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Household parking facilities: relationship to travel behaviour and car ownership

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Abstract

Few studies have investigated how parking requirements (norms) for households and home parking availability influence car ownership and car-use. The common practice of local authorities is to use minimum parking norms for housing, and, in some urban areas, also maximum parking norms. This means that local authorities in general do not aim to influence car-use or car ownership by, for example, restricting the number of parking spaces or locating them some distance away. The objective of this paper is to analyse whether there are systematic differences in car ownership and car-use that can be linked to differences in parking norms, parking facilities and location. This knowledge would be of value to both the research community and authorities.

We use the dataset of the Norwegian National Travel Survey (NTS) 2013 consisting of about 60,000 interviews of individuals 13 years and older. A sample of over 2,000 urban dwellers was selected from this NTS for an additional in-depth parking survey. We asked detailed questions about home parking. The NTS 2013 and parking survey were merged and travel habits and background variables linked with detailed information about home parking availability. This provided an excellent opportunity to analyse how variations in parking facilities influence travel behaviour and car ownership.

Our data show that access to private or reserved parking triples the likelihood of car ownership. Trip frequency does not change with car ownership or access to home parking, but it does affect mode share. The longer the distance between home and the actual location of home parking the more reduced the car modal share. People are on average willing to accept more than 100 m between home and home parking. Physical separation of the two would therefore facilitate more efficient housing and less car driving. Free street parking may jeopardise this, however.

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1. Introduction

Any car trip involves three stages: picking up the car (at home), driving to a destination and parking. Inci (2015) observes that while the car is parked for most of the day's 24 hours, scientists are primarily occupied with the transit stage. Much less attention is paid to the parked car. Furthermore, Inci's (2015) wide-ranging review suggests that an overwhelming share of this limited parking literature is concerned with parking at the destination, *i.e.*, work, downtown areas, shopping malls and the like.

It all starts with the effects that home (or residential) parking has on car ownership, trip frequency, mode choice, all of which are still in general under-studied (Guo, 2013a; Weinberger, 2012; Marsden, 2006). A few quotes substantiate this:

> *We do not understand nearly enough about how individuals respond to parking policy interventions […]* (Marsden, 2006, p. 456)
>
> *[…] a major reason why residential parking is neglected is the lack of empirical evidence to support policy interventions, namely how residential parking policy could influence travel behaviour* (Guo, 2013, p. 18)
>
> *But, another such interaction – the relationship between parking and mode choice – is somewhat understudied, especially theoretically*. (Inci, 2015, p. 61)

In both the European and North American literature, residential parking supply is seen primarily as a result of parking norms (Willson, 1992; Litman, 2013; Litman and Durning, 2013; Manville, 2010, 2013; Weinberger, 2012; WSP, 2011), and not as a market solution. Willson (1992), however, acknowledges that there are different views about what drives parking supply, but goes on to scrutinise only norms. The same literature is unison in that parking norms cause an over-supply of parking (see also van Ommeren and Wentink, 2010), thereby affecting living costs, construction costs, land-use, etc., as well as the foci of this paper: car ownership and mode choice. In fact, Manville (2010; 2013) shows how housing developers would offer less parking without minimum norms, especially in downtown areas.

Residential parking is traditionally subject to minimum and, in a few instances, maximum norms. In Norway, Hanssen et al. (2014) in a study of parking norms found that they originate from a 1965 Land Use Act which required developers to supply sufficient parking if the local municipality ruled so. Among the rationales behind the legislation was the need to reduce pressure on street parking. Urban parking norms have been subject to frequent revisions and, over time, Hanssen et al. (2014) have observed a shift towards maximum regimes for non-residential parking and that norms are increasingly seen as a tool for mobility management. However, the actual levels that the norms set out are rarely based on empirical evidence. Instead, they are pragmatic rules and quite often a result of historic developments or replications of practice in neighbouring areas.

There is a paucity of literature on the impact on car ownership and car-use of parking norms, home parking availability, and home parking facilities. This paper sets out to shed some light on these relationships using evidence from the 2013–14 Norwegian National Travel Survey (NTS) and a follow-up survey of 2,439 NTS respondents living in urban areas about their home parking situation.

Our paper is organised as follows. In section 2 we review the literature on the relationships between residential parking availability, car ownership, travel habits and mode choice, and in section 3 present our data. In section 4 we analyse the data and in Section 5 discuss our findings and draw conclusions.

2. Home parking availability, car ownership and travel habits

The direction of causation between car ownership and parking availability is often unclear. Endogeneity, related to the fact that people choose dwellings with a parking supply that fits their needs, is noted (see, e.g., Guo, 2013a, b; Weinberger, 2012). Owing to various sources of self-selection, this means that there is no one-way order of causation from which car parking availability affects car ownership. However, the fact that housing in areas with limited parking supply can be very expensive (see, e.g. van Ommeren et al., 2011) can be taken as a sign that parking demand is not just driven by parking supply, but also by car ownership, income, etc. Weinberger (2012) argues, however, that the self-selection problem is not important for policy considerations.

Donald Shoup has shown in several works, not least in his 2005 work, that parking is never free. The question is really: who pays the cost and how much of it? The general wisdom is that motorists rarely bear the full cost of parking alone. Under-priced, usually free and over-supplied parking drives the demand for parking. van Ommeren et al. (2011) looked at willingness to pay for parking permits using a hedonic price approach and found that it considerably exceeded their actual price. This fact causes too many people to use them. Correctly priced permits would increase social welfare. Guo and McDonnell's (2013) study, inspired by Ommeren et al. (2011), used a contingent valuation approach to willingness to pay for parking and compare their findings with the usually zero cost of parking. They conclude that both over- and under-priced parking cause problems in terms of parking under- and over-utilisation, respectively.

In regard to parking supply, several voices claim that private parking is wasteful compared with shared parking facilities (see, e.g., Guo, 2013b). Shared parking, including street parking, serves a given parking demand with fewer parking places than private parking does. In line with this, Litman (2013) shows how a more flexible use of parking capacity would reduce the total need for parking spaces. London and Williams-Derry (2013) studied the phenomenon and found that, during peak demand for home parking, i.e., at nights, an average of 37 percent of parking spaces in 23 apartment building were not in use. As a corollary to these claims, "unbundling", i.e. the physical and financial separation of parking from housing supply, is put forward as more efficient and fair (Litman, 2013; Manville, 2013; Department for Communities and Local Government, 2007).

The question of whether and how origin-parking affects car ownership and use is treated in only a few contributions in the research literature. Recent research finds that households own more cars and use them more if they have access to off-street parking (Guo, 2013c), make more car trips and drive further if there is good access to off-street parking (Guo 2013b); they also tend to choose the car even to destinations that are well served by public transport if parking norms are generous (Weinberger, 2012). Marsden (2014) writes that there is limited evidence of this, but refers to Zhan (2013), who found that free on-street parking was estimated to increase car ownership by up to 9 percent. Guo (2013a) analyses how parking convenience affects households' travel activities, mode choice, distances, trip chaining, etc., combining household travel survey with information recorded from Google street view. He suggests that parking convenience comprises two aspects: namely, parking certainty and parking ease. They may have different effects; for example, because a private garage offers parking certainty but not necessarily the ease of parking that is associated with street parking. He finds that parking certainty affects car ownership levels, the amount and distance of car driving, and the amount of travel with alternative modes. Parking certainty increases driving distances by about 10 percent. Guo (2013a) anticipates that parking permits have the same effect. Parking ease works differently. Despite access to a private garage, households often choose to park on-street or in their driveway. Weinberger et al. (2008) compare two New York neighbourhoods: Park Slope has all the characteristics of a car-dependent community, but the observed car-use for work trips is lower than that of Jackson Heights. The authors examine possible explanations and conclude that differences in access to private parking are the key explanation. Park Slope was developed before the 1961 zoning revision, which required driveways and garages. Weinberger (2012) extends the Weinberger et al. (2008) analysis and finds that conclusions from the 2008 study hold. Parking supply induces car ownership and car-use. Transport for London (TfL, 2012) studied how parking affects car ownership and use in newer developments (built 2004–19) with ten or more housing units. Compared with London averages, these have better access to off-street parking and higher car ownership levels, even when corrected for public transport access, household income and household structure. WSP (2011) studied many of the same mechanisms, also in London, on behalf of the Berkeley Group, a housebuilding company, and arrived at a different conclusion. It found no relationship between access to parking and car ownership and peak hour car-use. Only a small share of dwellers' cars is in use during rush hours.

In total, the limited available research concludes, unisonly, that home parking availability induces car ownership and car-use. However, this conclusion rests much on studies from the US, and on aggregate and secondary data. Our paper thus contributes with new empirical results, since it is based on data from a European setting. In addition, we have rich details concerning travel behaviour and parking facilities and can therefore shed light on a broad spectre of parking availability effects.

3. Data

Our respondents were recruited during the 2013/14 Norwegian National Travel Survey (NTS; documented in Hjorthol et al., 2014). The 2013–14 Norwegian NTS is the seventh national survey of travel behaviour in Norway. A total of 60,000 persons aged 13 and above were interviewed about access to transport resources and everyday mobility. The survey covers personal travel of all types and purposes, and by all transport modes, including walking and cycling. All trips are geotagged. However, NTS records only a few variables related to home and workplace parking.

In total, the differences are so small that no additional weighting is done in the following analyses. 11,930 NTS respondents aged above 18 years and with their home address in the Norwegian main city areas were invited to participate in a follow-up survey about parking at home. They were invited irrespective of car ownership and car-use. Forty-three percent agreed to participate and were sent an email with link to the follow-up parking survey. Sixteen percent had an error with the email address and therefore 4,889 persons received the email; 2,439 persons answered the survey.

Table 1 compares key characteristics of respondents of the follow-up survey and of NTS respondents from the same areas. The percentages of men and people with higher incomes and education are a little higher in the follow-up survey. Table 1 also shows the spread of respondents over four city areas.

Table 1. Comparison of respondents in NTS and the parking follow-up survey.

Background variable	NTS 2013/14	Follow-up survey
Male	50	53
Female	50	47
Age		
18–24	8	4
25–34	18	17
35–44	17	18
45–54	18	21
55–66	21	25
67+	18	15
Household income, NOK*		
<200	7	3
200–399	11	7
400–599	18	16
600–799	14	15
800–999	15	18
1000 +	34	41
Education		
Primary	5	3
High school	31	23
Lower university degree	34	36
Higher university degree	30	37
City area		
Oslo		31
Trondheim		28
Bergen		23
Stavanger–Sandnes		18
N	12620	2439

* €1 equals about NOK 8 at time of survey

The parking follow-up survey went into great detail with respect to respondents' access to, and use of, parking resources and how these affected travel habits. Respondents were asked about: type of dwelling; whether they consider

moving house and if parking is one of the triggers; availability of various forms of parking, and whether the spaces are reserved or shared; distance to different parking options; the ease of finding a parking space; what times of the day it is difficult to find available parking places; maximum distance they are willing to walk from home to parking; where the household's cars are usually parked; payment for different forms of parking; time spent searching for parking; visitor parking availability; availability, cost and satisfaction with residential parking permits; statements about how parking affects car ownership; to what degree various trip purposes are affected by availability of and payment for parking. All information from the original NTS and the follow-up parking survey was merged into one data file.

4. Analysis

In this section, we present some general observations of our dataset regarding home parking availability and, then, in the following sub-sections we analyse impacts on car ownership and car-use.

Table 2 illustrates the range in availability of various forms of parking in the sample. Note that availability does not necessarily coincide with use. Availability of parking on one's own property is by far the most frequent available alternative, and 95 percent have a distance of less than 50 m between home and their parked car. About a quarter have access to reserved parking at home and almost one-third regard street parking as an alternative. It is clear that, even in Norway's largest city areas, a majority have access to private or reserved home parking and that distances from home to any form of parking are generally short. The exception is the small proportion of parking disconnected from home. Only one in five of these are less than 50 m away from home and more than 100 m away.

Table 2. Home parking availability and share of respondents who have less than 50 m distance from home to the respective parking alternative. More than one alternative is possible. Percentages.

	Percent	Percent <50 m distance from home
Can park on own property	58.1	95
Reserved parking space connected to dwelling	24.1	75
Shared parking connected to dwelling	7.2	77
Parking disconnected from dwelling (e.g. parking house)	4.6	20
Street parking	30.3	69
Other	2.8	48

In another question, we asked respondents about the maximum distance between home and home parking that they were willing to accept. On average, this was a maximum distance of 155 m. However, the answers differ substantially, between 0 and 2000 m. Standard deviation is 167 m. Men, younger people, car owners and those who live in apartment buildings accept on average a longer distance between the home and home parking. On the other hand, women, older people, people with young children and those who already have good access to parking accept, on average, shorter distances to home parking.

Among those who have access to reserved parking, 79 percent do not pay for it directly, while the remaining 20 percent pay an average of NOK 400 per month for their reserved home parking. There is a great variety in prices paid for parking and the reported amounts most certainly suffer from errors, e.g. when monthly costs are, erroneously, reported as annual costs. Eighty-six percent of those who have access to street parking state that it is free. Only 5 percent live in places where street parking is subject to payment any time of the day, and 8 percent where there is payment during daytime only.

Although parking may be available, it is not necessarily easy to find a vacant spot. About 32 percent of those who have access to street parking state that they can run into difficulties finding a space. In shared but not reserved parking, 11 percent experience problems finding a space. We asked those who experience problems with finding a parking space about what times it was most difficult. Afternoons and evenings are by far the most troublesome times (53 percent for street parking and 29 percent for shared parking), followed by weekends. Only 10 percent state that it is

most difficult to find a vacant space during weekday daytimes. This situation generates cruising for parking. Table 3 shows average time spent searching for parking during different times of the day and averages for those who state that it is difficult to find a space. A further investigation of those who struggle to find vacant space shows that they predominantly live in downtown central business districts.

Table 3. Average time spent cruising for parking at home, by time of day. Minutes.

	Daytime	Afternoon	Evening
Average, N=403	1.91	2.90	3.79
Average if stated difficulty finding a space, N=117	2.83	5.01	7.26

4.1. Parking and car ownership

Details of car ownership in relation to home parking are given in Table 4. Non-car owners have less access to reserved parking or parking on their own land than car owners do. However, non-car owners have more access to street parking. There are differences, too, between single car households and multi-car households. Single car households report access to reserved parking in a common parking area much more frequently than multi-car households. It may be that they acquire this parking place once they purchase their car, or, they may have access to a maximum of one parking space in the shared facility, which is a relatively common arrangement in Norway. Although Table 4 cannot determine the direction of causation, it still provides important insights. About half the non-car owning households have access to own or reserved parking. These spaces are vacant, rented out or serve purposes such as storage. Parking availability is not the reason for not owning a car for this part of our sample. The other 50 percent of non-car owners do not enjoy reserved parking. Car ownership may be less attractive for them.

Table 4. Car ownership in relation to parking availability. More than one alternative is possible. Percent.

	No car	One car	2+ cars
Can park on own property	29	52	80
Reserved parking space in common parking lot connected to dwelling	21	29	16
Shared parking connected to dwelling	12	7	6
Street parking	56	29	21
No parking available	1	-	-
Other	4	3	2
Total	123 (N=305)	120 (N=1393)	125 (N=725)

Parking is of course not the only determinant of car ownership. We therefore carry out a logistic regression, which controls for other factors that affect car ownership. Table 5 presents the result. Higher incomes and children in the household have a profound positive impact on car ownership. When controlling for other variables, public transport service levels have no significant effect on car ownership. As expected, driving license holders have a significantly much higher likelihood of owning a car. Turning to parking availability, access to reserved parking increases the odds for owning a car by a factor of more than 3 and apartment building dwellers have about two-thirds reduced likelihood of car ownership. However, this is not a causal model. The direction of causation cannot be interpreted from this.

Table 5. Logistic regression of car ownership*

	B	p-value	Exp(B)
Constant	-3.556	.000	.029
Gender = Male	.329	.016	1.389
Age	.030	.000	1.031
Household income	.383	.000	1.466
Children in household	.613	.001	1.846
Public transport service	.104	.350	1.109
Driving license	1.771	.000	5.879
Reserved parking	1.203	.000	3.331
Attached house	-.415	.116	.661
Apartment building	-1.029	.000	.357

*Dependent variable: car ownership yes/no. Percentage correctly estimated: 88.4 (against 86.2% without independent variables). Cox & Snell R^2 .193, Nagelkerke R^2 .347

4.2. Parking and car use

Parking norms may affect car ownership levels. However, if car owners and non-car owners have roughly the same travel patterns, one can see that the personal consequences of reduced car ownership are small. Table 6 compares car owners with non-car owners in respect of the number of trips they make for various purposes. There are very small differences between the two groups. They make roughly the same total number of trips per day. The only statistically significant difference relates to escort trips. Non-car owners make fewer escort trips than car owners do. Escort trips are predominantly transporting of children to nursery or education. It is well known that this kind of trip in general is by car (Hjorthol, 2002; Hjorthol et al., 2008). However, families with children to escort are also likely to have the characteristics of typical car owners with respect to household size, age, housing location, income and so on. Therefore, the significant differences between the two groups need not be due to car ownership, but rather to self-selection. It is likely that non-car owners, rather than being deprived of escort trips, are in a situation with less need for escorting.

Table 6. Average number of trips per day by purpose and car ownership.

	Car owner	Non-car owner
Total no. of trips	3.73	3.53
Work trips	0.88	0.84
Shopping trips	1.06	1.10
Escort trips	0.43	0.19**
Leisure trips	0.72	0.70
Visits	0.33	0.34
Other trip purposes	0.19	0.17
N	2132	305

In total, we find little support for differences in travel patterns and trip frequencies between car owners and non-car owners. We therefore move on to study whether there are differences between car owners with different access to parking. For total number of trips and for any trip purpose, we find no significant differences in trip frequencies between people who have access to parking within 50 m distance of home relative to those with more than 50 m.

Distance to home parking appears to have no impact on the number of trips made by car owners for any trip purpose. However, it affects their mode choice. In Table 7 we compare mode choice between the two groups with long vs. short distance to home parking. There are significant differences. The number of car trips is significantly lower among those who have more than 50 m distance to their parked car, and they travel significantly more on foot and by public transport. Although trip frequencies are similar between the two groups, their mode choice is significantly different.

Table 7. Average number of trips per day by mode and by distance to parking among car owners.

Number of trips by ...	0-50 m	50 m or more
… foot	0.83	1.25**
... bicycle	0.20	0.24
... car driver	2.08	1.54**
... car passenger	0.22	0.25
... public transport	0.33	0.45**
Total number of trips	3.72	3.77
N	1781	280

Next, we look at the trip purpose most affected by distance to parking. If work trips by car were discouraged by longer distances from home to home parking, then rush hour traffic levels would be reduced by a simple policy of separating residential parking from the home location.

Figure 1 plots mode shares for various trip purposes for people with short (up to 50 m) and long (>50 m) distances between home and home parking. Car shares of all trip purposes are affected. However, work trips are least affected and a general policy of separating home and parking locations is likely to have a minor impact on rush-hour car traffic. Mode shares of shopping, service and leisure trips, however, vary greatly with distance to home parking.

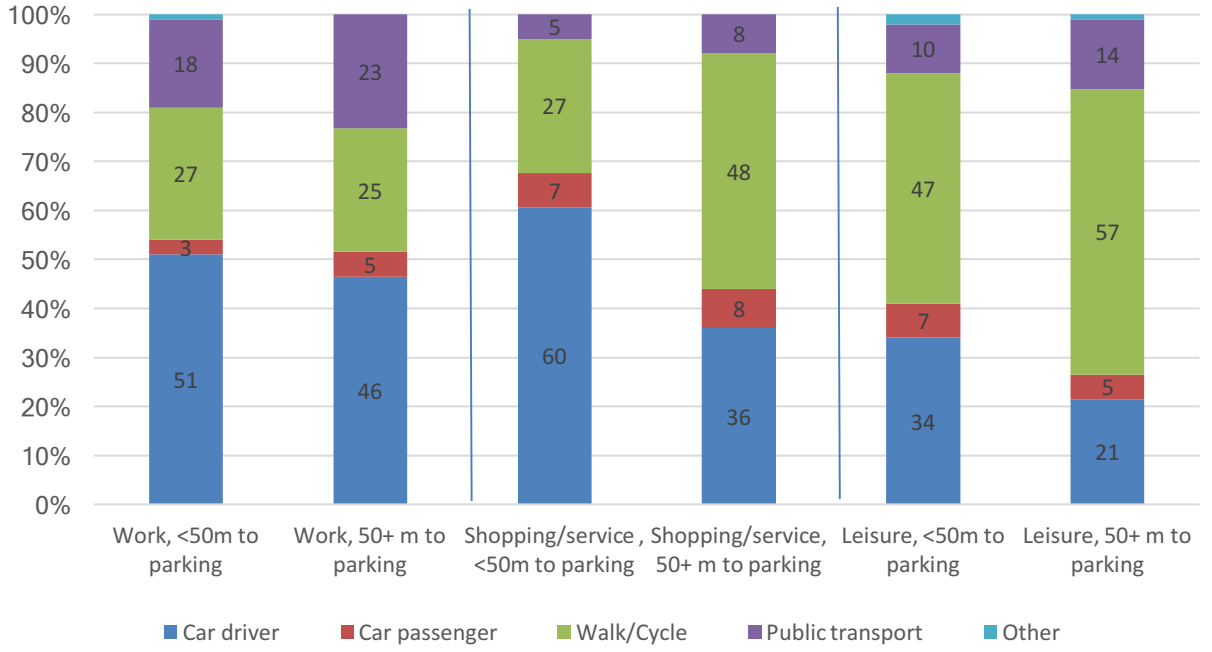

Figure 1. Mode shares by trip purpose for people with up to 50 m distance to home parking (N=6620) and those with more than 50 m distance to home parking (N=1058).

The above bivariate relations show that parking distance affects mode choice in different ways for different trip purposes. However, we have not controlled for factors such as income, gender, availability of public transport services, and so on. Therefore, we set up a logistic regression model which performs these controls. Hjorthol et al. (2014) show that inhabitants in Oslo use their car less than those of any other Norwegian city. Oslo is therefore chosen as reference category. Two parking variables are included in the model. The first is the distance to the nearest home parking they use. The second is the number of reserved parking spaces the household holds.

The results are presented in Table 8. The odds of using the car are less for women, those with higher education, married/cohabiting persons and others who have access to good public transport services. Driving licence holders, those with a high degree of car availability within the household and higher household income levels are associated

with considerably higher odds of being a car driver. The urban indicators show that inhabitants of other cities than Oslo have higher odds of using the car. When controlling for all these factors, increased distance to home parking significantly reduces the odds of using the car. Each additional reserved parking space increases the likelihood of using the car by 13 percent.

Table 8. Logistic regression. Members of car owning households. Dependent variable: Travelled by car this day.

	B	Sig.	Exp(B)
Constant	-6.096	.000	.002
Gender (0=woman; 1=man)	.424	.000	1.528
Education (4 levels)	-.157	.023	.855
Household income (6 levels)	.106	.029	1.112
Married or co-habiting	-.491	.001	.612
Driving licence	3.458	.004	31.739
Public transport service	-.184	.016	0.832
High degree of access to the household's car	.720	.000	2.054
Made escort trips on that particular day	1.137	.000	3.117
Bergen	.657	.000	1.929
Trondheim	.491	.001	1.634
Stavanger	.583	.001	1.792
Sandnes	.659	.013	1.932
Number of reserved parking spaces at home	.122	.020	1.129
Distance to parking (3 levels 0-50 m; 50-100 m; >100 m)	-.452	.000	.637

N=1732. Percentage correctly estimated: 67.0 (against 57.8% without independent variables). Cox & Snell R^2 = .168, Nagelkerke R^2 = .225.

5. Discussion and conclusions

In this paper we have presented responses from 2,439 Norwegian urban dwellers asked to describe their home parking arrangements. We linked this information to the same person's full 2013/2014 National Travel Survey travel diary and other information about their household and access to transport resources. The approach is analogous with Guo's (2013a), who linked travel survey data with parking information that was coded from observations in Google street view. Our approach is unique, however, in its wealth of detailed parking, car ownership and travel data. We are not aware of any studies that have combined travel survey data with detailed home parking information of comparable accuracy, detail and sample size from the same individuals.

Given the thorough NTS recruitment strategy and subsequent weighting procedure, we certainly have a good and representative sample of the largest Norwegian cities. Nevertheless, our data inevitably contain inaccuracies and measurement errors. One example is the reported cost of reserved parking. Respondents may have reported the wrong unit of time they pay for, i.e. month versus year. Also, note that our findings rely on data from major cities where distances are relatively short and public transport offers a relatively good alternative to the car. Our findings should not be transferred to rural contexts.

Self-selection and endogeneity are inherent challenges when analysing parking, car ownership and car-use data. Our study is no exception. We have identified bivariate and multivariate associations and strong correlations between parking, car ownership and car-use. However, we have not established the direction of causation. People's car ownership and use may be a function of access to residential parking, but it may also be the other way round, i.e. that people with different preferences for car ownership and car-use choose housing with different parking options. In section 2 we referred to Weinberger (2012), who argued that the self-selection problem is not very important for policy considerations. That may be the case, but it is still an unsatisfactory state of affairs. Further studies and analysis of these dynamics should be done.

Our study demonstrates a positive relationship between parking availability and car ownership. People with access to owned and reserved parking have about three times higher car ownership levels than others. This is in line with previous research. Also those without reserved car parking own cars, but less so. Fifty percent of those who have to rely on street parking own one or more cars.

Interestingly, we find no evidence that car ownership is associated with higher trip frequencies in our urban sample. Non-car owners make about the same number of trips for various purposes as car owners do. When focusing on car owners only, a similar picture emerges. Ease of access to home parking has no impact on trip frequency. People with more than 50 m distance from home to their home parking location make the same number of trips as those with short and immediate access to home parking. This means that limited parking availability does not necessarily have significant negative welfare effects. However, varying distances to home parking give significantly different modal shares. Longer distances to home parking are associated with more walking and public transport trips and fewer car trips. Shopping, service and leisure trips are most affected, while the differences in commuting mode choice are relatively minor.

Our multivariate analysis of parking and car-use confirms that longer distance to the parked car is associated with less car-use, and that access to a higher number of reserved parking spaces increases the likelihood of car-use.

One may expect parking availability to be low and that home parking is troublesome in major cities. In Norway, that seems not to be the case. A majority of our urban sample has access to private and reserved home parking within very short distances from home. In Guo's (2013a) terms, they enjoy considerable parking certainty and relatively high levels of parking ease. Previous research has analysed residents' willingness to pay for parking (Guo and McDonnell 2013), but not as far as we know, the distance residents are willing to walk to the parking lot. In fact, people are willing to accept considerably longer distances between home and home parking – on average 155 m. For city planners, this means that parking and housing need not be located on the exact same plot of land. The two may be managed more efficiently as two distinct aspects of housing and urban development when people on average are prepared to accept relatively long distances. Given the likely impact on modal shares, physical separation of homes and parking may have further benefits in terms of reduced urban car driving.

Furthermore, one might expect that street parking in urban areas would usually be subject to pricing. The opposite holds true for Norway. Only 8 percent of the urban population live in areas where street parking is subject to payment. The vast majority park free of charge on their local roads.

It is most difficult to find a vacant parking space near home during afternoons and evenings. Work trips (commuting) are affected since this coincides with the return trip back home. However, our data indicate new insights into which trips are most affected by home parking availability. The analysis suggests that work trip mode choice is relatively insensitive to home parking hassle. Shopping and leisure trips are typical afternoon activities for many people, and these trips are also likely to be affected by parking uncertainty. These are trip purposes where mode choice is more flexible. Few, about 10 percent, find it difficult to find vacant space near home during daytime. Still, parking management, like charging, usually applies only during daytime. Many would agree that pricing is a more efficient tool for rationing a scarce resource like parking spaces, than queueing, cruising and searching. Still, charged parking is almost absent – usually during daytime and almost always during night-time. Gradual introduction of modest 24/7 charging in pressure areas would contribute by reducing the difficulties of finding available parking in evenings, nights and weekends and allocate parking space more efficiently.

Current and historic parking norms have largely satisfied demand. Guo (2013a, b) argues that maximum norms can reduce car ownership and thereby reduce congestion and emissions. Our study supports this, and finds that parking affects not only car ownership but also mode choice among car owners. In this respect, distance between home location and home parking location has a significant effect. Longer distances increase the generalised costs of car-use and also the relative competitiveness of alternative modes. This is especially the case in cities and urban areas where distances are short and alternatives are readily available. The implication is that land-use planners and lawmakers must see street parking, residential parking and housing as a whole. In line with Guo (2013a) and Guo and Ren (2013), maximum norms and regulation of distance between home and parking would be less effective when free street parking is abundant.

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