No. of bivariate residuals >3.84***
1	7	3,251.082	2,239.283	3,011.082	2,119.283	120	2.3E-597	-	19
2	15	2,242.544	1,298.198	2,018.544	1,186.198	112	4.9E-393	Yes	12
3	23	1,360.072	483.1789	1,152.072	379.1789	104	9.30E-218	Yes	9
4	31	861.5795	52.1401	669.5795	-43.8599	96	2.30E-123	Yes	5
5	39	648.5664	-93.4197	472.5664	-181.42	88	2.60E-86	Yes	6
6	47	488.7351	-185.798	328.7351	-265.798	80	5.90E-60	Yes	5
7	55	333.8223	-273.257	189.8223	-345.257	72	2.40E-35	Yes	1
8	63	252.0017	-287.625	124.0017	-351.625	64	3.90E-24	Yes	0
9	71	196.0926	-276.08	84.0926	-332.08	56	1.90E-17	Yes	0
10	79	155.5031	-249.217	59.5031	-297.217	48	2.90E-13	Yes	0
11	87	128.5262	-208.74	48.5262	-248.74	40	3.20E-11	No	0

Tab. B.10 – Measures of fit for the latent class models. Source: own elaboration based on MiD 2008.

	Number of clusters									
	2	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
Classification errors	0.04	0.13	0.16	0.12	0.09	0.11	0.15	0.16	0.15	0.16
Reduction of errors (Lambda)	0.71	0.71	0.72	0.82	0.86	0.84	0.79	0.78	0.78	0.78
Entropy R-squared	0.77	0.65	0.67	0.80	0.86	0.83	0.80	0.80	0.80	0.79
Standard R-squared	0.75	0.66	0.66	0.77	0.83	0.80	0.74	0.73	0.74	0,73
Classification log-likelihood	-19,860	-20,554	-20,632	-20,041	-19,610	-19,878	-20,221	-20,310	-20,257	-20,420
AWE	40,017	41,564	41,880	40,856	40,154	40,848	41,693	42,031	42,082	42,567

Tab. B.11 – Classification statistics for the latent class models. Source: own elaboration based on MiD 2008.

The table shows clearly that, on virtually all parameters, the six-cluster model is the one that performs better. Classification error (only 9% of misclassified cases) is here lowest (with the exception of the two-class model). Similarly, other classification statistics (Reduction of errors, entropy R-squared, standard R-squared, classification log-likelihood) reach their maximum value for the six-cluster solution, indicating a better performance. Finally, the AWE statistic (similar to the BIC but taking into account classification performance) also suggest the selection of the six-cluster model (even though the two-cluster model performs even better[291]).

Overall, based on the measures of fit and classification statistics reported in Tab. B.10 and Tab. B.11, I argue that the six-cluster model represents the better compromise between model fit, parsimony and classification performance, as indicated by the 'Average Weight of Evidence' statistics (AWE). The conditional and latent class probabilities for this model are reported in Tab. B.12.

	Cluster number					
	1	**2**	**3**	**4**	**5**	**6**
Latent class probabilities	0.3507	0.1915	0.1630	0.1414	0.1060	0.0473
Not necessary	0.6701	0.2827	0.2384	0.1080	0.9979	0.0048
Deliberate abstinence	0.9970	0.3576	0.0014	0.0682	0.0044	0.0166
Too expensive	0.5551	0.3805	0.9992	0.1983	0.3321	0.1977
Health reasons	0.1392	0.4919	0.0473	0.0020	0.0581	0.9940
Age reasons	0.0748	0.9196	0.0001	0.0618	0.0003	0.0073
Other reasons	0.1694	0.1624	0.0188	0.9961	0.1100	0.1161
Household without licensed members	0.3746	0.6559	0.2580	0.8213	0.5156	0.6244

Tab. B.12 – Cluster profile for the six-cluster model, probabilistic assignment (conditional and latent class probabilities). Source: own elaboration on MiD 2008 data.

	Cluster number					
	1	**2**	**3**	**4**	**5**	**6**
Cluster size	35	19	17	14	10	5
Not necessary	67	29	27	12	100	0
Deliberate abstinence	100	39	0	4	0	0
Too expensive	56	39	100	20	27	17
Health reasons	13	49	6	0	8	100
Age reasons	5	100	0	5	0	0
Other reasons	17	17	0	100	9	14
Household without licensed members	38	65	19	84	60	69

Tab. B.13 – Cluster profile for the six-cluster model, modal assignment (percentage values for the resulting clusters). Source: own elaboration on MiD 2008 data.

291 In order to ensure model identification (see §A.4.2), the model has been estimated several times using several sets of random starting values. All runs have led to the same estimates, thus suggesting that the model is identified.

The substantive interpretation of the clusters is the object of §6.1.1. In this section, it is interesting to observe the differences between Tab. B.12, showing the conditional probabilities for each cluster, and Tab. B.13, showing how many of the cases assigned to each cluster (according to modal assignment) selected each of the seven items. Consistently with the good classification performance of the six-cluster model (see Tab. B.11), the differences are very small. Notably, cluster sizes in Tab. B.13 almost exactly correspond to latent class probabilities in Tab. B.12. Similarly, for 29 out of 42 percentage values reported in Tab. B.13, the difference with the corresponding conditional probabilities reported in Tab. B.12 is less than two percentage points.

Tab. B.14 shows the classification table, showing the degree of overlap between the cluster profile (probabilistic assignment) and the 'real' clusters obtained by modal assignment. It shows clearly that, for all clusters, the large majority of cases is not misclassified when modal assignment is applied. This confirms what suggested by the classification statistics in Tab. B.11, namely the good classification performance of the six-cluster solution.

Probabilistic assignment	***Modal assignment***						
	Cluster1	**Cluster2**	**Cluster3**	**Cluster4**	**Cluster5**	**Cluster6**	**Total**
Cluster1	1,525.9147	70.1393	1.5567	10.0085	1.9890	0.1493	1,609.7575
Cluster2	48.1709	780.8878	8.6611	16.3227	10.9057	14.1926	879.1408
Cluster3	0.9636	0.3950	690.1675	10.0994	41.0830	5.6951	748.4036
Cluster4	20.3269	19.7451	0.4202	598.7563	8.8771	1.0388	649.1644
Cluster5	2.0744	0.5582	72.4230	28.8941	382.4786	0.0486	486.4769
Cluster6	3.5065	2.2896	15.6961	0.1532	0.9072	194.6185	217.1710
Total	1,600.9570	874.0150	788.9246	664.2341	446.2405	215.7430	4,590.1141

Tab. B.14 – Classification table for the six-cluster model, probabilistic assignment by modal assignment (number of weighted cases). Source: own elaboration on MiD 2008 data.

		8-cluster model								***Total***
		1	***2***	***3***	***4***	***5***	***6***	***7***	***8***	
6-cluster model	***Car abstinence***	89	0	4	0	0	8	0	0	100
	Too old to drive	0	0	50	1	0	9	13	27	100
	Economically car deprived	0	95	0	0	0	0	5	0	100
	No driving licence	0	0	0	83	0	17	0	0	100
	Car free	0	0	3	0	97	0	0	0	100
	Health impaired	0	0	0	0	0	0	100	0	100
	Total	31	16	11	12	9	7	8	5	100

Tab. B.15 – Classification table, six-cluster solution by eight-cluster solution, modal assignment (percentage values). Source: own elaboration on MiD 2008 data.

While the good classification performance is arguably a good reason to prefer the six-cluster solution over the eight-cluster solution (which performs better on other measures of fit), it is still necessary to compare the results for the six-cluster solution with those that would be obtained with the eight-cluster solution. Tab. B.15 is a contingency table between the eight-cluster and the six-cluster solution (modal assignment). It shows that for five clusters out of six (in the six-cluster model), more than 80% of households would be assigned to the same clusters. The main difference between the two models is the ‘too old to drive’ cluster, that is split into different groups in the eight-clusters model: while 50% of households are reassigned to the same cluster (that includes also a small percentage of ‘car free’ households), the remaining households are assigned to the ‘health-impaired’ cluster (13%) or to two new clusters, accounting respectively for just 7% and 5% of the carless households group.

Overall, the main difference between the six-clusters and the eight-clusters solution is the existence of two additional small clusters, mostly composed by households belonging to the ‘too old to drive’ group. In light of the results of the descriptive analysis illustrated in chapter 6 (showing the difference between AR and NAR clusters), one can argue that adopting the eight-cluster solution is unlikely to make a great difference on the analysis in terms of substantive interpretation. Moreover, given the small sample size of the carless households subsample, the addition of two very small groups (accounting for 100-200 observations each) would arguably further complicate the analysis. Overall, then, I conclude that it is preferable to adopt the six-cluster solution.

B.3.3. Multinomial logistic regression model

In §6.1.3 the results of a multinomial logistic regression model (§A.2) for the probability of belonging to NAR or AR clusters, rather than owning cars are presented and discussed. In this section, I present a few methodological details that have been omitted from the empirical findings chapter (in order not burden the text).

The model takes into account sampling design in terms of weighting, clustering and stratification (see §B.1.2). Notably, the clustering of cases into 342 stratified primary sampling units (16 strata corresponding to the German *Bundesländer*) has been taken into account. Similarly, household weights have been applied. Accordingly, the multinomial logistic regression model table in chapter 6 (Tab. 7.23) include robust standard errors.

The goal of the model illustrated in §6.1.3 is very specific, namely to test the hypothesis that AR and NAR clusters correspond respectively to a ‘clustered’ and ‘scattered’ form of non-car ownership (across different types of area). The grouping of clusters is based on the descriptive analysis illustrated in §6.1.3, and is thus not further justified here. Similarly, the predictors included in the model are the same used for the logit model presented in §6.1.1: this means that the model has not undergone the process of model selection,

Omitted outcome	Log likelihood (full model)	Log likelihood (model with omitted outcome)	Chi-square	Degrees of freedom	P>Chi2	Evidence: support for H_0
1 (AR clusters)	-1100.701	-1468.625	-735.849	32	1.000	Yes
2 (NAR clusters)	-1946.264	-2476.698	-1.1e+03	32	1.000	Yes

Tab. B.16 – Results of the Small and Hsiao’s test of IIA assumption for the multinomial logistic regression model reported in Tab. 6.20. Source: own elaboration on MiD 2008 data.

As illustrated in §A.2.1, multinomial logistic regression models make the assumption of ‘independence of irrelevant alternatives’ (IIA) (Long & Freese, 2001, p. 188-191; Pisati, 2003, p. 258-259). For the model discussed here, this implies assuming that adding or deleting any of the alternative outcomes (car ownership; NAR clusters; AR clusters) “does not affect the odds among the remaining outcomes” (Long & Freese, 2001, p. 188). This means for example assuming that, if AR clusters did not exist, households belonging to them would be proportionally assigned to car ownership and to NAR clusters (cfr. Pisati, 2003, p. 258-259).

To test this assumption, I computed the Small and Hsiao's test of IIA assumption (Small & Hsiao, 1985; Long & Freese, 2001, p. 189-191). The results for this test, reported in Tab. B.16, provide support for the null hypothesis H_0 that, for every possible outcome omitted, the odds between the other outcomes are independent of other alternatives.

Appendix C. Data analysis for NTS 2002-2010 and NTS 1995-2001

In chapter 7, the empirical results for the British case are illustrated. In this Appendix, further details about the secondary data analysis are presented. First of all (§C.1) I provide technical details about the datasets (NTS 2002-2010 and NTS 1995-2001), in terms of survey design, sampling design, weighting, dataset structure, key definitions, etc. In section §C.2, I provide details for variables that have been manipulated. In the following section (§C.3), I provide details about multivariate models, focusing notably on model selection.

C.1. National travel survey: the datasets

Most analysis reported in chapter 7 refer to the NTS 2002-2010 database (DfT, 2012). Only a few analyses in section §7.2.1 take into account also data from the NTS 1995-2001 (DfT, 2010d). For this reason, in the following sections (§C.1.1-§C.1.7) I describe the technical details for the NTS 2002-2010. The different characteristics of the NTS 1995-2001 database are the object of the last section (§C.1.8).

C.1.1. Survey design

The data collection methods used for the NTS are two (Hayllar et al., 2005, p. 1):

- face to face interviewing using computer assisted personal interviewing (CAPI), for the household and person interviews
- self-completion of a 7 day travel record (travel diary)

The face to face interview ('placement interview') consists in turn of several sections[292] (Pickering et al., 2006, p. 9)

- a household section, that is "answered by the Household Reference Person"[293] (Pickering et al., 2006, p. 9), collects information about the household
- the individual section "is asked of everyone in the household" (*ibidem*). Children are included, but most interviews with under 11s are proxy interviews (Hayllar et al., 2005, p. 18). Proxy information is also collected for adults who are "difficult to contact" (*ibidem*)
- the vehicle section "is asked of the main driver (or another household member if necessary) for each vehicle owned by a member of the household" (Pickering et al., 2006, p. 9)

The self-administered part of the survey consists of a travel diary that is completed by all households members (if necessary by proxy) (Pickering et al., 2006, p. 9). The travel diary records all "all journeys made in a selected 7-day period", the 'travel week' (*ibidem*). However, 'short walks' (under one mile) are recorded only on the seventh day (*ibidem*) and thus need to be weighted accordingly (see §C.1.3). There are two versions of the travel diary: one for children under 16, and one for adults (Hayllar et al., 2005, p. 23-24). The self-completed travel diaries are then collected during the so-called 'pick-up interview' (Hayllar et al., 2005, p. 3-4, 28).

Households are classed as 'fully co-operating' when "the placement interview (is) fully completed and filled in (and) travel diaries (are) collected for all household members" (Hayllar, 2005, p. 29). 'Partially cooperating' households are defined as those who completed the placement interview, but not the travel diaries. All other households are not included in the final sample (p.6). In 2010, the response rate (taking into account only 'fully co-operating households') was 60% (Rofique et al., 2011, p. 5).

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[292] Prior to the placement interview, sampled households receive an advance letter explaining the purpose of the survey and announcing that each respondent would receive an incentive (gift voucher) upon completion of the survey (Hayllar et al., 2005, p. 3-4).

[293] The Household Reference Person (HRP) is defined as "the householder with the highest income, or their spouse or partner" (Hayllar et al., 2005, p. 18).

C.1.2. Sampling design

For all waves of NTS 2002-2010, the initial sample consists of "15,048 private households, drawn from the Postcode Address File (PAF)" (Hayllar et al., 2005, p. 3; Rofique et al., 2011). As a result, the sample represents "the population of people within households in Great Britain" (Hayllar et al., 2005, p. 159). This is different from the *resident* population of Great Britain in that it does not include "people in communal and institutional establishments", such as "care homes and student halls of residence" (*ibidem*).

The sample is also limited from a geographical point of view. First of all, the survey refers to Great Britain and not the whole UK, thus excluding Northern Ireland. Moreover, "for practical reasons, the Scottish islands and the Isles of Scilly (are) excluded from the sampling frame" (Hayllar et al., 2005, p. 7).

The sample design consists of two stages. In a first step, 684 primary sampling units (PSUs) – defined as postcode sectors – are selected (Hayllar et al., 2005, p. 7). The sampling is stratified using a regional variable (40 regional strata based on a modified version of NUTS2 areas), car ownership (three equal sized bands within each regional strata) and population density (p.8). PSUs are then randomly selected within each stratum (*ibidem*). According to Hayllar et al., the stratification "is done in order to increase the precision of the sample and to ensure that the different strata in the population are correctly represented" (2005, p.8). In a subsequent step, adresses are randomly selected from the "small user' Postcode Address File (PAF)" i.e. "a list of all addresses (delivery points) in the country which receive less than 25 items of mail per day"[294] (Hayllar et al., 2005, p. 7). Within each postcode sectors, 22 addresses are sampled (p. 10).

To sum up, the NTS is based on multi-stage sampling design. This means that the sample is clustered into 684 primary sampling units stratified by region, car ownership and population density. The NTS 2002-2010 database includes a PSU identifier; however, it does not include the stratification variable. Therefore, in most analyses reported in chapter 7 (significance tests, multivariate models, etc.) I take into account the clustering into PSUs when computing the standard errors of the estimates, but not the stratification of clusters. It is important to observe that this tends to result in an overestimation of standard errors[295].

Another feature of the NTS is the 'quasi-panel design', introduced in 2002 (Hayllar et al., 2005, p. 7). This can be described as follows (*ibidem*):

> "According to this design, half the PSUs in a given year's sample are retained for the next year's sample and the other half are replaced. This has the effect of reducing the variance of estimates of year-on-year change. Hence 342 of the PSUs selected for the 2002 sample were retained for the 2003 sample, supplemented with 342 new PSUs. The PSUs carried over from the 2002 sample for inclusion in 2003 were excluded from the 2003 sample frame, so they could not appear twice in the sample. The dropped PSUs from 2002 were included in the sample frame. The same procedure of dropping PSUs was carried out to create the 2004 sample. Whilst the same PSU sectors might appear in different survey years, no single addresses were allowed to be in more than one year. The PSUs which were carried over each year had different addresses selected to those selected in the same PSU in the previous year. (..) This meant respondents to the previous year's survey in the PSUs which were carried over could not be contacted again." (Hayllar et al., 2005, p. 7)

In order to compensate much lower response rates for Inner and Outer London, the NTS oversamples London PSUs (Hayllar et al., 2005, p. 7-8; Rofique et al., 2011, p. 32).

In order to take into account seasonal variation in travel, an equal number of PSUs is assigned to each quota month (57 per month) (Hayllar et al., 2005, p. 10). Travel week start dates are in turn allocated within quota months (p.3), meaning that the choice of travel week "was not left to the discretion of the respondent or interviewer as this could lead to bias" (p.17).

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294 Each PSU contains on average about 2,900 delivery points (Hayllar et al., 2005, p. 8).

295 Moreover, standard errors tend to be particularly high when very small sample sizes are used. In chapter 7, in accordance with the NTS guidelines (Hayllar et al., 2005, p. 175), I have not used sub-samples of under 100 for estimates at the household and individual level.

C.1.3. Weighting

As illustrated above (§C.1.1), in NTS a distinction is made between 'fully' and 'partially' co-operating households. This is important because, according to the NTS guidelines (Pickering et al., 2006), depending on the type of analysis, different samples have to be used and different weighs have to be applied.

As Pickering et al. explain (2006, p. 9), the NTS response rate has fallen steadily in the last two decades. For this reason, studies carried out on behalf of the Department of Transport suggested to include the partially responding households in the analysis, in order to use as many data as possible and to limit selection bias (*ibidem*). In a nutshell, data users should use the sample of 'fully co-operating' households (the *diary sample*) and apply *diary sample weights* for analyses that include the travel diary data. For other analyses, the *interview sample* (including both fully and partially co-operating households) should be used and *interview sample weights* should be applied (Pickering et al., 2006, p. 6,9). In chapter 7 for each figure and table I specify which of the two samples is considered.

Until 2006, the NTS data were not weighted: as a result "no correction (was) made for any biases resulting from unequal probability of selection and/or differential non-response" (Pickering et al., 2006, p. 7). After the publication of a revised methodology for weighting (Pickering et al., 2006), previous waves (from 1995 to 2005) have been re-published including weights (p. 7). All following waves include interview and diary weights as a default.

When applying interview sample weights, the following sources of sampling bias are corrected for (Pickering et al., 2006, p.6, 13):

- selection of the household at the sampled address, household-level non-participation and exclusion of participating household at which not every individual completed the interview. Notably, two-phase calibration weighting is used "so that the age/sex and GOR (Government Office Regions) distributions of the respondents (match) household population estimates" (p.6)
- removal of households with missing individual interviews

When applying diary sample weights, the same sources of sampling bias are taken care of, and in addition partially responding households are removed from the sample (*ibidem*).

When analysing data at the trip level, travel diary weights have to be applied. These are aimed to correct the following sources of bias. Firstly, as Pickering et al. explain (2006, p.21), there is a drop-off in the number of trips reported during the course of the travel week, whereby respondents report on average 10% less trips on the seventh day as compared to the first, regardless of on which weekday the travel week starts. Furthermore, the drop-off is more pronounced for certain journey purposes (e.g. shopping) (*ibidem*). Travel diary weights aim to reduce any biases resulting from this phenomenon. Secondly, as illustrated above, the travel diary records short walks (under one mile) only on the seventh day: in order to obtain correct estimates, values associated with 'short walk' trips must be multiplied by a factor of seven (UK Data Archive, 2012, p. 1). Furthermore, short walk weights also aim to reduce the biases associated with the over-reporting of short walks on Mondays, Fridays and Saturdays (Pickering et al., 2006, p.23).

All analyses reported in chapter 7 apply the correct weights for each level of analysis. All analyses at the travel diary level report values that are grossed up for short walks.

C.1.4. Dataset structure

The NTS 2002-2010 database consists of several datasets, organized hierarhically, as illustrated in Fig. C.1. Cross-level analysis is possible using the set of identifier variables included in the dataset, as illustrated in Fig. C.1 (UK Data Archive, 2012, p. 2-3). The analysis reported in chapter 7 is based on data from the PSU, household, individual and trip datasets exclusively. For each figure and table, the level of analysis is specified in the caption.

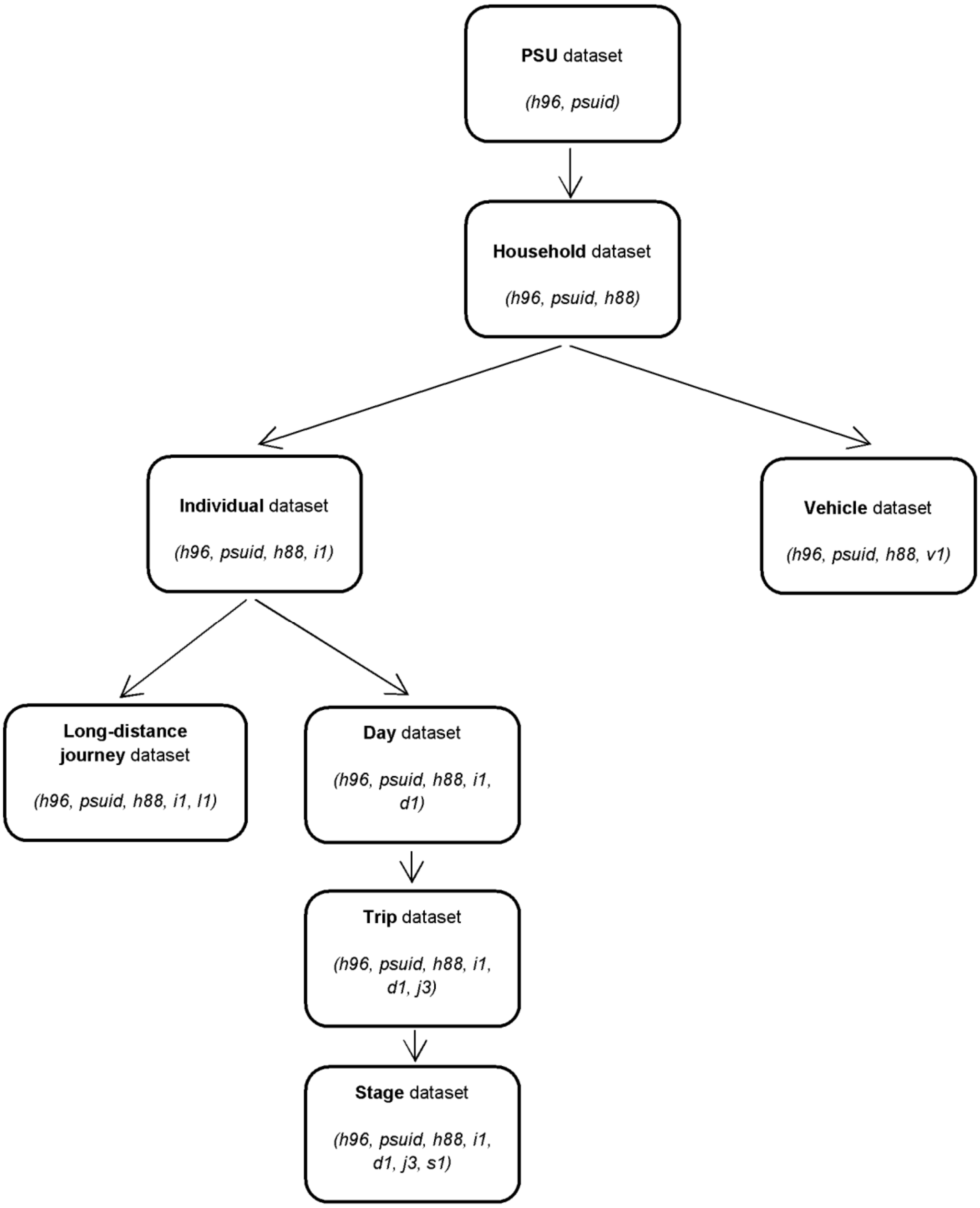

Fig. C.1 – Datasets and identifier variables in the NTS 2002-2010 hierarchical database. Source: adapted from UK Data Archive (2012, p.3)

C.1.5. Additional geographical variables

As illustrated in the previous section, the NTS 2002-2010 database includes a PSU-level dataset including variables referred to the postcode sectors that are not collected directly from the households (Hayllar et al., 2005, p. 6). In chapter 7, I use the three following PSU-level variables (Rofique et al., 2011, p. 12):

- *Type of Area (urban/rural classification)*: this variables is “constructed from a classification of urban areas derived by ONS and DfT from the 2001 Census of Population” (*ibidem*)
- *PSU Population Density*: this variable is “derived from 2001 Census figures on the number of people living in private households per hectare” (*ibidem*)
- *LA Population Density*: derived from the same figures as the previous, and referred to the local authority

In the latest release of the NTS data (2002-2010), however, PSU and LA population density are not available. Therefore, in the analysis in chapter 7 I use the variables obtained from a previous release, NTS 2002-2008 (DfT, 2010c). For this reason, analyses involving population density variables do not include the years 2009 and 2010. A more detailed account of the derivation of the derivation of PSU-level variables is given in Hayllar et al. (2005, Chapter 5).

C.1.6. Key definitions

As explained in §3.4.2, the definitions of key concepts such as 'trip' vary between national travel surveys. In the British NTS, a trip is defined as "a one-way course of travel having a single main purpose (..) without any break in travel" (UK Data Archive, 2012, p. 4). This implies that complex travel involving a number of different activities is broken into separate trips (*ibidem*). Moreover, trips can include more than one 'stage' defined as "when there is a change in the form of transport or when there is a change of vehicle requiring a separate ticket" (Rofique et al., 2011, p. 51).

Certain types of trips are excluded from the NTS, that is focused on *personal travel*. These include (Rofique et al., 2011, p. 49) : leisure pursuits, i.e. trips "made for the pleasure of going out in a boat or plane rather than to get somewhere" (*ibidem*); trips off the public highway; some travel made in the course of work (commercial travel), such as trips made by professional drivers and/or to deliver/collect goods in the course of work. 'Very short walks' (of less than 50 yards) are also excluded (Rofique et al., 2011, p. 51), as well as playing in the street by children (UK Data Archive, 2012, p. 16-17). As illustrated above, 'short walks' of 50 yards or more but less than one mile are recorded only on the seventh day of the travel diary, and then weighted accordingly (Rofique et al., 2011, p. 51)

C.1.7. Differences between waves

The continuous nature of the British national travel survey has several advantages. However, this implies that "although the core survey has remained consistent over time, some relatively minor changes are made to the survey each year, e.g. addition/removal of questions, changes to filters and variable categories." (UK Data Archive, 2012, p. 1). Notably, from 2002 some questions are 'rotated' (i.e. asked every other year) and from 2009 sub-sample questions (whereby households are randomly assigned to two sub-groups with partially different questionnaires) have been introduced (Rofique et al., 2011, p. 19). This affects notably questions about the access to services and opportunities (see §C.2.4 below). In chapter 7, when a variable is not available for every survey year, this is specified in a footnote. Details about all changes made to the survey questionnaire between 2002 and 2010 are provided by Rofique et al. (2011, p. 133-158).

C.1.8. NTS 1995-2001

Most of what has been described in the previous sections for the NTS 2002-2010 database applies also to the NTS 1995-2001 (used for a few analyses in §7.2). However, a few differences must be pointed out.

- firstly, the sample size for the NTS was increased in 2002. For previous waves, the sample size was about a third (in 2002 the initial sample size was of 5,796 households clustered in 252 PSUs) and this makes it necessary to combine three years' data for the analysis (Hayllar et al., 2005, p. 7, 141). For this reason, all analyses of the NTS 1995-2001 data reported in §7.2 combine the survey years in two groups (1995-1997 and 1998-2000) and exclude data from 2001
- secondly, with regard to sampling design (see §C.1.2), waves prior to 2002 were not based on the 'quasi-panel' design, used a different region stratifier to select PSUs and a lower number of regional strata (Hayllar et al., 2005, p. 191). Also, a stratifier based on the socio-proportion of heads of households in professional employer/manager socio-economic groups was employed instead of a population density stratifier (*ibidem*).

Given that only the household and the individual dataset have been used for the analysis reported in §7.2, interview sample weights have been applied to the NTS 1995-2001 (§see C.1.3).

C.2. Variable manipulation

In many cases, the variables used for the data analysis in chapter 7 are different from the original variables included in the NTS 2002-2010 database. While in some cases the variables have been recoded in a simple way, in other occasions more complex recoding has been undertaken. In this section, the details of these operations are described.

C.2.1. Real household income equivalent quintiles

The NTS 2002-2010 database provides, besides household income, an additional measure of affluence labelled 'real household income equivalent' (DfT, 2008b, p. 53-54). The term 'equivalent' indicates that the household income relative to a married couple without children was obtained by using the McClements scale (*ibidem*). The term 'real' indicates that income values were "deflated to 1990 values using the Retail Price Index" (*ibidem*).

Income quintiles are then derived by ranking households according to the value of their real household income equivalent (UK Data Archive, 2012, p. 17). Since this process is repeated for each survey wave and for each sample (interview and diary sample), the NTS 2002-2010 database provides two versions of the 'real household income equivalent quintiles" variable for each of the nine survey waves (18 variables in total). In order to summarise this information and use it in the data analysis, I created two variables. 'Real household income equivalent quintiles (interview sample, 2002-2010)', assigns a case to the lowest quintile if it was in the bottom 20% of the real household income equivalent distribution *of the interview sample in the year of survey*. The same principle is applied to other quintiles. It is important to note that this complicates the interpretation of the variable when pooled data are used since cases in the lowest income quintile are not necessarily the bottom 20% of the *pooled* income distribution. The same method has been used to create the variable 'Real household income equivalent quintiles (diary sample, 2002-2010)'. This is used only for the analysis in §7.1.3.

C.2.2. Mobility difficulties

In chapter 7, several analysis take into account if at least one individual in the household is affected by mobility difficulties by foot and/or bus. From 2007 onwards, the NTS 2012 database includes a variable measuring the presence of mobility difficulties with one or more of three transport modes (car, foot, bus). For the waves 2002-2006, however, respondents were not asked about mobility difficulties by car. In order to use a single variable for the analysis of the pooled sample, I have generated a new variable, using the recoding scheme illustrated in Tab. C.1. It is important to note that in this way, individuals who reported mobility difficulties by car only in the most recent waves are considered as not experiencing any mobility difficulty. While this is a limitation, it allows me to use the variable 'mobility difficulties' for the analysis of the NTS 2002-2010 pooled sample.

Mobility difficulties (foot and/or bus)	**Travel difficulties (2002-2006)**	**Mobility difficulties (2007 onwards)**
No	No difficulties	No difficulties; car only
Yes	Foot and bus; Foot; Bus	Foot + bus + car; Foot + bus; Foot + car; Bus + car; Foot only; Bus only

Tab. C.1 – Recoding scheme of variables concerning mobility difficulties. Source: own elaboration.

C.2.3. Time to railway station

In NTS 2002-2010, information about the distance to the railway station is provided by two different variables, measuring walk time and bus time, as illustrated in Tab. C.2.

Walk time to railway station	Bus time to railway station
	No bus/quicker to walk
6 minutes or less	6 minutes or less
7-13 minutes	7-13 minutes
14-26 minutes	14-26 minutes
27-43 minutes	27-43 minutes
44 minutes or longer	44 minutes or longer

Tab. C.2 – Values of variables measuring distance from railway station in NTS 2002-2010. Source: own elaboration.

In order to reduce the complexity of the analysis I have recoded the variables into a new one 'Time to railway station (by quickest mode), according to the following criteria:

- when values were missing on both variables, the new variable was assigned a missing value
- when values were missing on only one variable, the value of the other one was assigned to the new variable
- when respondents selected 'no bus/quicker to walk" in the 'bus time' variable, the new variable was assigned the 'walk time' value
- in all other cases, the new variable was assigned the value corresponding to the shortest time: this is necessary because often respondents did not select 'no bus/quicker to walk' in the 'bus time' question, even if they had indicated a shorter time in the 'walk time' variable

For most analyses illustrated in chapter 7, the variable is used in recoded form (two or three categories).

C.2.4. Accessibility to services and opportunities

While variables measuring public transport service are available for every year in the 2002-2010 database, the same is not true for variables measuring the time needed to access essential services and opportunities. As illustrated in Tab. C.3, there are three main differences between waves in this respect: firstly, while from 2002 to 2004 the variables measured the 'walking time' needed to reach the closest facility separately from the 'bus time', from 2005 onwards, they measure the 'journey time' "on foot or by public transport (whichever is the quickest)" (Rofique et al., 2011, p.20). Secondly, while some questions are asked every year, others are asked on alternate years, or irregularly. Finally, starting from 2009, the sample is split in two halves, and each has to answer only half of the accessibility questions (in order to shorten the questionnaire) (Rofique et al., 2011, p.20).

Since they are more recent, and they measure access by alternative modes in a single variable, I used the 'journey times' variables for the analysis in chapter 8. However, the reader should keep in mind that the results for each one of them refers to a slightly different pooled sample, combining samples and subsamples from different years, as illustrated in detail in Tab. C.3.

While accessibility variables were measured at the household level, 'travel difficulties' questions were asked to individuals. 'Travel difficulties' variables are available only for the waves 2002-2008.

	Survey wave								
	02	**03**	**04**	**05**	**06**	**07**	**08**	**09**	**10**
Walk distance to doctor	Y		Y						
Bus distance to doctor	Y		Y						
Walk distance to nearest post office		Y							
Bus distance to nearest post office		Y							
Walk distance to nearest chemist	Y		Y						
Bus distance to nearest chemist	Y		Y						
Walk distance to nearest food store	Y	Y	Y						
Bus distance to nearest food store	Y	Y	Y						
Walk distance to nearest shopping center		Y							
Bus distance to nearest shopping center		Y							
Walk distance to nearer general hospital	Y		Y						
Bus distance to nearer general hospital	Y		Y						
Journey time to nearest general practitioner				Y	Y	Y	Y	SS	SS
Journey time to nearest chemist					Y		Y	SS	SS
Journey time to nearest hospital				Y	Y	Y		SS	SS
Journey time to nearest shopping center				Y	Y	Y		SS	SS
Journey time to nearest grocer				Y	Y	Y	Y	SS	SS
Journey time to nearest post office					Y		Y	SS	SS
Journey time to nearest primary school				Y	Y	Y		SS	SS
Journey time to nearest secondary school				Y	Y	Y		SS	SS
Journey time to nearest college				Y	Y	Y		SS	SS

Tab. C.3 – Availability of variables about the accessibility of services and opportunities in different waves of the NTS 2002-2010 sample. Source: own elaboration. Legend: Y: variable available. SS: variable available for split sample.

C.2.5. Main mode of transport

In the NTS questionnaire, a difference is made between 'trips' and 'stages'. While trips are defined by a main purpose, stages are defined by the use of a single mode of transport (see §C.1.6). The 'main mode of transport' for the trip is defined as "that used for the longest stage of the trip (or) with stages of equal length the mode of the latest stage is used" (UK Data Archive, 2012, p. 14). In the NTS 2002-2010 database, a 'main mode of transport' variable is provided (for detailed definitions of the different modes see UK Data Archive, 2012, p. 14). In the analysis presented in chapter 7, I have recoded this variable, according to the criteria illustrated in Tab. C.4. The coding scheme adopted has two main goals: first, to reduce the number of categories; second, to allow comparison with the corresponding variable in the MiD database (see §B.2.4).

Main mode of transport (original variable, NTS 2002-2010)	Main mode of transport (recode)
Walk	Walk
Bicycle	Bicycle
Car/van driver	Car/van driver
Car/van passenger	Car/van passenger
Motorcycle	Motorcycle / other private
Other private	Motorcycle / other private
London stage bus	Public transport
Other stage bus	Public transport
Non local bus	Public transport
LT underground	Public transport
Surface rail	Public transport
Taxi/minicab	Taxi/minicab
Other public transport	Public transport

Tab. C.4 – Criteria for recoding the variable 'main mode of transport' in NTS 2002-2010. Source: own elaboration.

C.3. Multivariate models: details and model selection

C.3.1. Logistic regression models

In chapter 7, the results of several logistic regression models (§A.1) for non-car ownership are presented and discussed. In this section, I discuss the methodological details that have been omitted from the empirical findings chapter (in order not to burden the text), focusing notably on model selection.

All logistic regression models take into account sample weights (interview sample) and the clustering of the sample into primary sampling units (683 or 684 units per survey wave) (see §C.1.2, §C.1.3). Accordingly, all logistic regression model tables in chapter 7 report robust standard errors[296].

As illustrated in §A.1.6, different measures of fit for logistic regression models exist. While in chapter 7 only the values for McFadden's pseudo R^2 are reported, other goodness of fit statistics exist, such as the AIC and the BIC, that take into account also parsimony. Such statistics are useful when the goal is to present a model that is as simple as possible, without losing (too much) predictive power. Indeed, the model presented in §7.1.1 (Tab. 7.9) includes all variables available in NTS 2002-2008 that I consider (on the basis of theory) as relevant determinants of household car ownership. During the process of *model selection* however, other, simpler models have been considered. Tab. C.5 shows the results for two logistic regression models: a 'complete' model, including all relevant predictors (according to theory), and a 'reduced' model, excluding the variable 'type of area'. The reason for excluding this variable is that hierarchical regression analysis shows that, after controlling for population density and public transport service, the relationship with non-car ownership is not clear, with the probability of not owning cars higher than in the reference category (London) for most types of areas, but only minor differences between them.

[296] As noted above (§C.1.2) , in NTS 2002-2010 PSUs are stratified using a a regional variable, car ownership and population density. However, the regional stratification variable is not available in the database. For this reason, in logistic regression models in chapter 7, I have taken into account case weighting and sample clusterization, but not the stratification of PSU into strata. Since taking into account stratification reduces the standard errors associated with the estimates (while taking into account the clusterization into PSUs increases them) this implies the risk of overestimating the robust standard errors.

As suggested in the literature (Freese & Long, 2001, p. 66-67), both models in Tab. C.5 refer to the same sample (n=62,503), including all observations without missing values on predictors included in the 'complete' model. This allows to rule out that different result between the two models might be the by-product of differences in the sample.

		Complete		Reduced	
		Coef.	Robust Std. Error	Coef.	Robust Std. Error
No. of HH members		-1.386***	(0.0379)	-1.388***	(0.0378)
No. of HH members (squared)		0.136***	(0.00594)	0.136***	(0.00590)
No. of minors in HH (under 16)		0.0953**	(0.0307)	0.0972**	(0.0308)
HRP female (dummy)		0.811***	(0.0249)	0.811***	(0.0249)
Age group of HRP (ref. cat. 16 – 29 years)	30 – 39	-0.757***	(0.0479)	-0.761***	(0.0478)
	40 – 49	-0.955***	(0.0498)	-0.957***	(0.0497)
	50 – 59	-1.196***	(0.0519)	-1.204***	(0.0517)
	60 – 69	-1.440***	(0.0537)	-1.452***	(0.0536)
	70 +	-0.689***	(0.0510)	-0.706***	(0.0509)
No. of employed members		-0.363***	(0.0251)	-0.366***	(0.0251)
HRP non-white (dummy)		0.457***	(0.0275)	0.465***	(0.0275)
Presence of member(s) with mobility difficulties (foot and/or bus) (dummy)		0.251***	(0.0546)	0.236***	(0.0540)
Real household income equivalent quintile (ref.cat.: Lowest):	Second	-0.430***	(0.0316)	-0.427***	(0.0315)
	Third	-1.129***	(0.0373)	-1.130***	(0.0373)
	Fourth	-1.681***	(0.0454)	-1.692***	(0.0453)
	Highest	-2.126***	(0.0511)	-2.149***	(0.0511)
Region (ref. cat.: England)	Wales	0.254***	(0.0595)	0.214***	(0.0597)
	Scotland	0.512***	(0.0441)	0.519***	(0.0433)
Type of area (thousands of inhabitants) (ref. cat.: London Boroughs)	Metropolitan built-up areas	0.255***	(0.0632)		
	Other urban over 250k	0.0427	(0.0663)		
	Urban over 25k to 250k	0.198**	(0.0689)		
	Urban over 10k to 25k	0.320***	(0.0805)		
	Urban over 3k to 10k	0.232**	(0.0854)		
	Rural	-0.265**	(0.0864)		
Population density – Local Authority (persons / hectare)		0.00890***	(0.000847)	0.00911***	(0.000817)
Population density - primary sampling unit (persons / hectare)		0.0142***	(0.00131)	0.0119***	(0.00108)
Walk time to bus stop: 7 minutes or more (dummy)		-0.0960**	(0.0351)	-0.121***	(0.0348)
Frequency of bus service: less than 1 every half hour (dummy)		-0.329***	(0.0341)	-0.435***	(0.0321)
Time to railway station (by quickest mode) (ref. cat.: 13 minutes or less):	14-26 minutes	-0.102***	(0.0295)	-0.106***	(0.0294)
	27 minutes or longer	-0.214***	(0.0349)	-0.258***	(0.0342)
Type of railway station: frequent service rush hour only or less (dummy)		-0.119**	(0.0434)	-0.140**	(0.0434)
Rail/metro/tram stop not closer than railway (dummy)		-0.309***	(0.0531)	-0.301***	(0.0528)
Survey year		-0.0187**	(0.00677)	-0.0209**	(0.00678)
(constant)		2.571***	(0.145)	2.811***	(0.129)
N		62,503		62,503	
McFadden's pseudo R^2		0.338		0.336	

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Tab. C.5 – Logistic regression models for the probability of not owning a household car (complete and reduced version) (logit coefficients and robust standard errors). Unit of analysis: households. Source: own elaboration on NTS 2002-2008 data (interview sample).

A comparison of the models illustrated in Tab. C.5 indicates that:

- with regard to variables included in both models, there is no significant difference between the two models in terms of logit coefficients and statistical significance of the terms

- (almost) all coefficients associated with the variable included in the complete model, but not in the reduced model (type of area) are statistically significant at (at least) the 5% level
- the goodness of fit, as measured by McFadden's pseudo R^2, is only very slightly higher in the complete model (0.338) than in the reduced model (0.336)

These observations would suggest that the exclusion of the predictor 'type of area in the reduced model is justified, since it does not result in significant changes in the coefficients nor in the predictive power of the model. Substantively, this can be interpreted as follows: most of the effect of different types of area (in terms of municipality size) is mediated by population density at the local level and the quality of public transport service. Therefore, when these factors are controlled for, the relationship between type of area and non-car ownership is not clear, even though the effect is still statistically significant (probably because of very large sample size).

Tab. C.6 compares goodness of fit statistics for the models reported in Tab. C.5. It shows that, while the exclusion of three territorial variables in the reduced model results in only a very slight reduction in McFadden's pseudo R^2, information measures taking into account not only the goodness of fit but also the parsimony of the model provide support for the complete model. Notably, while there is only a minimal difference in the value of the AIC, the difference in BIC provides very strong support for the complete model (see Long & Freese, 2001, p. 86-87). Therefore, in §7.1.1, I present and discuss the complete model, without making any reference to the reduced model.

Measure of fit	**Complete model**	**Reduced model**	**Difference**
McFadden's pseudo R^2	0.338	0.336	-0.002
AIC	0.757	0.759	0.002
BIC	-642,598.262	-642,508.515	89.746

Tab. C.6 – Measures of fit for the logistic regression models reported in Tab. C.5. Source: own elaboration on NTS 2002-2008 data (interview sample).

Other logistic regression models discussed in chapter 7 include only socio-demographic variables (those in the upper half of Tab. C.5). Since they are aimed at measuring the conjoint effect of *all* the socio-demographic determinants of non-car ownership, they have not undergone the process of model selection and will not be further elaborated upon here.

C.3.2. Cluster Analysis

Sections §7.1.3 and §7.1.4 present and discuss a typology of carless individuals. This was obtained by applying cluster analysis (§A.3) to four indicators of travel behaviour, based on the one-week travel diary. In this section, I present the methodological details omitted from the empirical findings chapter (in order not burden the text), focusing notably on the six main choices a researcher has to make when performing cluster analysis (Everitt et al., 2011, p. 257):

- defining the reference sample
- selecting input variables
- manipulating input variables (standardization, etc.)
- choosing a clustering method
- opting for a proximity measure
- choosing the best clustering solution (number of clusters)

With regard to the first step, the reference sample includes all individuals living in households without cars over the age of 15 included in the diary sample who made at least one trip during the survey week. The reasons for these choices are illustrated in §7.1.3, and will thus not be repeated here.

With regard to the second step, four variables drawn from the individual database were used as input variables for the cluster analysis: first, the weekly travel distance. Second, the average speed of travel: this was obtained by dividing the travel distance (in miles) by the travelling time (in hours). Third, the share of the weekly travel distance that the individual travelled by car (either as driver or passenger), taxi or other private motorized transport means during the travel diary week. Finally, the share of trips that the individual made in order to carry out work or education-related activities during the travel diary week. This includes the following purposes: 'commuting', 'business', 'education' and 'escort education'. The reason for using these input variables are illustrated in §7.1.3, and will thus not be repeated here. Descriptive statistics for the four original variables are reported in Tab. C.7, with reference to the estimation sample.

	No. of observations	Mean	Standard deviation	Min	Max
Travel distance (tenth of miles)	24,081	677.79	977.93	2	19,830.63
Average travel speed (mph)	24,081	10.30	8.39	0.23	122.83
Share of travel distance by car, taxi and other private motorised modes	24,081	34.03	38.66	0	100
Share of trips for work / education	24,081	22.25	32.65	0	100

Tab. C.7 – Descriptive statistics for the original input variables for the cluster analysis, based on the estimation sample[297]. Unit of analysis: individuals. Source: own elaboration on NTS 2002-2010 data (diary sample).

	No. of observations	Mean	Standard deviation	Min	Max
Travel distance (tenth of miles)	24,081	0	1	-0.69	20.31
Average travel speed (mph)	24,081	0	1	-1.21	13.52
Share of travel distance by car, taxi and other private motorised modes	24,081	0	1	-0.91	1.65
Share of trips for work / education	24,081	0	1	-0.64	2.53

Tab. C.8 – Descriptive statistics for the standardized input variables used for the cluster analysis, based on the estimation sample. Unit of analysis: individuals. Source: own elaboration on NTS 2002-2010 data (diary sample).

With regard to the third step, input variables were standardized before the clustering. The reason for this is that the four input variables are not measured in the same units, as they refer respectively to tenth of miles, miles per hour, share of travel distance and share of trips. Moreover, they do not have the same range of variation: for example, while the values of 'share of travel distance' and 'share of trips' range by definition between 0 and 100 (see Tab. C.7), travel distance varies between 0.2 and 1,983.6 miles during the travel diary week. In these circumstances, using unstandardized variables as input variables is not sensible, as illustrated in §A.3.2. For this reason, input variables were standardized using the z-scoring technique (Corbetta et al., 2001, p.84, see §A.3.2): It is important to note that the z-scoring was based on the reference sample (individuals over 15 living in households without cars who did at least one trip during the travel diary week, diary sample). This means that mean and standard deviation were calculated from this subset, and not from the whole NTS 2002-2010 sample. Since clustering did not take into account case weighting (see below), z-scoring was also based on *unweighted* means and standard deviations. Descriptive statistics for the standardized variables are reported in Tab. C.8, showing that for each variable the mean value is 0 and the standard deviation is 1.

297 All estimates in Tab. C.7 are weighted using diary sample weights, although these have not been taken into account in the cluster analysis.

As illustrated in §A.3.4, different clustering methods exist. The main difference is between hierarchical clustering techniques (including both agglomerative and divisive methods) and optimization clustering techniques (Everitt et al., 2011). Since hierarchial methods encounter problems with very large data sets, I used an optimization clustering technique that uses a hill-climibing algorithm known as *k-means* (Everitt et al., 2011, p.121-123). Preliminary analysis (not reported here for the sake of brevity) shows that, if an alternative algorithm known as *k-medians* is used, this produces a very similar solution: this arguably increases the confidence in the validity of the cluster solution discussed in chapter 7 (Everitt et al., 2011, p.259-260). As illustrated in §A.3.4, when using k-means clustering it is necessary to define how the initial group centres for the k clusters are to be obtained. In the case of the cluster solution discussed in chapter 7, initial centres were chosen at random among the cases to be clustered (StataCorp., 2009, p. 117).

The fifth choice that a researcher has to make when doing cluster analysis is choosing a proximity measure among the vast range of possible measures mentioned in the literature (Everitt et al., 2011, p. 43-68; Gordon, 1999, p. 15-26; Romesburg, 1984, p. 93-118, see §A.3.3). As illustrated by Romesburg (1984, p. 93-118) and Everitt et al. (2011, p. 68) the choice of the proximity measure ultimately depends on whether the researcher is interested in ‘size’ and/or ‘shape’ of the objects. In order to obtain the cluster solution discussed in chapter 7 I chose Euclidean distance as the proximity measure, as I wanted size displacement to affect similarity (Romesburg, 1984, p. 93-118).

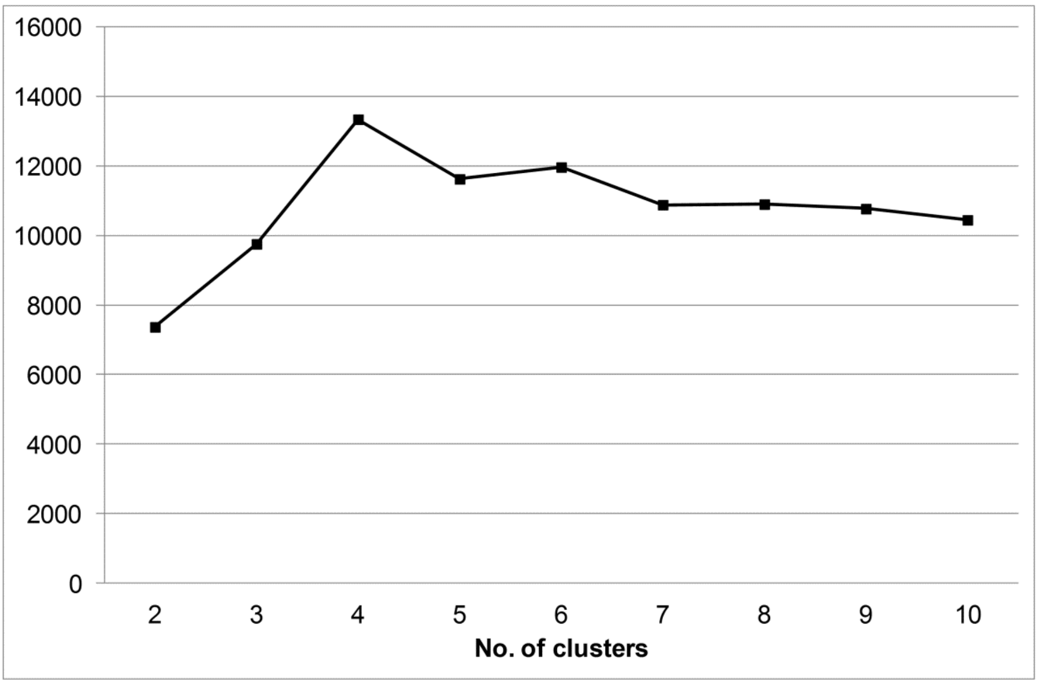

Fig. C.2 – Value of the Caliński and Harabasz pseudo-F index, by number of clusters. Source: own elaboration on NTS 2002-2010 data (diary sample).

With regard to the number of clusters, I relied on the cluster-analysis stopping rule known as the ‘Caliński and Harabasz (1974) pseudo-F index’. Large values on these index are considered to indicate distinct clustering (StataCorp., 2009, p. 159-166). Fig. C.2 show the values of the index for solutions obtained using the settings illustrated above (standardized variables, k-means method with random initial centres and Euclidean distance measure), with a number of cluster ranging from 2 to 10. The graph shows clearly that the index peaks for the four-cluster solution, and then decreases constantly for solutions including a larger number of clusters. Therefore, the four-cluster solution is retained as the most satisfactory in terms of distinct clustering.

The values of the centroids for the clustering solution retained are reported in Tab. C.9. As the clustering did not take into account weighting, the table shows the unweighted mean values for the clusters on the standardized input variables. Cluster number and names in Tab. C.9 correspond to those used in chapter 7. The weighted mean values for the clusters on the unstandardized input variables are reported in Tab. 7.15 in §7.1.3.

Cluster number	**1**	**2**	**3**	**5**
Cluster name	**Slow and local (SL)**	**Car reliant (CR)**	**Public transport commuters (PTC)**	**Long distance week (LDW)**
Travel distance (tenth of miles)	-0.28	-0.18	-0.01	+2.87
Average travel speed (mph)	-0.42	+0.34	-0.25	+2.46
Share of travel distance by car, taxi and other private motorised modes	-0.63	+1.30	-0.42	+0.36
Share of trips for work / education	-0.53	-0.49	+1.63	+0.16

Tab. C.9 – Cluster analysis results, cluster profile (mean values, standardized input variables). Unit of analysis: individuals over 15. Source: own elaboration on NTS 2002-2010 data (diary sample).

In §7.1.3, I discuss a multinomial logistic regression model to predict if a household belongs to AM or to NAM cluster. However, the cluster analysis has taken the individual (rather than the household) as the unit of analysis. It is therefore necessary to define rules to assign a household to one of the two macro-clusters, depending on the values of household members on the clustering variable. These rules are summarized in Tab. C.10.

Characteristics			**Clustering variable (household)**
1 member over 15	*AM*		AM
	NAM		NAM
	LDW		Missing value
2 or more members over 15	*HRP in AM clusters*		AM
	HRP in NAM clusters		NAM
	HRP in LDW	*At least one member in AM clusters*	AM
		No member in AM clusters, at least 1 member in NAM clusters	NAM
		All members in LDW	Missing value

Tab. C.10 – Rules used to assign households to carless macro-clusters, based on the values of household members. Source: own elaboration.

In detail, all households including more than one adult member were assigned to the macro-cluster of the HRP. Households with a HRP belonging to the LDW cluster have been assigned to another macro-cluster, based on the values for other household members. In doing that, I assumed the following order of priority: AM; NAM. The reason for this is that the main difference between the two macro-clusters is the reliance on modes of transport that are alternative to the car: therefore, if one household includes members who reported a 'long distance week' and at least another member in a AM cluster, I assumed that they can rely on alternative modes, even if the household includes one or more other members belonging to NAM clusters. A household with a LDW HRP is assigned to the NAM macro-cluster only if all members except the HRP are classified into NAM clusters. Finally, households including only LDW members were excluded from further analysis.

		Cluster variable (household level) AM	NAM	Missing value	Total
Cluster variable (individual level)	AM	59.60	3.37	0.00	62.96
	NAM	3.56	27.58	0.00	31.14
	LDW	1.69	0.54	3.67	5.90
	Total	64.84	31.48	3.67	100.00

Tab C.11 – Typology of carless individuals, by typology of carless households (percentage values). Unit of analysis: individuals over 15. Source, own elaboration on NTS 2002-2010 (diary sample)

Tab C.11 compares the classification of individuals with clustering at the households level. It shows clearly that most individuals (87%) are assigned exactly to same cluster in the household-level typology. Therefore, it can be argued that transferring the travel behaviour typology from the individual to the household database does not result in a significant distortion of the clustering. Fig. C.3 shows how the distribution of the household clustering variable across different types of area: it shows that the 'clustering' of AM clusters in largest urban areas is still apparent, as well as the 'scattering' of NAM clusters across different types of area.

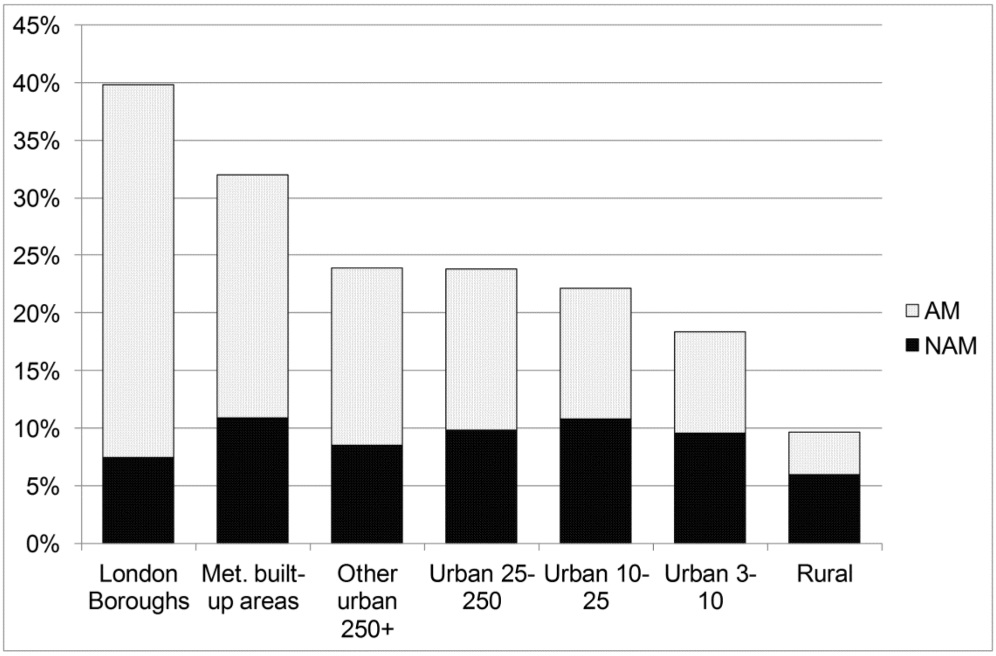

Fig. C.3 – Size and composition of the group of carless adults by simplified travel behaviour typology. Unit of analysis: households. Source: own elaboration on NTS 2002-2010 data (diary sample).

C.3.3. Multinomial logistic regression model

In §7.1.3, the results of a multinomial logistic regression model (§A.1) for the probability of belonging to AM or NAM clusters, rather than owning cars are presented and discussed. In this section, I present a few methodological details that have been omitted from the empirical findings chapter (in order not burden the text).

The model takes into account sample weights (diary sample) and the clustering of the sample into primary sampling units (683 or 684 units per survey wave) (see §C.1.2). Accordingly, the model reports robust standard errors. Just like other regression models in chapter 7 it does not take into account the fact that primary sampling units are stratified: as a result, robust standard errors might be overestimated.

The goal of the model illustrated in §7.1.3 is very specific, namely to test the hypothesis that AM and NAM clusters correspond respectively to a 'clustered' and 'scattered' form of non-car ownership (across different types of area). The grouping of clusters is based on the descriptive analysis illustrated in §7.1.3, and is thus not further justified here. The individual clustering variable was transformed into a household clustering variable as described in §C.3.2 above. The predictors included in the model are the same used for the logit model presented in §7.1.1: this means that the model has not undergone the process of model selection.

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