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Transportation Research Procedia 19 (2016) 215 – 224

Transportation Research Procedia

www.elsevier.com/locate/procedia

International Scientific Conference on Mobility and Transport Transforming Urban Mobility, mobil.TUM 2016, 6-7 June 2016, Munich, Germany

The Impact of Carsharing on Car Ownership in German Cities

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Abstract

Carsharing, currently growing strongly in Germany, is an important instrument for sustainable urban mobility. The present boom is mainly due to so-called "free-floating carsharing". Whilst the environmental effects of station-based carsharing have been intensively studied in the German-speaking context, to date there have been hardly any empirical findings on the effect of free-floating carsharing.

Using the example of DriveNow and Flinkster in Berlin and Munich, this article examines to what extent free-floating carsharing leads to a reduction of car ownership compared to station-based carsharing. Based on online surveys (n=819/227) carried out within the "WiMobil" project (9/2012 – 10/2015), descriptive analyses and two binary logistic regressions were performed.

The findings show that station-based and free-floating carsharing leads to a reduction of private cars but to different degrees (DriveNow 7%; Flinkster 15%). The shedding of cars is influenced by the frequency of use of carsharing and the increasing membership of station-based carsharing providers. Furthermore, for many people of both systems carsharing is an important reason not to buy a car. But there is also a significant proportion of people planning a car purchase. This is true especially for car-savvy persons for whom car ownership is very important. Thus, carsharing can be an important factor for sustainable urban mobility. In order to maximize the positive effects of carsharing, it is of central importance to reach additional user groups such as women and elderly people with private car ownership.

Peer-review under responsibility of the organizing committee of mobil.TUM 2016.

Keywords: Carsharing; Car Ownership; Urban Mobility; Berlin; Munich; Germany

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Peer-review under responsibility of the organizing committee of mobil.TUM 2016.
doi:10.1016/j.trpro.2016.12.082

1. Introduction

In Germany, the car is the dominant means of transport – 58% of all trips and 79% of passenger-kilometers are covered by car. Even in larger cities (cities with more than 100,000 inhabitants) with good public transport, cars are used for 50% of journeys and 71% of passenger kilometers (infas & DLR 2010). Urban car traffic causes many negative effects, including air pollution and CO2 emissions, congestion, parking pressure, and noise. Strategies promoting a reduction in car traffic are becoming ever more important.

Carsharing, which is currently expanding rapidly in Germany and reporting a strong increase in user numbers, is an important instrument for sustainable urban mobility (BCS 2016). The present boom is mainly due to so-called "free-floating carsharing" offering one-way rentals with per-minute billing. Station-based carsharing is also continuously growing, both in terms of cities offering carsharing services and number of customers. The potential of carsharing for sustainable urban mobility results from various vehicle- and behavior-related effects. Carsharing vehicle fleets consist of new models with low emission values and low energy consumption and are characterized by an expanding number of electric vehicles. On the user side, carsharing aims at reducing the use of cars as well as car ownership, in order to counteract the above-mentioned negative effects of car dominance.

Whilst the effects of station-based carsharing on transport, mobility and the environment have been intensively studied in the German-speaking context (e.g. Baum & Pesch 1994; Petersen 1995; Krietemeyer 2003; Maertins 2006), to date there have been hardly any empirical findings on the use and effect of free-floating carsharing (Firnkorn & Müller 2012; Müller et al. 2015; team red 2015).

The present study is based on the research project "WiMobil" (9/2012 – 10/2015) funded by the Federal Ministry for the Environment, Nature Conservation, Building und Nuclear Safety (BMUB). The aim of the project was to analyze the effects of carsharing on transport demand and the urban environment, taking Flinkster (DB Rent GmbH) and DriveNow (BMW AG) as an example. Flinkster is a station-based carsharing provider that operates exclusively in Germany. With about 7,000 cars at over 1,000 stations in over 200 cities, Flinkster is the largest carsharing provider in Germany. The free-floating carsharing provider DriveNow is currently operating in five German cities (nine cities in total). The entire fleet includes about 3,800 cars. With more than 500,000 registered persons, DriveNow has the highest number of carsharing costumers in Germany.

Based on these case examples, we shall discuss to what extent station-based and free-floating carsharing contribute to how many private cars are shed. It is of particular interest if there are any differences between station-based and free-floating carsharing. For many cities and municipalities, the car shedding rate is a key indicator for the evaluation of carsharing. Only with a positive evaluation will carsharing be promoted in the future by public administrations.

2. Impact of carsharing on car ownership

The effects of carsharing on mobility and the environment are varied and can be both positive and negative (Baum et al. 2012). This is also true for the impact of carsharing on private car ownership. Although it is possible that car owners shed their cars due to carsharing, it is also conceivable that carsharing actually leads to car purchase. Especially for non-car owners, carsharing could be a "gateway drug" into car ownership. We now turn to the current state of research on the respective carsharing systems in greater detail.

Station-based carsharing has existed in Germany for a long time. In the late 1980s, the first carsharing provider started its service in Berlin (BCS 2014). In the following period, more and more carsharing provider entered the market. As of the beginning of 2016, station-based carsharing providers collectively count 430,000 registered customers in 537 cities and communities in Germany (BCS 2016). To date there have been many studies dealing with the environmental effects of station-based carsharing providers. One of the first analyses can be found in Wiederseiner (1993), who showed, using the example of STATTAUTO in Nuremberg, that a large number of respondents, 54%, were car owners prior to their carsharing membership. In another study, Baum & Pesch (1994) proved that 23% shed their private cars because of carsharing. In his study on STATTAUTO Berlin, Petersen (1995) calculated that, with each purchased carsharing car, 3.89 private cars will be shed. Similar studies in the mid-2000s also confirmed the high impact of station-based carsharing on private car ownership. Maertins (2006), for example, proved that 33% of users do not purchase a private car and 16% got rid of a car due to carsharing. Comparable values can also found in Krietemeyer (2003). Even the example of North America shows the impact of carsharing on vehicle holdings impressively. Martin et al. 2010 reveal that, while some households purchased a car after joining the carsharing

organization, many more households shed a car. To sum up, all the different studies document the high impact of station-based carsharing on car ownership. By joining a carsharing organization, the number of carless households increases significantly (BCS 2010).

In contrast, there are currently only a few studies about free-floating carsharing regarding this topic. It must be taken into account that this carsharing system has only existed since 2009. Nevertheless, the registered customers are much higher compared to station-based carsharing. At present, 830,000 persons are registered in 16 cities in Germany (plus the "Rhein-Main-Region") and are able to use free-floating carsharing or combined services (BCS 2016). First studies indicate free-floating carsharing reduces car ownership. An initial analysis can be found in Firnkorn & Müller (2012), who showed that, after 1.5 years of car2go operating in Ulm (Germany), about 5% of people who still owned a car at the time of the survey had shed one or more other cars due to using this carsharing service. Regarding non-car owners, as many as 5% had shed a car and 17% did not purchase a car because of car2go. In contrast, a study of car2go in Amsterdam confirmed that only 4% from about 1,600 respondents shed a private car since becoming a member. Furthermore, nearly one quarter will reconsider their car ownership (Suiker & van den Elshout 2013). The "share" research project's initial interim panel-study results showed that about one third of non-car-owning car2go members in Cologne and Stuttgart do not have a private car due to carsharing. No less than 5% shed private cars without replacement after three months of membership, whereby every fifth person mentioned carsharing as the reason. Two percent purchased a car but there are no differences to the control group (Öko-Institut & ISOE 2014). Further results of this project may give first indications of the long-term effects of free-floating carsharing on car ownership. In another study, different carsharing providers were extensively investigated in the city of Munich. In the case of DriveNow and car2go, approximately 10% of the respondents got rid of a private car because they used carsharing and about 40% forewent buying a car. Beyond that, 20% of car2go users with a private car in their household are planning, or can just imagine, shedding a car in future. This rate is still higher in the case of DriveNow (team red 2015).

In summary, many studies have investigated the impact of station-based carsharing on car ownership and have frequently proven the positive effects for different providers. The first analyses of free-floating carsharing indicate similar effects. But it is also clear that the impact on car ownership differs depending on the carsharing provider, the time of the survey, and the respective city. Other case studies are therefore needed to verify the influence of free-floating carsharing on car ownership.

3. Data background and methods

The data used for this article originate from the above-mentioned "WiMobil" project. Within the project, a similar set of surveys (online, panel, focus groups) was carried out in two survey periods. In each survey period, both carsharing systems were analysed by interviewing customers of DriveNow and Flinkster. The spatial focus was set on the two cities Berlin and Munich. The analysis presented in this article is mainly based on data originating from online surveys, see description below. If another dataset is used, it is pointed out in the text.

In March 2015, a randomized sample of 6,000 DriveNow customers living in Berlin and Munich received a link to an online survey by email. The only necessary condition to be potentially part of the sample was to have used DriveNow at least once within the last twelve months. In total, 819 DriveNow users (14%) participated in the survey. In the case of Flinkster, 3,077 randomly selected costumers of Berlin and Munich were contacted by email in March 2014. Flinkster customers who generally do not want to participate in surveys were excluded from the sample. Due to a high number of previous surveys, Flinkster customers were mostly unwilling to take part in the online survey. 227 people completed the questionnaire, equalling a return rate of 7%. The reason for comparing online surveys of DriveNow and Flinkster customers from two different points in time is the better comparability of the samples. In the first survey period, DriveNow customers who frequently use carsharing had a higher probability of selection due to the specific survey design. As the response rate of Flinkster customers dropped in the second survey period, the data of the first survey period were preferred.

Comparing the sample with the basic population of all DriveNow and Flinkster customers living in Berlin and Munich, it can be seen that there are only small differences in terms of age and gender distribution. Thus, the datasets used give a good picture of the typical costumers of both systems.

In the next section, the impact of station-based und free-floating carsharing on car ownership will be explored in detail. Descriptive analyses are completed by two binary logistic regressions to ascertain the factors influencing the car shedding and car purchase of DriveNow and Flinkster customers.

4. Results

This section presents the results of the empirical analysis. First, the socio-demographic characteristics of DriveNow and Flinkster customers will be explained. For a better classification, the number of cars in the household is shown too. Following this, different aspects of the impact of carsharing on car ownership are discussed.

4.1. Description of the sample

In table 1 some socio-demographic facts are summarized. It can be seen that DriveNow is increasingly used by younger age groups compared to Flinkster. On average, DriveNow users are 36 years old. In contrast, the average age of Flinkster users is 45. According to the lower age of DriveNow customers, the proportion of students is significantly higher. Furthermore, there are only small differences between the carsharing providers.

The proportion of men is very high in both carsharing systems. Moreover, carsharing users are mostly highly educated and live in one- or two-person households. The majority of customers are also employed full-time. Accordingly, the average net monthly equivalent income of over 2,500 euros is also relatively high. In 2013, the net equivalent income in Germany was 22,471 euros per year (Destatis 2015). This corresponds to a monthly income of 1,873 euros. Between the cities Berlin und Munich there are only minor differences regarding socio-demographic characteristics. DriveNow customers in Munich have a significantly higher income than Berlin costumers (2,849 euros compared to 2,220 euros). This mainly reflects the higher income levels in Munich.

Table 1. Sociodemographic structure of DriveNow and Flinkster users.
Authors´own analysis, based on data from the project "WiMobil".

	DriveNow	**Flinkster**
Average age (n=720/211)	36 years	45 years
Men (n=776/222)	74%	80%
University degree (n=760/214)	71%	78%
One- and two-person household (n=796/224)	68%	71%
Full-time employment (n=632/221)	71%	77%
Students (n=632/221)	13%	5%
Equivalent net income per month (mean) (n=561/187)	2,514 euros	2,646 euros

Most DriveNow and Flinkster users (about 60%) live in high density areas in the inner city. As the operating area of DriveNow and most of the Flinkster stations are located in the city center, a residence outside the city is very rare.

Regarding the number of cars in the households, there are relatively large differences between DriveNow and Flinkster (see fig. 1). While 72% of the Flinkster customers live in a household without a private car, this share is much lower in comparison to DriveNow. Only 43% of the DriveNow respondents have no car in their household. It is remarkable that there are not only differences between the carsharing providers but also between the cities in the case of DriveNow. Forty-nine percent of DriveNow users in Berlin and 39% in Munich have no car in the household. This is significantly lower. In line with the higher income level, more households in Munich are in possession of a car than in Berlin. Nonetheless, compared to the average in Berlin and Munich, both user groups own cars to a smaller extent. On average, 41% of households in Berlin and 26% of households in Munich have no private cars (infas, DLR 2010).

Summarized, regardless of the carsharing system and the city, the socio-demographic profile of carsharing users is relatively homogenous. The users consist to a large extent of young, highly educated men with high incomes;

DriveNow users are a bit younger compared to Flinkster's. Concerning car ownership, there are differences between DriveNow and Flinkster, but both rates are much lower compared to the average of Berlin und Munich.

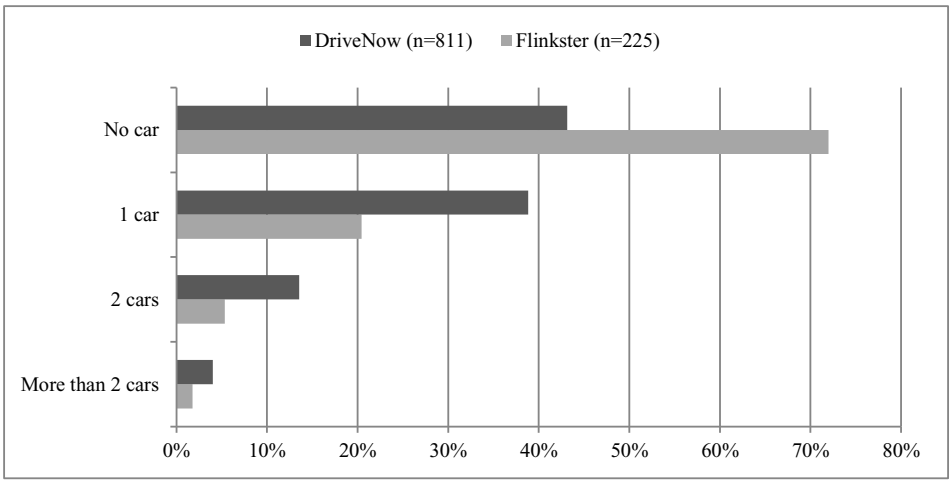

Fig. 1. Number of cars in the household of DriveNow and Flinkster users.
Authors´own analysis, based on data from the project "WiMobil".

4.2. Reasons for not owing a private car in the household

As already shown, 72% of the interviewed Flinkster users and 43% of the DriveNow users live in a household without a private car. These people were asked about the reasons for not possessing a car (see fig. 2). We can see that different answers were given. In both carsharing systems, the most common reason given is that a private car is not necessary. Other important reasons are "due to costs" and "carsharing is sufficient". There are differences between the carsharing providers by looking at the combination of reasons. Many DriveNow customers combined the answers "no private car needed" and "due to costs". In contrast, many Flinkster respondents stated the reason "environmental protection" in combination with "carsharing is sufficient". The analysis shows that the customers of both carsharing systems are satisfied with their everyday mobility, even without of the use of a private car.

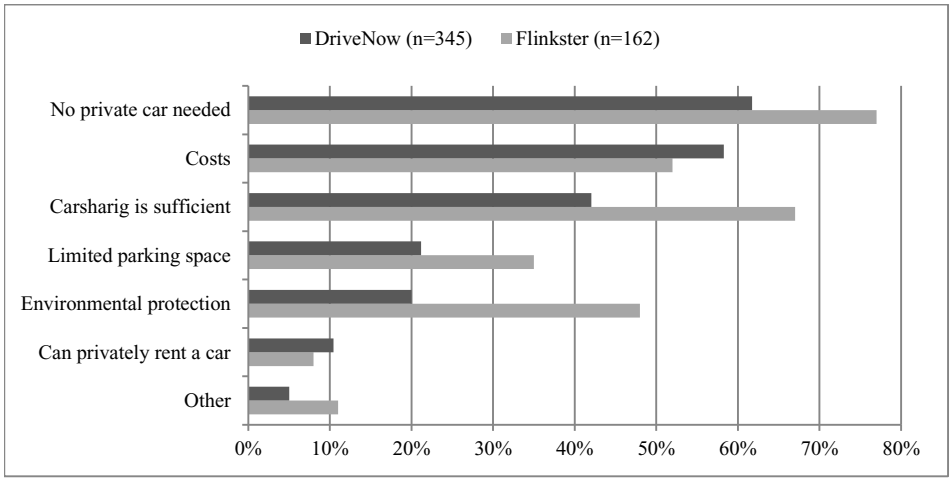

Fig. 2. Reasons given by DriveNow and Flinkster users for not owning a car in the household (multiple response were possible).
Authors´own analysis, based on data from the project "WiMobil".

4.3. Conditions for a potentially shedding a car

This chapter focusses on car owners. According to the above values, only 28% of the Flinkster users and 57% of DriveNow users have a private car in their household. Around two-thirds of these people live in a household with only one car, while one-third owns several cars. Our survey shows that a small part of this group is planning to shed a car (see chapter 4.4.), while the vast majority do not call car ownership into question (91% of DriveNow car owners and 90% of Flinkster). People of this latter group were asked under what conditions shedding a car was conceivable (see fig. 3). From the various reasons, especially Flinkster but also DriveNow customers mentioned most frequently the reason that "carsharing is always available". Thus, carsharing has the greatest potential for potential shedding of cars. Furthermore, rising car internal costs and well-interconnected transport modes could promote the shedding of private cars.

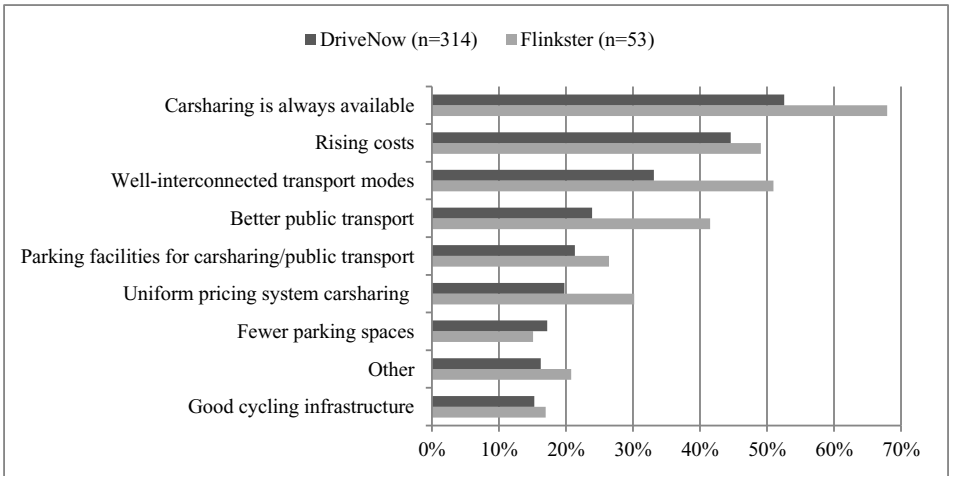

Fig. 3. Conditions of DriveNow and Flinkster users to potentially shed a car (multiple response were possible). Authors´own analysis, based on data from the project "WiMobil".

4.4. Car shedding

This section is about the people who shed a car in the past. For this purpose, everybody was asked – independently of whether they live in a household with or without a car – whether a car has been shed in the household since joining carsharing and what were the reasons for shedding it. The crucial question in this context is what significance carsharing plays in shedding private cars and again if there are any differences between carsharing providers.

In table 2 the car-shedding rates are shown. The table also includes the rates of people who are currently planning to shed a car. For both aspects a distinction is made whether carsharing has played a role or not. The comparison between DriveNow and Flinkster shows that significantly more interviewed costumers from Flinkster have indicated that they have shed a car due to carsharing. Nevertheless, an appreciable rate is also true for DriveNow. It needs to be borne in mind that Flinkster (already under the name of "DB CarSharing") has been active in the market for longer than DriveNow. DriveNow started its business only in 2011 in Berlin and Munich. Additionally, the degree of influence that carsharing has on car shedding was investigated. It became clear that, although carsharing was rarely the main reason, in most cases it was an important factor for shedding a private car.

It is remarkable that some respondents stated that carsharing was not of any importance regarding them shedding a car even though they were already customers of carsharing. In these cases important reasons were "the high costs of a private car" and "a private car is no longer needed". Table 2 also shows that there is a significant proportion of people who planning to shed a car due to carsharing. Although there are intentions that will not necessarily be turned into action, this result illustrates the given saving potential of private cars by carsharing.

Table 2. Car shedding rates of DriveNow and Flinkster users.
Authors´own analysis, based on data from the project "WiMobil".

	DriveNow	Flinkster
Car shed due to carsharing (n=772/216)	6.5%	15.3%
Car shed, other reason (n=772/216)	3.0%	6.5%
No car shed (n=772/216)	90.5%	78.2%
Planned car shedding due to carsharing (n=439/60)	7.1%	8.3%
Planned car shedding, other reason (n=439/60)	1.8%	1.7%
No planned car shed (n=439/60)	91,1%	90,0%

Using a binary logistic regression, we next investigated which factors significantly impact the shedding of cars. The value of 1 in the binary logistic regression represents all respondents who have shed a car since becoming a member. In contrast, the value of 0 represents the group of people with a car in the household where no change in car ownership has taken place or is not planned. In the case of Flinkster, no significant model could be defined; the following analysis refers only to DriveNow. Prior to the regression, two factor analyses were performed to summarize the wide range of preference variables for carsharing and other means of transport. In total, three factors were extracted and included in the regression. The other explanatory variables in the model are: sociodemographic characteristic (age, sex, education, household size), car ownership, use frequency of means of transport (carsharing, private car, bike, public transport), the number of carsharing memberships in station-based and free-floating providers, the duration of the carsharing membership, and the place of residence.

Table 3 shows all significant influencing variables of the regression model. The model is based on a sample size of 339 people and has a relatively high accuracy with 0.423 (Nagelkerkes R-squared). The significance of the model is p=0.000. The analysis shows that the likelihood of shedding a car increases if a person frequently uses carsharing and with increasing number of memberships of station-based carsharing. In contrast, the probability decreases the more a private car is used. The result shows that carsharing plays a crucial role in cars being shed by DriveNow users. In particular, heavy-users and people who combined both carsharing systems (station-based and free-floating carsharing) shed a private car more often.

Table 3. Factors influencing the shedding of cars by DriveNow users with the aid of a logistic regression.
Authors´own analysis, based on data from the project "WiMobil".

	B	S.E.	Wald	df	Sig.	Exp (B)
Use frequency private car	-1.018	.144	50.298	1	.000	.361
Use frequency carsharing	.938	.229	16.807	1	.000	2.555
Number of memberships at station-based carsharing	.841	.345	5.950	1	.015	2.319
Constant	-.604	.816	.547	1	.460	.547

B Logit-coefficient, *S.E.* standard error, *Wald* Wald-test statistic, *df* degrees of freedom, *Sig.* significance level, *Exp(B)* effect coefficient.

4.5. Planned car purchase

Regarding the influence of carsharing on car ownership, it is also important to know to what extent car purchases can be determined and what are the reasons for them. From a traffic policy perspective, persons without a private car in the household are especially relevant in this context. The question is whether such persons experienced the benefits

of private cars thanks to carsharing and thus want to buy a car. It must be noted that, due to comparability, another dataset has been used to analysis the DriveNow effects in this context.

Table 4. Planned car purchase of non-car owners by DriveNow and Flinkster users.
Authors´own analysis, based on data from the project "WiMobil".

	DriveNow	Flinkster
Planned car purchase (n=868/161)	18%	6%
No planned car purchase (n=868/161)	82%	94%

In the case of DriveNow, 18% of the non-car owners stated that they are planning a car purchase (see table 4). Again, there are significant differences compared to Flinkster. Only 6% of the same group wants to buy a car in the near future. So it can be seen that a significant proportion of the non-car owners are thinking about a car purchase. Therefore, the main reasons must be explained in this context. Due to a small number of cases at Flinkster the analysis can again only performed for DriveNow. For the DriveNow users, the main reasons for the car purchase are "the greater flexibility and "independence" and the improved accessibility.

Table 5. Factors influencing the car purchase of DriveNow users with the aid of a logistic regression.
Authors´own analysis, based on data from the project "WiMobil".

	B	S.E.	Wald	df	Sig.	Exp (B)
High school graduation (yes/<u>no</u>)	-.921	.328	7.875	1	.005	.398
Household size	.413	.122	11.371	1	.001	1.511
Factor: carsharing as a private car	-.549	.124	19.537	1	.000	.577
Factor: carsharing is ecology	-.281	.135	4.356	1	.037	.755
Factor: carsharing is more comfortable than public transport	.463	.134	12.003	1	.001	1.589
Factor: a private car is important	.493	.133	13.740	1	.000	1.638
Factor: public transport and bike are uncomplicated	-.349	.130	7.239	1	.007	.705
Use frequency of public transport	-.267	.134	3.982	1	.046	.766
Residence Berlin/<u>Munich</u>	-.519	.249	4.347	1	.037	.595
Constant	.027	.702	.001	1	.970	1.027

B Logit-coefficient, *S.E.* standard error, *Wald* Wald-test statistic, *df* degrees of freedom, *Sig.* significance level, *Exp(B)* effect coefficient, the reference category is underlined.

Even in this case, a binary logistic regression is used to determine the influencing factors (see table 5). The analysis is based on a sample size of 639 DriveNow users. All variables described above have been used. The quality of the model is 0.236 (Nagelkerkes R-squared) and is overall satisfactory. From the model, we see that the larger the household size, the more important a private car is deemed to be, and when a person assesses that carsharing is more comfortable than public transport, the probability of purchasing a car increases. In contrast, the probability is lower if the person has a high school degree, the more carsharing is assessed like a private car and the more carsharing is considered to be eco-friendly. Furthermore, DriveNow users are less likely to plan to purchase a car if they assess public transport and cycling to be uncomplicated, use public transport more frequently, and live in Berlin rather than Munich. In summary, the analysis shows that DriveNow users especially want to buy a car when they have a high

affinity to private cars. Additionally, with a start of a family, the purchase of a car is more likely. It cannot be confirmed that the use of carsharing is related to the planned car purchase.

5. Conclusions

The influence of carsharing on car ownership is versatile. For many people, carsharing is an important reason not to have a car in the household. Moreover, carsharing has great potential to bring current car owners to shed their car(s). An important condition in this case is good availability of carsharing vehicles. In discussion with some carsharing users, it became obvious that some car owners would under no circumstances renounce their own car. Especially for families – even in big cities – a private car seems to be absolutely necessary.

Looking at those persons who have already shed a car since joining carsharing, it is clear that among other reasons carsharing is often of high importance. A binary logistic regression showed that the frequency of use of carsharing and the increasing number of memberships in station-based carsharing providers have significant influence on whether people choose to shed a car.

When comparing the share of cars shed between DriveNow and Flinkster, differences become clear. Overall, more interviewed costumers from Flinkster have indicated that they have shed a car due to carsharing. Carsharing is rarely the main reason, but often plays an important role. It must be taken into account that Flinkster has been on the market for longer than DriveNow. In addition, the customers of Flinkster are older on average and are partly no longer in the period of starting a family. Furthermore, there are some DriveNow und Flinkster users who can imagine shedding private cars due to carsharing. But there are also a significant proportion of people – particularly at DriveNow – planning to purchase a car. This is especially true for car-savvy persons for whom a car ownership is very important.

To sum up, the empirical analyses illustrate that station-based and free-floating carsharing leads to a reduction of private cars. The combination of both carsharing systems (station-based and free-floating) in particular has the biggest impact on car ownership. Furthermore, carsharing tends to reduce car use. There are rare cases with an increase of car use since being member of a carsharing organization. In total the positive effects predominate by far. Thus, carsharing can be an important factor for sustainable urban mobility.

In order to maximize the positive effects of carsharing, more carsharing users of both carsharing systems are needed to make a private car redundant. Moreover, it is of central importance to reach additional user groups, such as women and elderly people with private car ownership, to gain higher shedding rates. In addition, the operated area of carsharing should be extended to reach more people (especially car owner) who live on the edge or outside the city. Further research (in particular longitudinal studies) is necessary to establish the long-term impacts of carsharing on car ownership.

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