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Shared vs. private e-scooters: Same vehicle – different mode? Empirical evidence on e-scooter usage in Germany

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Abstract

Various aspects of e-scooters as new mode of transport have already been discussed in science and society. However, little is known on differences between privately-owned and shared e-scooters regarding user characteristics and usage patterns. In this study, a large online survey is conducted to evaluate specific characteristics of the same vehicle in different usage contexts in Germany. It is seen that strong differences between the two groups exist. In particular, privately-owned e-scooters are characterized by longer trips and more frequent usage. On the other hand, e-scooters in sharing systems are combined much more often with modes of public transport. The substituted modes of transport strongly differ with private e-scooters replacing more car trips. The findings of the study help to understand obvious differences of e-scooter usage in different contexts.
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1. Introduction

In recent years, e-scooters became very popular in many cities all over the world (Hosseinzadeh, Algomaiah, Kluger, & Li, 2021). In prior research, several studies aim to quantify the potential of e-scooters to substitute car traffic and promote sustainable mobility (Gebhardt, Wolf, & Seiffert, 2021; Reck, Martin, & Axhausen, 2022). Other authors focus on the interrelation of e-scooters and public transport and the potential role of e-scooters as feeder for public transport, respectively (Gössling, 2020). In addition, various studies include live cycle assessment (LCA) to quantify environmental effects of e-scooters (de Bortoli & Christoforou, 2020; Reck et al., 2022)

Other studies use data recorded by operators of sharing systems or based on questionnaires to research trip patterns, usage behavior and the user itself (Caspi, Smart, & Noland, 2020; Hosseinzadeh et al., 2021). Given the nature of the

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data, these studies entirely focus on scooters in sharing systems. The big hype in the very beginning of the e-scooter as mode of transport was driven by sharing systems. But recently, market diffusion of private e-scooters increases and more and more privately-owned e-scooters are used (Haworth, Schramm, & Twisk, 2021).

Not many studies are aiming to differentiate private and shared usage patterns. Laa and Leth (2020) conducted a study differentiating between private owners of e-scooters and members in sharing systems in Vienna, Austria and delivered first valuable insights (Laa & Leth, 2020). Even though Vienna was one of the first cities to introduce e-scooters, this study was carried out in the early phase of the implementation and the sample size is limited and mainly consists of renters of e-scooters (Laa & Leth, 2020). In addition, Reck et al. (2022) deliver brief insight in modes of transport substituted by shared vs. owned e-scooters in Brussels and Zurich, respectively, but focus on LCA and environmental effects (Reck et al., 2022).

As known from other modes like bike sharing (Eren & Uz, 2020) or car sharing (Mueller, Schmoeller, & Giesel, 2015), in sharing systems, specific user groups, use cases and usage patterns can be observed. In addition, specific services and very small operating areas mainly limited to inner city areas are seen. These characteristics cause different conclusions and requirements of the mode of transport depending on weather shared or privately-owned (Hardinghaus, Seidel, & Anderson, 2019). Hence, these differences are important to evaluate. Bieliński and Ważna (2020) analyze differences between user and trip characteristics of e-bike sharing, and e-scooter sharing systems in Tricity, Poland (Bieliński & Ważna, 2020). Reck and Axhausen (2021) compare user characteristics of shared dockless e-scooter users, shared dockless e-bike users and shared docked (e-)bike users in Zurich, Switzerland (Reck & Axhausen, 2021).

Still research is needed regarding the entire context of use, including socio-demographics and usage patterns of e-scooter users, especially differentiating between privately-owned scooters and such in sharing systems (Gebhardt et al., 2021; Smith & Schwieterman, 2018). Only detailed view can help to gain an understanding of this new mode of transport and set the foundation for further valid potential analyses and an assessment of market. As seen, studies evaluating differences between private and shared use of e-scooters are rare and based on small sample size or constrained observation areas (Laa & Leth, 2020).

Hence, in this paper we focus on the behavior of both, private owners of e-scooters and users of scooters in sharing systems. We aim to compare individual characteristics of users and usage behavior. In order to do so, we conduct an online survey and present the results.

The paper is structured as follows. First, we describe the conceptualization of the online survey as well as the recruitment. Second, we describe subsampling and analyses. Third, we describe the results with focus on individual and trip-related issues of both, sharing users and private owners. Then, we discuss the results and draw conclusions.

2. Materials and Methods

2.1. Survey conceptualization and design

For this study, a Germany-wide online survey on the topic of e-scooters in road traffic was conducted in spring 2021. The questionnaire covers a wide range of questions on general mobility options and behavior, e-scooter usage, opinions on e-scooters in cities, experiences with potentially conflicting interactions between e-scooter users and pedestrians or cyclists, and socio-demographic information. First, availability and frequency of use of several private and sharing transport modes are queried. Based on this information, e-scooter users and non-users are filtered in order to ask separate questions to each sub-group (see 2.2).

The survey was available online between mid-April and mid-June, 2021. It was open to all interested persons. Both, e-scooter users and non-users participated. The link to the survey was widely publicized via social media, newsletters and disseminators. In addition, participants were recruited through a cooperation with an operator of e-scooter sharing. During the survey period, a link to the survey was displayed in the app for the duration of one week after a trip.

2.2. Sample description

The basis for defining the sub-groups is the reported frequency of use of sharing and private e-scooters according to the following classification: daily or almost daily; 1-3 times a week; 1-3 times a month; less frequently than monthly; never or almost never. A person who uses a shared or a private e-scooter (even if only ‘less frequently than

monthly') is defined as an e-scooter user. If a person (almost) never uses a shared and at the same time (almost) never uses a private e-scooter, he/she is classified as a non-user. Hence, by definition, users and non-users in the data set are distinct. Contrary, overlapping between sharing and private users is possible. The classification of the reported frequency is in accordance with the representative German National Household Travel Survey 'Mobility in Germany' ('Mobilität in Deutschland', MiD), last conducted in 2017 (Nobis & Kuhnimhof, 2018). The MiD data are also used in the following as a comparison for socio-demographic characteristics of the sample as well as the survey results for sharing and private e-scooter users.

Referring to this delimitation of the group of e-scooter users, 1,226 of the 3,834 participants in the survey were e-scooter users. Thereof, 1,031 participants state that they use shared e-scooters, 372 persons use a privately-owned e-scooter. Accordingly, 177 participants are experienced in using both.

The subsample of e-scooter users in our study shows a clear focus on the group of young adults. Compared to the German population, the age groups 18 to 29 years (e-scooter users: 38.7 %; MiD: 14.2 %) and 30 to 39 years (e-scooter users: 28.1 %; MiD: 12.3 %) are particularly highly-represented in the sample. There is a relatively large deviation in the gender ratio in the group of e-scooter users with an overrepresentation of males over females (males: 74.6 %; females: 24.5 %; diverse: 0.8 %). They live primarily in households with three or more persons (e-scooter users: 39.4 %; MiD: 24 %) or in two-person households (e-scooter users: 37.1 %; MiD: 34 %) whereas one-person households are less represented (e-scooter users: 23.5 %; MiD: 41 %). Participants are predominantly employed (80.7 %) and have a high level of education (graduate degree: 39.6 %). In the MiD, the proportion of employed persons is significantly lower (48 %), as schoolchildren and retired persons are more strongly represented in line with the age distribution. The share of higher education degree is 21 %, and 32 % in large cities, respectively (Nobis & Kuhnimhof, 2018). Places of residence of e-scooter users participating in the survey are spread throughout Germany with a concentration in large cities, consistent with the existence of e-scooter supply and corresponding age groups. Berlin accounts for the largest number with 102 participants. Therefore, in the comparison with MiD, data for large cities with at least 100,000 inhabitants are used where appropriate.

3. Results

3.1. Socio demographic characterization of users of shared and privately-owned e-scooters

With regard to age, it can be noted that the sharing users are even younger than the private users (average age: sharing users: 33.4 years; private users: 37.5 years), complementary to the general characterization of the e-scooter users. Among sharing users, 18-to-29-year-olds are the largest group at 43.5 % while among private users, 30-to-39-year-olds are the most represented at 30.5 %. Accordingly, the proportion of schoolchildren and students is also significantly higher among sharing users (sharing users: 13.7 %; private users: 3.0 %), while the proportion of professionals is particularly high among private users (sharing users: 78.1 %; private users: 87.1 %). Nevertheless, a significantly higher proportion of sharing users have already obtained a graduate degree (sharing users: 41.8 %; private users: 24.9 %). With regard to gender, the high proportion of men in the sample is particularly pronounced among private users (sharing users: 74.2 %; private users: 79.9 %).

3.2. Characteristics of e-scooter trips

Frequency of use and trip duration

Regarding frequency of use, about one third of sharing e-scooter users rent an e-scooter at least once a week (Fig. 1). In contrast, nearly three-quarters of owners use their private e-scooter at least once a week, and more than one third (37.1 %) use it even on a daily basis. This shows the different importance of sharing and private e-scooters in the everyday mobility behavior of the users.

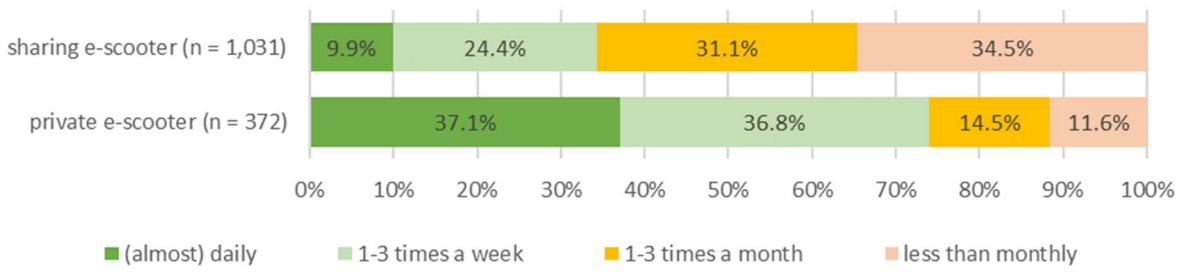

Fig. 1. Frequency of use of sharing and private e-scooters. Source: own data, 2021.

Fig. 2 shows the accumulated trip duration for trips with shared and private e-scooters. It is seen that trips with private e-scooters are longer than trips with sharing e-scooters. The mean duration is 16 minutes for shared e-scooters and 34 minutes for private e-scooters. More than half of the reported trips with shared e-scooters (55.9 %) are rather short with up to ten minutes. In contrast, the duration of the reported trips with private e-scooters is rather equally distributed. Only 23.4 % of these trips last up to ten minutes, 11.7 % even exceed one hour.

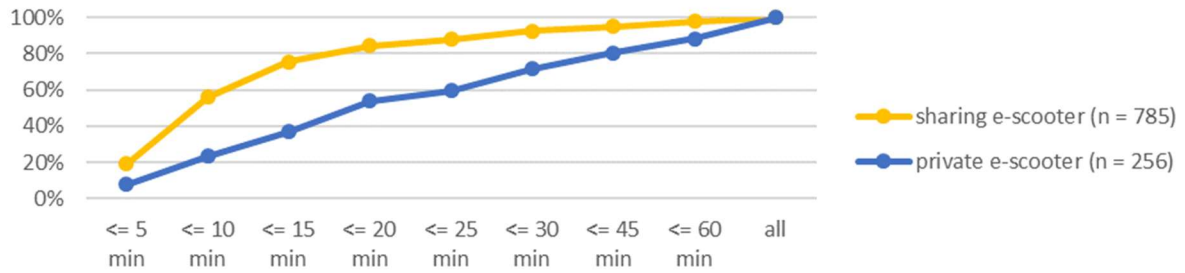

Fig. 2. Accumulated trip duration with shared and private e-scooters referring to last trip. Source: own data, 2021.

Trip purposes

Shared e-scooters are predominantly used for leisure trips (26.5 %), private errands (23.1 %), trips to work (17.2 %), and less often for shopping (7.9 %). Private e-scooters are used much more frequently on trips to work (30.9 %) and for shopping (14.9 %), while their use for leisure trips (19.8 %) and private errands (16.8 %) is less popular. The trip purpose 'just for fun' is significant in both groups (sharing users: 13.2 %, private users: 11.8 %).

Compared to trip purposes in the representative German mobility study MiD (Nobis & Kuhnimhof, 2018), the share of trips with shared e-scooters to work and leisure activities corresponds approximately to the average of all modes in the MiD, while trips for private errands are much more frequent. With private e-scooters, share of trips for shopping and private errands match well with MiD data for all modes, whereas trips to work are far exceeded. The trip purpose 'just for fun' was not gathered in MiD survey.

E-Scooter usage and public transport

In some cases e-scooters are used as a feeder mode to public transport. Nearly one quarter (23.6 %) of trips with a shared e -scooter led to or from a public transport stop. For trips with private e-scooters, this combination with public transport is much less popular (14.5 % of all trips).

Fig**.** 3 shows the individual changes in use of public transport since using e-scooters. It can be seen that many participants use public transport significantly less often compared to the time before their e-scooter use (**Fig.** 3). Comparing users of shared and private e-scooters, people who have their own e-scooter are even twice as likely to say that they now use public transport 'much less frequently' (sharing users: 19.9 %; private users: 39.1 %). In contrast, nearly half of sharing users (sharing users: 46.0 %; private users: 30.9 %) say that the frequency of their public transport use has not changed.

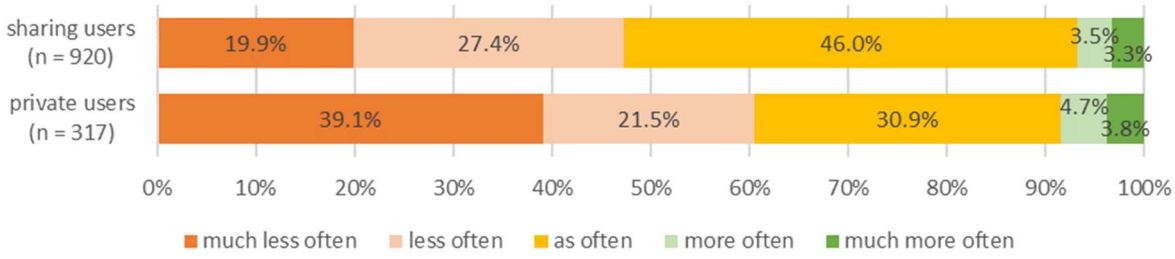

Fig. 3. Personal assessment of change in public transport use since using e-scooters. Source: own data, 2021.

Substituted modes

Participants of the survey also stated the mode of transport they would have used on their last trip with an e-scooter if the e-scooter would not have been available. Regarding these substituted modes of transport, large differences can be observed between the two groups of e-scooter users (Fig. 4). For privately owned e-scooters, one third (34.4 %) of all trips reported replace a car trip, while for shared e-scooters this refers to 11.2 % of all trips reported. In contrast, trips with sharing e-scooters replace trips on foot significantly more often (sharing users: 42.8%; private users: 20.7%). The question arises to what extent this is related to the available means of transport - in particular the availability of a private car - and less to the type of e-scooter. A differentiated analysis shows that, as expected, people with access to private cars in both groups replaced car trips significantly more often and public transport trips less often than people without access to private cars. However, also when analyzing people with access to private cars only, the proportion of replaced car trips is significantly higher for private e-scooter users (48.8 %) than for sharing e-scooter users (20.1 %). For users of sharing e-scooter, car availability also does not affect the amount of replaced walking trips.

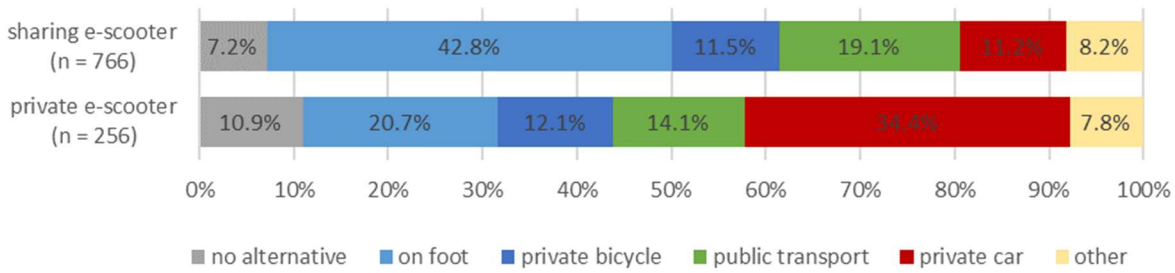

Fig. 4. Substituted mode of transport on last trip with an e-scooter. Source: own data, 2021.

The reported reasons for preferring the e-scooter instead of another mode of transport are diverse and depend on the mode replaced. In general, by far the most important reasons were ‘less time spent’ (50.5%) and ‘more fun’ (46.0%), followed by ‘direct route (door to door)’ (22.6%) and ‘more flexibility’ (20.2%). Significant differences can be identified in many of the stated reasons between users of private e-scooters and users of sharing e-scooters, each of which can be attributed to the different modes of transportation replaced. Private users, who replaced car trips to a large extent as previously described, are significantly more likely to cite the following reasons for e-scooter use: ‘lower costs’, ‘no need to find a parking space’, ‘sustainability / environmental friendliness’, ‘more physical activity / fresh air’, and ‘avoiding traffic jams’. In contrast, sharing users, who overall tended to replace trips on foot, particularly frequently cite ‘less time spent’ as an advantage of the e-scooter.

4. Discussion

The present study provides empirical evidence on user characteristics and usage patterns of e-scooters in Germany. In particular, we focus on differences between shared and privately-owned vehicles. Overall, the observed user

characteristics in this study are consistent with insights from literature: across various countries, e-scooter users are rather young, male, employed and in most studies have a high education (Bieliński & Ważna, 2020; Gebhardt, Wolf, & Seiffert, 2021; James, Swiderski, Hicks, Teoman, & Buehler, 2019; Krier, Chretien, & Louvet, 2019; Laa & Leth, 2020; Smith & Schwieterman, 2018). Our study specifies differences between users of shared and privately-owned e-scooters. For example, sharing users are even younger and use more sustainable transport modes in general.

Regarding trip characteristics, major differences between the two groups of interest are evident. In comparison to private e-scooters, shared e-scooters are used less often, for shorter trip durations, for different trip purposes, and as a consequence substitute different transport modes. The tendency of private e-scooters showing more trips, diverse purposes, and more substituted car trips is supported by earlier research (Laa & Leth, 2020; Reck et al., 2022).

The shorter trip duration of shared e-scooters is in line with data from sharing operators (Caspi et al., 2020; Heumann et al., 2021; Hosseinzadeh et al., 2021; Jiao & Bai, 2020; Liu et al., 2019). Leisure purposes play a major role particularly in sharing trips (26.5 % or 39.7 % aggregated with trip purpose 'just for fun'). The significant number of trips 'just for fun', indicating that e-scooters are not only used as a means of transport but also as a toy or leisure equipment, was also found comparably high at about 10 % in prior studies (Krier et al., 2019). Regarding trips to work, the most important purpose for trips with privately-owned e-scooters (30.9 %) in our study, other studies show a wide range of proportions, ranging from 20 % to more than 50 % (Gebhardt, Wolf, & Seiffert, 2021; Krier et al., 2019; Smith & Schwieterman, 2018). In contrast to several prior studies finding e-scooters being mainly used for leisure and recreation (Badia & Jenelius, 2021; Bai & Jiao, 2020; Liu et al., 2019; McKenzie, 2019) or concluding no utilization for commuting (McKenzie, 2019), the present study finds diverse trip purposes and a large share of commuting trips. Comparing the trip purposes observed to national travel survey data (Nobis & Kuhnimhof, 2018) reveals, that e-scooters are used for a broad cross section in transport and differences to average mobility purposes are smaller than earlier research suggests (Bai & Jiao, 2020; Liu et al., 2019; McKenzie, 2019). Possible explanations for varying findings are spatial and temporal: Most cited studies originate from the US with a different mobility system and from the early phase of the establishment of e-scooters.

E-scooters are often discussed as one component for multimodal sustainable mobility and as a feeder mode to public transport (Gössling, 2020). Sharing e-scooters offer greater flexibility in renting and parking at the starting point and destination, making it easier to combine these with public transport. The proportion of intermodal trips with e-scooters and public transport in our study lies in the same range as in others (Gebhardt, Wolf, & Seiffert, 2021; Krier et al., 2019; Smith & Schwieterman, 2018). The participants report a significantly lower overall use of public transport since they use e-scooters. Various reasons are feasible for that (e.g. the influence of the Corona pandemic), but cannot be derived from the survey. On the other hand, e-scooters (especially private ones) replace car trips to a significant amount. In this context, earlier research sees e-scooters as an enabler for public transport commuting trips as the scooters improve public transport connectivity (Heumann et al., 2021).

The mode replaced by an e-scooter differs greatly between shared and privately-owned e-scooters. Modeling results from a study in Zurich confirm that sharing e-scooters replace walking trips more often (sharing: 51 %, private: 35 %) and private car trips less often (sharing: 12 %; private: 17 %) compared to private e-scooters (Reck et al., 2022). Findings from other studies more focus on differences between the US and the European context (Gebhardt et al., 2021; Smith & Schwieterman, 2018). The rather low number of car trips replaced by sharing e-scooters was also ascertained in a study in France (8 %), whereas replacement of public transport modes was observed to be higher (30 %) than in our study (Krier et al., 2019). Overall, studies from European cities (Paris, Oslo, Vienna) show that sharing e-scooters mainly replace trips on foot (35-60 %) or public transport (23-37 %) and less frequently trips by car (8-16 %) (Christoforou, de Bortoli, Gioldasis, & Seidowsky, 2021; Fearnley, Johnsson, & Berge, 2020; Laa & Leth, 2020). The results on the mode replaced by an e-scooter raise some questions to be investigated in more detail, for example correlations with the different trip purposes, and trip lengths as it is reasonable to assume that e-scooter trips that replace car trips are longer than those replacing other modes. Further research similar to recently published studies, e.g. Reck et al. (2022) is needed to evaluate interrelations between user characteristics, replaced modes of transport and the related emissions (Reck et al., 2022).

It becomes obvious that the data on e-scooter trip purposes is still very diverse and may depend on the study area. Our study with a high number of participants across Germany and differentiated by shared and privately-owned e-scooters therefore makes an important contribution to this debate. The following limitations of the survey need to be considered when interpreting the results and highlight further opportunities for future research. The survey period was

during times of Corona and terminating lockdown in Germany which suggests a potential influence on the user behavior of e-scooter users (e.g. less trips in general, avoidance of public transport, fewer foreign tourists). At the same time, the provision of e-scooter sharing continues to be very dynamic and varies between cities. Further, the sample is self-selective and not representative. Hence, some user groups of e-scooters are probably underrepresented. Given the user recruitment via social media and newsletters, a sample bias is likely and differences to national travel survey data may to some extent caused by this bias. Therefore, it is required to conduct further empirical research on e-scooter users and their behavior against the background of current and local developments and with different methods, including qualitative approaches. Particularly, studies on private e-scooters are missing.

5. Conclusions

The present study provides a multifaceted overview on e-scooter usage in Germany. Differences between user characteristics and usage patterns of sharing and private e-scooters are revealed based on a substantial sample. The main findings of the study are as follows:

Regarding user characteristics, trip lengths and trip purposes, e-scooter usage appears diverse. A large share of e-scooter trips is commuting trips, especially for privately-owned scooters. In addition, a significant share of all trips is done “just for fun”. Many scooter trips replace car trips, especially in case of privately-owned scooters. Trips with shared e-scooters are significantly shorter than such with private e-scooters.

The relation between e-scooters and public transport appears complex: A considerable part of e-scooter trips replaces public transport trips. In contrast, on a similar share of trips, the e-scooter is used as a feeder for public transport. In addition, a large share of users states to use public transport less often since using e-scooters. More research is needed to carefully evaluate the impact of e-scooters in this context.

Gathering the data and exploring e-scooter usage in the present contribution opens up possibilities for further research. Future work of the authors will focus on substituted modes of transport, the interrelation with public transport and the related environmental impact. In addition, special attention will be paid to the conflicts experienced by users of e-scooters and other road users.

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