# Exploring the Potential of *Free Cargo-Bikesharing* for Sustainable Mobility

*Sophia Becker, Clemens Rudolf*

*How can cities solve the pressing environmental problems caused by the excessive use of private cars? By creating* Free Cargo-Bikesharing *systems, citizens are taking forward the transition to sustainable transportation systems.*

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**Abstract**

Shifting user behavior from private car use to low-carbon mobility routines is a crucial factor in the transition to sustainable cities. A cooperative network of 46 *Free Cargo-Bikesharing* operators *(Freie Lastenräder)* with 9,750 registered users has grown rapidly within the last four years in Germany and Austria. However, little is known about the characteristics and usage behavior of these early adopters. Moreover, we still lack even a rough estimate of the ecological impact of cargo-bikesharing. In order to address these questions, we co-created an empirical survey among users ($n = 931$) in a transdisciplinary cooperation with 30 *Free Cargo-Bikesharing* operators. Results show that 46 percent of respondents maintain that they would have made the trip by car in the absence of a cargo-bikesharing operator, indicating the high potential of cargo-bikesharing to reduce car usage. We recommend that municipal policymakers support cargo-bikesharing in two ways: 1. by complementing existing bikesharing systems with cargo bikes, and 2. by supporting local initiatives for citizen engagement in cargo-bikesharing.

**Keywords**

cargo bikes, cargo-bikesharing, mobility behavior, shared mobility, sustainable urban mobility

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Today, most European cities face the challenge (and opportunity) of transforming themselves into sustainable cities. The transport sector represents one of the most difficult fields within this context. Extensive private car use and ownership in German cities causes not only $CO_2$ emissions but also noise, space issues, and serious air quality problems. The German government is undertaking huge efforts to support the diffusion of electric vehicles via a top-down approach, for example, by incentivizing the purchase of electric cars (BMWi 2016). However, many cities are looking beyond the substitution of fossil-fuel-based technologies and wish to bring about a change in the behavior of city dwellers, mainly through an overall reduction in individual car ownership and use.[1] The support for urban carsharing and the wide adoption of municipal or public-private bikesharing systems are just two examples of numerous efforts towards the adoption of new low-carbon mobility behaviors. Despite the popularity of classic bikesharing, there is currently no scientific consensus on whether it has considerable reduction effects on car use or not (Fishman et al. 2013, Shaheen et al. 2010, Zademach and Musch 2016).

Meanwhile, citizens are also taking action and experimenting with innovations for sustainable mobility via a bottom-up approach. For example, a network of 46 urban cargo-bikesharing operators has evolved in Germany and Austria since 2013. Together, these *Free Cargo-Bikesharing* (in German: *Freie Lastenräder*) operators provide free access to a total of 40 electric and 94 non-electric cargo bikes, and their membership has grown to 9,750 registered users within the last four years (status as of 31 December 2016, own data collection). These users can be considered "early adopters" because they adopt cargo-bikesharing at a very early stage of its diffusion (Rogers 2003). In sum, this new mobility service seems to meet the important individual need to transport "cargo" (e.g., bottle crates, foodstuffs) within cities. In Germany, one fifth of all private trips are trips with potential cargo-transportation needs, such as shopping or service rides (e.g., bringing children to kindergarten), according to Weiß et al. (2016).

However, a systematic assessment of cargo-bikesharing in terms of user population and future potential to reduce private car use

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has not been conducted to date. Consequently, local governments lack guidance on whether they should support these initiatives – or whether they should even consider setting up cargo-bikesharing schemes themselves.

Our aim is to provide fundamental knowledge about the bottom-up mobility innovation of *Free Cargo-Bikesharing* and to explore its potential for sustainable urban mobility. To this end, we first describe the concept of *Free Cargo-Bikesharing*. We then present current developments and report on the findings of a quantitative survey ($n = 931$) of *Free Cargo-Bikesharing* users. Finally, we draw conclusions from our data and make policy recommendations.

## Evolution and Concept of Cargo-Bikesharing Systems

The current system of *Free Cargo-Bikesharing* emerged around 50 years after the first classic bikesharing system (Shaheen et al. 2010). However, the history of cargo bikes as a means of transport actually dates back to the beginning of the 20th century (Ghebrezgiabiher and Poscha-Mika 2018). They were especially popular from the 1920s through to the 1950s for postal delivery and among small businesses (Basterfield 2011).

In general, a cargo bike (also known as a transport bike, bakfiets, carrier cycle, box bike) is a bicycle designed and constructed specifically for transporting loads and children. Cargo bikes are available in different shapes (e. g., three-wheeled/two-wheeled), sizes, and fit-outs such as electric pedal-assist systems (figure 1). In this study we also treat large bicycle trailers[2] as cargo bikes because they serve the same purpose of transporting loads and they are offered by some of the *Free Cargo-Bikesharing* operators.

Several developments have fostered the recent resurgence of the cargo bike as an emission-free[3] means of transport: the envi- >

1 In addition, the recent decision of the Federal Administrative Court to allow bans to be imposed on older diesel cars in cities will increase the pressure to find acceptable alternatives to car transportation.

2 These trailers are big "cargo" trailers such as the model *Carla Cargo*, not conventional trailers with seats to transport children.

3 In this study, electric cargo bikes are considered "emission-free" vehicles, because the vast majority of the *Free Cargo-Bikesharing* initiatives use renewable energy to charge the electric cargo bikes. For a more detailed discussion of electric bikes and their environmental impact see Wachotsch et al. (2014).

**FIGURE 1:** Free cargo bikes in Stuttgart, Germany: in the center, one of the most common models of cargo bikes – a two-wheeled *Long John* (in combination with an additional trailer), to the left, a three-wheeled cargo bike with an orange box.


© Blattkunst/Universität Stuttgart *Reallabor für nachhaltige Mobilitätskultur* ronmental and climate crises and the livable city movement on the one hand, and the development of new technologies such as electric motor-assist systems with Li-ion batteries and new digital open-source booking software for collaborative use on the other (Zademach and Musch 2016).

Over the last four years, a network of over 46 independent *Free Cargo-Bikesharing* operators has evolved in Germany and Austria.[4] The *Free Cargo-Bikesharing* scene is characterized by the following five features:

1. The operators provide cargo bikes to everyone; no formal membership of an organization or business is required.[5]
2. The idea that cargo bikes are common goods: that explains why the operators do not charge their users any obligatory rental fee but ask for donations (to maintain the bicycles) or voluntary participation and engagement. Users thus become co-producers; their motivations, knowledge and abilities are now part of the service (Quilligan 2012).
3. Civil society actors (individuals or associations) are the initiators and operators of most *Free Cargo-Bikesharing* systems. They acquire funding for the cargo bikes, for example, via crowdfunding. In a few cities, local municipalities are also involved.
4. Good use of online information and communication technology: most *Free Cargo-Bikesharing* operators use the *Commons Booking* software developed by the voluntary organization *wielebenwir e.V.* (Cologne, Germany) to organize the rental process. This digital mediation platform for private parties was a key factor in the successful development of the *Free Cargo-Bikesharing* scene.
5. Most operators work with "hosts" for the cargo-bike rental process, typically shops that are accessible at fixed times, where the cargo bike is handed over to the user in a personal transfer situation. In most cases, the operators recruit a suitable voluntary host; this can be a café, a small food shop, a kindergarten or a university institution, for example. To increase diffusion, several operators organize a rotation of hosts within their city (e.g., a new host for the same cargo bike every month).

Recently, much attention has been paid to the substitution of cars by electric cargo bikes in the context of inner-city courier deliveries and commercial transport in Germany (Athanassopoulos et al. 2015, Gruber et al. 2014, VCD 2017). However, national authorities have not yet actively promoted the use of cargo bikes as an alternative to private car use, even though the results of initial studies on *privately-owned* cargo bikes are encouraging: they enable users to transport children and loads and to considerably reduce the number of car trips they make, as shown by Riggs (2016) in his survey of new cargo bike buyers in California (USA).

Nevertheless, on a municipal level, some cities and districts are funding the purchase of cargo bikes for commercial and private use/ownership to a varying degree (in some cases covering up to one third of acquisition costs). Currently, 15 cities or municipalities in Germany, Austria, and Switzerland provide financial support for the acquisition of a cargo bike (Behrensen 2017). In some cities, this support is only granted to applicants that operate sharing systems or other collective access models. While municipal subsidies for shared cargo bikes are a rather new development, the existing network of 46 *Free Cargo-Bikesharing* operators in Germany and Austria already constitutes a testing field to gain systematic insights and learn valuable lessons. With the present study we want to develop these insights and make them more widely known using a transdisciplinary approach.

## Transdisciplinary Approach

According to Lang et al. (2012), an ideal-typical transdisciplinary (td) research process can be divided into three phases: 1. problem framing and team building, 2. co-creation of solution-oriented transferable knowledge, and 3. (re-)integration and application of created knowledge. In what follows, we briefly describe how we implemented this ideal-typical process in the field of cargo-bikesharing.

### *Phase 1:* Pilot Study and Forming the Transdisciplinary Research Team (January to June 2016)

The core td research team was formed within the *Real-World Laboratory for a Sustainable Mobility Culture (Reallabor für nachhaltige Mobilitätskultur,* Parodi et al. 2018) at the University of Stuttgart, Germany. It consists of the two authors of this paper, with the first author bringing her social science background, and the second author contributing his network and practical expertise as co-founder of the *Free Cargo-Bikesharing* initiative in Stuttgart. Together, we first developed and implemented a pilot survey with the *Free Cargo-Bikesharing* initiative in Stuttgart that served as a pre-test. To extend the research team, we held a first workshop at the annual meeting (June 2016, in Wuppertal, Germany) of the *Forum for Free Cargo-Bikesharing (Forum Freie Lastenräder)*, a network that serves as collaborative platform for the various *Free Cargo-Bikesharing* initiatives in German-speaking countries. In this workshop, we presented the results of the pilot study and discussed the survey design as well as the general problem framing. In sum, the "societal" problem framings emerged as (A) "What is the positive environmental impact (i.e., reduction of $CO_2$ emissions) of using cargo bikes and how could that knowledge be used for proposals to get public funds or donations for shared cargo bikes?" and (B) "How can initiatives gain more visibility and support?", while the "scientific" research problems were (C) "What specific user groups are currently adopting cargo-bikesharing?" and (D) "What is the environmental and behavioral potential of cargo-bikesharing for sustainable mobility in cities?".

4 In several Swiss cities, the operator *Carvelo* also provides cargo-bikesharing services for a rental fee (albeit relatively small). Strictly speaking, *Carvelo* is not part of the commons-oriented *Free Cargo-Bikesharing* landscape. The same holds true for the pilot project *TINK* in Germany.

5 There are also cargo-bikesharing systems with restricted user groups (e.g., the residents of a particular housing block). These closed cargo-bikesharing systems are not part of our study.

In this article, we focus on the research questions formulated in (C) and (D), because we think that (D) incorporates (A). While we do not consider it our main goal to help the initiatives gain more visibility (B), this might be a side effect of our study. Thus, the overall matching of the societal problem framings with the scientific research problems was feasible, and a common understanding and goal for the td research endeavor could be identified (Lesjak et al. 2014). At the end of the workshop, most initiatives committed themselves to collaborating with us.

#### *Phase 2:* Collaborative Study with 30 *Free Cargo-Bikesharing* Initiatives (July to December 2016)

After integrating the comments and supplementary questionnaire items that we collected in workshop 1, we carried out an online survey for the users of those initiatives that had promised to collaborate. In addition, we sent out invitations to all those initiatives that had missed the annual meeting via the email list of the *Forum for Free Cargo-Bikesharing*. In order to ensure concrete benefits for the cooperating initiatives (Di Giulio et al. 2016), we offered every initiative the opportunity to add up to three items to the city-specific part of their questionnaire. In addition, we pledged to send them the raw data file for their city. In total, 30 *Free Cargo-Bikesharing* initiatives (out of 46) collaborated with us by sending the city-specific survey link to their registered users via email. At the same time, we tried to get information on the (partially estimated) number of registered users in all initiatives via separate emails.

#### *Phase 3:* Discussing and Disseminating the Results (January to October 2017)

After integrating, cleaning, and analyzing the empirical data, we presented the results in workshop 2 at the next annual meeting of the *Forum for Free Cargo-Bikesharing* (July 2017 in Essen, Germany). Here, the initiatives commented on and interpreted the results of the survey. This allowed us to benefit from their practical and local expertise and integrate their knowledge (Lesjak et al. 2014). As the format and timing of academic publications do not always serve practical needs (Di Giulio et al. 2016), we decided to publish an open access *Fact Sheet* in German on the *Forum*'s wiki within a week of the annual meeting. This *Fact Sheet* (Becker and Rudolf 2017) outlined the most important results, highlighting reduced car usage and avoided $CO_2$ emissions in particular. In this way, the initiatives were able to use the results in new funding applications, award applications,[6] and public relations materials. The present paper will disseminate the results to a scientific and transdisciplinary community.

## Methods

We gathered quantitative data on the operators, their cargo bikes, and the number of registered users via direct personal contact with each operator (email or phone). In parallel, we designed the online questionnaire for our user survey using the web-based survey software *Typeform*. The questionnaire contained 46 items, mostly in a multiple-choice or *Likert* scale format. Three items were open-ended questions. The items covered aspects like usage experience ("How often have you used a cargo bike to date?"), usage behavior ("What distance did you cover in the course of your main cargo-bike tour? The main tour means the tour that was your main reason for borrowing the cargo bike"; "In the absence of a cargo-bikesharing service, how would you have made your trip?", single choice), purposes ("What did you transport with the cargo bike?", multiple choices), infrastructure perceptions ("What, in your experience, are the main obstacles to cargo biking in your city?", multiple choices), future use and purchase intentions ("Do you intend to use a cargo bike again in the future?" and "Do you intend to purchase a cargo bike in the medium to long term?", both on a 5-point *Likert* scale ranging from 1 = "no" to 5 = "yes"), environmental and air quality concerns ("How concerned are you about climate change?" and "How concerned are you about air quality in your city?", on a 5-point *Likert* scale ranging from 1 = "not concerned at all" to 5 = "very concerned"), as well as sociodemographics (age, gender, family and job situation) and reports on daily travel behavior (main mode of transport). A total number of 931 *Free Cargo-Bikesharing* users participated in our survey. They represent ten percent of all registered users (9,750 in total, see table 1, p. 160). The response rate was 12.3 percent, since solely the users (7,600) of the 30 operators that participated in the study could be contacted (see table 1).

## Results

We first present data on the status quo of the *Free Cargo-Bikesharing* landscape by way of a *quantitative overview* of the operators, their cargo-bikesharing services, and the number of their registered users. We then reveal the results for our first research question "What specific user groups are currently adopting cargo-bikesharing?" by describing the *user characteristics*. Finally, we present the results for the second research question "What is the environmental and behavioral potential of cargo-bikesharing for sustainable mobility in cities?" by reporting data on actual *usage behavior,* future behavior *intentions,* and on the estimated reduction effect of cargo-bikesharing on car use *(impact)*.

#### Status Quo: Quantitative Overview of the Current *Free Cargo-Bikesharing* Operators and Their Users

Table 1 shows the names as well as the size of the 30 F*ree Cargo-Bikesharing* operators that participated in the present study (65 percent of the total). Among these, the 13 sharing operators that each provided at least 27 survey respondents are listed with details of their cargo-bike portfolios. In this sample, a total of 99 cargo bikes and trailers are available, of which slightly less than a >

6 The *Forum for Free Cargo-Bikesharing (Forum Freie Lastenräder)* was awarded the German local sustainability prize *ZeitzeicheN* 2017 in the category *Climate Protection and Climate Adaption*.

**TABLE 1:** Quantitative overview of the participating *Free Cargo-Bikesharing* operators and number of survey respondents as of 31 December 2016. Source: own data collection via direct contact with the respective operators.

| CITY | NAME OF THE *FREE CARGO-BIKESHARING* OPERATOR | REGISTERED USERS | SURVEY PARTICI-PANTS | CARGO BIKES (TOTAL) | ELECTRIC CARGO BIKES | 2-WHEELED CARGO BIKES | 3-WHEELED CARGO BIKES | TRAILERS |
|---|---|---|---|---|---|---|---|---|
| **Hannover** | *Hannah* | 1,360 | 214 | 13 | 6 | 12 | 1 | 0 |
| **Cologne** | *Kasimir* | 1,062 | 94 | 5 | 0 | 3 | 2 | 0 |
| **Munich** | *Freie Lastenradler* | 718 | 106 | 9 | 2 | 5 | 4 | 0 |
| **Hamburg** | *Klara* | 675 | 48 | 1 | 0 | 1 | 0 | 0 |
| **Vienna** | *Lastenrad-Kollektiv* | 400[a] | 34 | 16 | 0 | 9 | 2 | 5 |
| **Stuttgart** | *Freies Lastenrad* | 362 | 91 | 6 | 5 | 4 | 1 | 1 |
| **Berlin** | *Freie Lastenradler* | 354 | 39 | 3 | 0 | 1 | 2 | 0 |
| **Freiburg** | *LastenVelo* | 347 | 43 | 5 | 0 | 3 | 2 | 0 |
| **Dresden** | *Frieda und Friedrich* | 192 | 45 | 4 | 1 | 3 | 1 | 0 |
| **Düsseldorf** | *Schicke Minna* | 121 | 28 | 2 | 0 | 1 | 1 | 0 |
| **Bonn** | *Bolle* | 120[a] | 27 | 1 | 0 | 0 | 0 | 1 |
| **Ruhr Area** | *Rudolf* | 119 | 29 | 3 | 0 | 2 | 1 | 0 |
| **Münster** | *Lasse* | 106 | 39 | 1 | 1 | 1 | 0 | 0 |
| **16 other cities** | 17 other operators[b] | **1,664**[a] | 94 | 30 | 15 | 14 | 12 | 4 |
| **29** | **30** | **7,600**[a] | ***n* = 931** | **99** | **29** | **59** | **29** | **11** |
| | 16 non-participating operators | **2,150**[a] | | **35** | **11** | **unknown** | **unknown** | **unknown** |
| | | **total: 9,750** | | **134** | **40** | | | |

a partially estimated numbers (source: the respective operators) | b $n < 27$ survey participants each

third are electric cargo bikes. The majority (60 percent) are two-wheeled cargo bikes, while 29 percent are three-wheeled cargo bikes and eleven percent are trailers.

## User Characteristics: Sociodemographics, Level of Experience, First Contacts

The mean age of respondents is 38 years and the age distribution is heterogeneous (standard deviation [SD] = 11.5; range: 14–76). Similarly, the life situation of the respondents is heterogeneous. A third (31 percent) of respondents' households have children (under 18 years old), a quarter (25 percent) of users live as a couple without minors, while a fifth (22 percent) of users live in shared flats, and 17 percent live in a one-person household (remaining five percent: no answer [NA]). The majority (63 percent) of respondents are men, 35 percent are women (two percent: NA). The sample is homogenous with regard to environmental attitudes: 92 percent of respondents are "rather" or "very concerned" about climate change and 84 percent feel the same about air quality.

With regard to the main mode of transport, the sample is characterized by a large proportion of cyclists: a majority of users (71 percent) name the bicycle as their daily means of transport (69 percent non-motorized bicycle, two percent electric bicycle), while 13 percent mainly use public transport, and six percent mainly use a car. A further six percent of respondents indicate that they are flexible users, who switch and combine different modes of transport on a regular basis (multimodal users). Only three percent of respondents indicate that walking is their main mode of transport.

When asked about their previous level of experience of cargo bikes, about two thirds (69 percent) of respondents turned out to be inexperienced users (first to third time using a cargo bike), while 14 percent indicated that they already had some experience of cargo bikes (fourth to seventh time using a cargo bike), and 17 percent were advanced users who have used cargo bikes eight times or more. This highlights the novelty of this mobility option and shows that a lot of users first come into contact with cargo bikes via the *Free Cargo-Bikesharing* operators.

To investigate how the diffusion process for the new mobility service provided by *Free Cargo-Bikesharing* worked, we coded respondents' free text answers to the question of how they first made contact with the sharing operator. Results show that a vast majority of users first came into contact with cargo-bikesharing through personal contacts, work colleagues, and acquaintances in associations (368 mentions). The internet and social media were also significant points of contact (290), followed by the presence of cargo bikes at stations in the urban landscape (147) and classical media coverage on cargo-bikesharing (112).

## Usage Behavior

As figure 2 illustrates, the shared cargo bikes are mainly used for errands where users need considerable transport capacity. Food

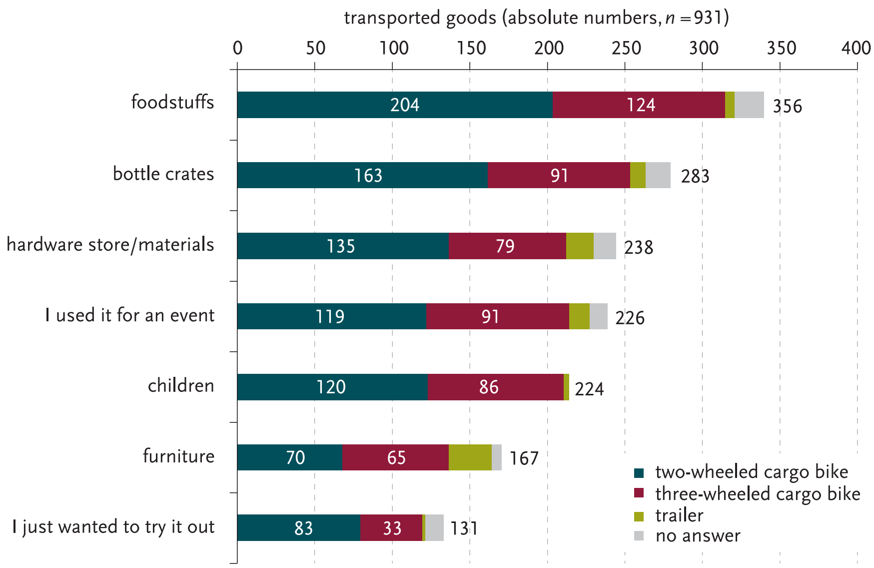


**FIGURE 2:** Goods transported with the shared cargo bikes, related to the type of cargo bike used ($n$ = 931). Usage motives vary but transport of food and bottle crates are most frequently named. There is no clear link between the type of cargo bike used and the type of goods transported. Absolute frequencies, multiple answers possible, 1,625 nominations of different cargos/use purposes; no answer = missing values concerning the type of cargo bike.

and drinks are the two most frequently mentioned types of cargo, which suggests that users integrate cargo bikes into daily life. Using the cargo bike to move around materials or furniture is also popular and represents trip purposes that might not occur on a daily basis but often surpass the capacity of a conventional bike. Moreover, the frequent mention of children and babies as transported "cargo" shows that families experiment to meet their transport needs without a car. In addition, numerous respondents indicated that they used the cargo bike for an event. The comments made on this topic suggest that users chose the cargo bike to facilitate local events such as information stands at street festivals or picnics in a park. Furthermore, the comments also reveal that the purposes extend from "transporting my dog" to "bringing my garbage to the recycling station". Finally, the high total number of indicated purposes (1,625 nominations) illustrates that most respondents have more than one use purpose in mind when they borrow a cargo bike.

The majority (52 percent) of respondents indicated that they used a two-wheeled cargo bike, typically a *Long John* model. About a third (35 percent) used a three-wheeled cargo bike with a box, and six percent chose a trailer to transport their loads (remaining six percent: NA). These proportions correspond to the portfolio of the participating cargo-bikesharing operators (see table 1). As illustrated in figure 2, there is no clear tendency to use one type of cargo bike more often than others for certain loads. That said, users tend to use three-wheeled cargo bikes a bit more for events, furniture, and children (if compared to the actual availability of three-wheeled cargo bikes in this sample).

The mean trip length of users is 14.57 kilometers (SD = 16.43), but this number should be interpreted with care since it is influenced by outliers, that is, particular users who made extremely long trips (maximum: 170 kilometers). After removing statistical outliers ($y > mean + 3*SD$), the remaining cases ($n = 864$) are plotted in figure 3 (p. 162), which also differentiates between the use of electric and non-electric cargo bikes.

In sum, a quarter (26 percent) of users rode electric cargo bikes, while 69 percent of users rode cargo bikes without electric assistance (remaining five percent: NA). The share of electric cargo bikes used corresponds roughly to the percentage of available electric cargo bikes in the current fleets (29 percent, see table 1) and increases slightly as the journeys traveled get longer.

## Intentions for Future Cargo-Bike Use and Purchase

Asked if they intend to use a cargo bike again in the future, a total of 93 percent gave a positive reply (figure 4, p. 163). Only one percent of respondents have no intention of using a cargo bike again.

At the same time, the intentions to purchase a cargo bike are mixed, as illustrated in figure 4: 35 percent of respondents are planning to buy a cargo bike and 26 percent are unsure, whereas 38 percent do not intend to buy a cargo bike. The two latter groups together represent 63 percent of the respondents. These users still intend to use cargo bikes in the future and are thus among the prospective customers of cargo-bikesharing systems.

The ratings of different motivating factors for future cargo-bike usage confirm the need for shared cargo-bike usage, since the availability of a sharing station close to one's home is rated as most important (mean [M] = 8.59, SD = 2.06, on a scale from 1 to 10, with 1 = "not motivating at all" and 10 = "very motivating"). This factor is rated even more important than a purchase premium for cargo bikes (M = 7.63; SD = 2.68). Safe parking possibilities at home are also considered to be a motivating factor (M = 7.72; SD = 2.44), as well as better cycling paths (M = 7.45; SD = 2.61).

With regard to the built environment, the majority of respondents characterized cycling infrastructure as insufficient for cargo-bike usage, with 90 percent of users identifying at least one issue. The most frequent issue is the width of cycling lanes (535 nominations). The second most commonly encountered problem is cars parking in cycling lanes (454 nominations), thereby putting (cargo) cyclists at risk.

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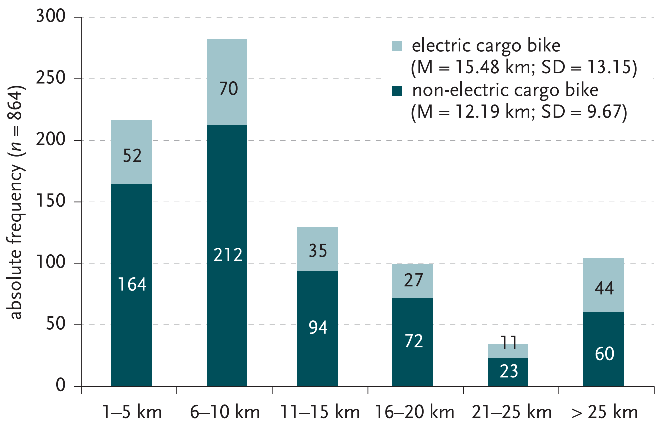


**FIGURE 3:** Length of main trip with the shared cargo bike, broken down for electric and non-electric cargo bikes (*n* = 864). The majority of trips with the shared cargo bike are short or medium trips up to ten kilometers. M: mean; SD: standard deviation.

### Impact on Car Use

The question of whether cargo bikes can help to reduce individual car use is highly relevant to sustainable urban development. Asked what they would have done in the absence of cargo-bikesharing systems, 45.6 percent of respondents indicate that they would have used a car to make their trip (25.0 percent carsharing, 16.1 percent own car, 4.3 percent car of friends/family, 0.2 percent taxi) (figure 5). This corresponds to an absolute number of 425 avoided car trips with a total of 5,509 kilometers in the current sample. Based on estimated mean real-world emissions in the German car fleet (167 grams of $CO_2$ per kilometer, cf. Tietge et al. 2016) this equates to 920 kilograms of $CO_2$ emissions[7] that were directly avoided by the present user sample in the course of their recent cargo-bike trips[8]. About a quarter of respondents would have made their trip by conventional bike, in some cases using extensions such as their own trailers. Only a small number of users would have made the trip by public transport or even on foot. The remaining 13 percent of respondents would not have undertaken the trip at all. Thus, cargo-bikesharing enabled these users to make trips that would not have been possible otherwise.

## Shared Cargo Bikes for a Sustainable Urban Development

Our analysis of user characteristics reveals that the current *Free Cargo-Bikesharing* network reaches a broad audience: the user group of shared cargo bikes is heterogeneous with regard to age and household situation. At the same time, the user group appears to be homogenous with regard to high environmental concerns. In this regard, the current sample is comparable to the general public and only slightly more concerned about climate change (BMUB and UBA 2017, p. 18). However, we captured environmental concerns in only two items, and the answers might be distorted by social desirability.

In addition, men use shared cargo bikes more than women, which corresponds to the findings of previous studies on cargo-bike usage (Carvelo 2016, Riggs 2016) and utilitarian cycling (Winters et al. 2007). Thus, future research should investigate in more detail under what conditions women's participation in cargo biking could be increased (Schwartz 2016).

It is not surprising that cyclists are largely overrepresented in the current user group of *shared* cargo bikes and represent roughly two thirds of these early adopters. Thus, people who are inclined towards cycling might be one of the most important target audiences for the early diffusion stage of shared cargo bikes. At the same time, a third of users have a main mode of transport that is not the bicycle: public transport, cars, or walking. Future studies should examine whether and how cargo biking can further diffuse into those user segments.

In contrast to Riggs' (2016) study of cargo bike buyers in California, our results show that *shared* cargo-bike usage is not focused on the transportation of children. While children are also identified as "cargo" by our respondents, food and bottle crates are named most frequently. Other frequently named purposes include the transportation of materials (e. g., from a hardware store) and the facilitation of events within the city. Thus, the usage motives vary considerably and include some of the most typical purposes where people might otherwise feel the need to use a car.

The findings of this study indicate that cargo-bikesharing has a high environmental and behavioral potential for urban sustainable development:

1. Cargo-bikesharing can help to reduce private car use in urban areas and the associated negative environmental impacts: almost half of the respondents (46 percent) indicated that they would have made their trip by car in the absence of cargo-bikesharing services. This comparatively high car substitution effect is consistent with the impact found for Swiss cargo-bikesharing (34 percent, Carvelo 2016). Thus, the environmental potential of cargo-bikesharing is considerably higher than that of classical bikesharing systems, where a majority of users make a switch from other sustainable modes of transport rather than from the car (Fishman et al. 2013, Shaheen et al. 2010, Zademach and Musch 2016).
2. The *Free Cargo-Bikesharing* network has a behavior change potential because it brings people into contact with innovative low-carbon mobility solutions and enables them to gain experience in the handling of cargo bikes, as illustrated by the high percentage of unexperienced users among the survey respondents. This "information diffusion" is an important step towards greater usage diffusion of a technology (Geroski 2000).

7 We consider cargo bikes and electric bikes to be "emission-free" vehicles, cf. footnote 3.

8 Here, we simply report the directly avoided emissions, referring to the present sample without estimating the impact of all cargo-bikesharing operators. Such an impact estimation depends on numerous context factors and would go beyond the scope of the present study. For an impact estimation of cargo bikes in the field of city logistics, see Gruber and Rudolph (2016).

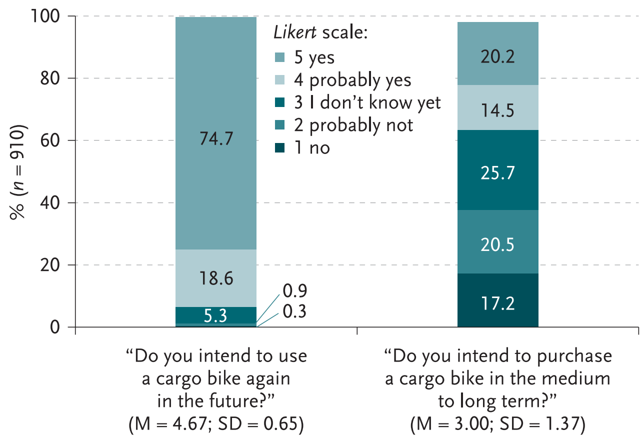


**FIGURE 4:** Usage intentions compared to purchase intentions for cargo bikes ($n = 910$). Most users intend to use a cargo bike again. This indicates a considerable future demand for shared cargo bikes. M: mean; SD: standard deviation.

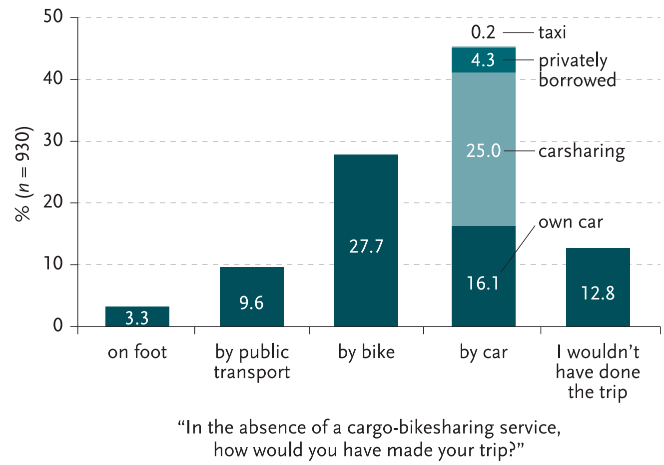


**FIGURE 5:** Substitution effects of cargo bikes on car use and other means of transport ($n = 930$). The biggest portion of respondents maintain that they would have made the trip by car in the absence of a cargo-bikesharing operator, indicating the high potential of cargo-bikesharing to reduce car usage.

The need for more information diffusion is illustrated by the fact that 61 percent of Germans haven't heard about cargo bikes at all (Borgstedt et al. 2017).

The vast majority of respondents intend to continue using a shared cargo bike, while a smaller group of respondents intend to purchase a cargo bike of their own. Thus, there is a considerable need for cargo-bikesharing systems because they offer a permanent mobility solution for those people who have a continuous but irregular need to transport goods. In addition, the shared use of resources is in most cases a more sustainable way of using a good.

### Limitations

The aim of the present study was to provide empirical knowledge about cargo-bikesharing and its current users. The methodological design has several limitations. First, the sample might be biased by the positive experiences of users. It is possible that those users that are satisfied with cargo-bikesharing participated more than those users that were disappointed with their cargo bike experience. That said, in their comments, the users also raised some criticisms and made suggestions for improving the way cargo-bike operators work.

Second, we could not estimate users' preferences for each single type of cargo bike (two- or three-wheeled, electric or non-electric) because of the heterogeneity of the operators' cargo bike portfolio (see table 1): the individual preference for a certain type of cargo bike might lie simply in its local and temporal availability.

Third, in our analysis we focused on descriptive statistics in an explorative manner because the research field lacked basic empirical data to date. With more and more research findings on cargo-bikesharing and its users, sound hypotheses can hopefully be derived and tested with inferential statistics in the future.

### Conclusion and Policy Implications

As underlined by the participants in the present user study, the improvement of cycling infrastructure to meet the needs of cargo bike users is an important condition for the diffusion and wider adoption of cargo-bikesharing in cities. This includes broadening cycling lanes, keeping them free of parked cars (e.g., by stricter law enforcement), and providing sufficient space for halt situations on street islands and intersections.

Furthermore, a dense network of cargo-bikesharing stations or a station close to user's residences is very important to the vast majority of users. At the same time, a substantial proportion of users favors the introduction of a purchase scheme for cargo bikes in their city. Thus, two types of cargo-bikesharing users might emerge in the coming years: those who would like to purchase their own cargo bike for daily usage (e.g., to transport kids or gear) and those who have an occasional need for cargo bikes and would benefit most from a network of cargo-bikesharing stations in their neighborhood or city.

As Rüdiger et al. (2016) highlight, municipalities should support cargo-bikesharing systems. Our results point in a similar direction. We recommend that cities supplement their existing urban bikesharing systems with cargo bikes in a top-down approach. This would create synergies, a comprehensive supply of shared cargo bikes, and an increased car reduction effect. At the same time, cities should support bottom-up movements like the *Free Cargo-Bikesharing* operators because they have a well-established and vibrant social network in their respective city district and would benefit considerably from municipal infrastructure support such as free and safe parking facilities.

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