WORKING PAPER

ITLS-WP-21-05

Multimodal Transportation Plans: Empirical Evidence on Uptake, Usage and Behavioural Implications from the Augsburg MaaS Trial

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March 2021

ISSN 1832-570X

INSTITUTE of TRANSPORT and LOGISTICS STUDIES
The Australian Key Centre in
Transport and Logistics Management

The University of Sydney
Established under the Australian Research Council's Key Centre Program.

NUMBER: Working Paper ITLS-WP-21-05

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ABSTRACT: The integration of shared mobility modes with public transportation to provide 'mobility as a service' (MaaS) in a sustainable way has received substantial attention from transportation scholars, practitioners and policymakers. In fully integrated systems, customers are offered a choice between 'pay-as-you-go' and monthly subscription plans. While there has been considerable research into the configuration, willingness to pay and resulting market potential of such plans using stated preference methods, only few trials have been conducted to validate previous results and evaluate their potential to foster sustainable travel behavior. To this end, we report on the first MaaS trial in Germany. Between November 2018 and June 2020, 341 customers bought bundles including monthly public transportation, carsharing and bikesharing allowances. While uptake has been substantial, first indications of market saturation suggest that the (currently offered) MaaS bundles including these modes might be more of a niche product than a 'game changer' in urban mobility. Analyzing longitudinal panel data on bundle uptake and carsharing usage, we find that a substantial number of customers underutilize their carsharing allowances. Still, consumer gain is substantially higher than producer gain due to bundle discounts, dampening providers' hopes of a new business model. We further find that carsharing allowances in bundles increase carsharing usage of subscribers.

KEY WORDS: ***Mobility as a Service (MaaS), Service Bundling, Multimodal Transportation Plans, Public Transportation, Carsharing, Travel Behaviour***

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Acknowledgements: The authors are very thankful to swa Augsburg for providing the data used in our analyses.

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DATE: March 2021

INTRODUCTION

Mobility as a Service (MaaS) is a concept that only recently emerged, however despite its relative youth, it has received considerable attention ever since (for a recent review, see (*1*)). In broad terms, it can be conceived as an alternative system to private mobility tool ownership. As such, it comprises (emerging and established) mobility services (e.g., bikesharing, carsharing, ridehailing, taxi, public transportation) as well as the actors enabling, providing, receiving and orchestrating them (e.g., government, providers, customers, brokers). Importantly, MaaS is 'a means to an end', though ends differ by actor. From a societal perspective, MaaS is commonly regarded as a way to achieve sustainable changes in travel behavior such as decreasing private car ownership and increasing the use of shared, low-emission modes such as public transportation (*2-6*).

For MaaS to be ultimately successful, it needs to have scale and thus be appealing to the end user. To be appealing to the end user, in turn, it needs to be seamlessly integrated across different mobility services. Indeed, while the term 'MaaS' is relatively young (*7*), the concept of mobility integration is much more established. The US Department of Transportation (DoT) described it as early as 1991 in the context of 'Mobility Management': "The Mobility Manager accomplishes its goals by linking together all travel modes - bus, taxi, vanpools, express bus, specialized services, carpools etc. at an informational level and, in most cases, at a transactional level as well" (*8*, p. 16). Correspondingly, recent contributions structure the field by levels of integration (*9-11*). These typically range from 'no integration' to 'full integration' along various dimensions such as operational, informational and transactional (from a provider perspective), or planning, booking and payment (from a user perspective). In fully integrated systems, users typically have the choice between 'pay-as-you-go' (PAYG) and monthly subscriptions (also commonly named 'multimodal transportation plans', 'mobility bundles' or 'MaaS bundles').

MaaS bundles have recently become an active area of research due to their centrality to MaaS business models and their potential to promote sustainable travel behavior (see (*12*) for a current review). Early studies investigated willingness to pay, potential market uptake and motivations to subscribe by employing stated preference surveys and discrete choice modelling (*13-21*). Meanwhile several trials around the world (e.g., UbiGo in Sweden, Tripi in Australia) and commercially operating organizations (e.g., WHIM in Finland and the Netherlands, swa Augsburg in Germany, Yumuv in Switzerland) have enabled revealed preference studies to validate earlier SP studies and evaluate the potential of MaaS bundles to change travel behavior. While early evidence suggests that MaaS bundles can indeed reduce private car use (*22-23*), many questions remain to be answered. To our best knowledge, there is no quantitative evidence yet on how MaaS bundles influence the usage of other car-based modes (e.g., carsharing, taxi, ridehailing) that are included as allowances in a bundle, and how such allowances are utilized. These questions are relevant to clarify for several reasons. If the usage of non-private car-based modes increased while private car usage decreased, sustainability impacts of MaaS bundles, and consequently public investment into the MaaS ecosystem, might be evaluated differently. Clarifying how allowances are used (or, in other words, how many allocated hours of carsharing remain unused and expire each month) is central to pricing MaaS bundles and their evaluation as a potential business model.

This research aims to start filling these gaps by reporting the Augsburg MaaS trial. Between November 2018 and June 2020, 341 paying customers signed up and collectively bought 672 bundle months. We collect longitudinal panel data on trip-level carsharing usage of all customers and an additional control group of 3387 participants starting ~1 year before the first bundle was introduced. This unique dataset allows analyses of the effect of bundle uptake on carsharing usage as well as of the utilization of carsharing budgets in MaaS bundles. It also offers a new geographical perspective (previous trials were conducted in Sweden and Australia) and first evidence on the actual market size for three trialed bundles where previous analyses were either limited in time or only offered to subgroups of the population.

The remainder of this paper is structured as follows. We first review the literature on MaaS bundles with a particular focus on empirical evaluations of trials. We then introduce the Augsburg MaaS trial and the empirical context of our analyses. We proceed by introducing the data and methods, before presenting the results of our analyses. We discuss their implications for research, policy and practice in the following section and close with a summary of the main contributions and suggestions for future work.

LITERATURE REVIEW

To our best knowledge, only two trials of MaaS bundles have been thoroughly and independently evaluated and documented (UbiGo in Sweden and Tripi in Australia). The UbiGo trial was conducted in Gothenburg, Sweden, between November 2013 and April 2014 (see (*22*) and (*24*), for detailed reports). In its core, it consisted of an integrated app offering one-stop access to the region's public transportation, carsharing, bikesharing, rental car and taxi services. Participating households could customize their subscription plans containing monthly budgets and discounts for each service. All members of a particular household were subsequently allowed to use the services, and any trips that exceeded the monthly budget were charged using a 'pay-as-you-go' scheme while unused credit was transferred to the next month. A total of 83 households (195 individuals) signed up for the trial. Females and males were equally represented in the sample, most households lived in apartments (80 %) in the city center (42 %) and already owned a public transportation card (88 %). 30 % were members in a carsharing scheme before joining the trial. Data collection was conducted through three online questionnaires (one each before, during and after the trial). By means of qualitative analyses of the questionnaires and personal interviews, Strömberg et al. (*22*) found that UbiGo induced behavioral changes in mode choice for 42 % of the sample. The overall trend was less car use and more walking; however, some individuals used substantially more carsharing than before. While the UbiGo trial undisputedly has provided many invaluable lessons for subsequent MaaS trials and is one of the best documented trials yet, it also has shortcomings. One is the self-reported nature of all data which is known to be subject to response biases (i.e., social desirability bias, acquiescence bias). As the authors conclude, it is thus "difficult to draw any general conclusions regarding how many people will change behavior due to a service of this type and how big the changes will be" (*22*: p. 1668).

The Tripi trial (see (*25*) for a detailed report) was conducted in Sydney, Australia, between November 2019 and April 2020 as a partnership between the Institute of Transport and Logistics Studies (ITLS) at the University of Sydney, Insurance Australia Group (IAG) and SkedGo, and financed by the iMOVE Coorperative Research Centre. The trial was designed for IAG employees only, who were offered an integrated app from November 2019 to April 2020 and different, subsidized monthly mobility bundles between December 2019 and March 2020 (see (*26*) for a detailed report on the bundle design and implementation). Five different modes of transportation were available to be booked through the app: public transportation, carsharing, rental car, Uber and taxi services. A total of 93 participants were onboarded to participate in the trial. All participants lived or worked in the Sydney metropolitan area and most also lived near train tracks indicating a high level of public transportation accessibility among the participants. 43 participants bought one or more of the four bundles that were iteratively developed and offered. Various quantitative and qualitative data sources were utilized for subsequent analyses: trip-level booking data from the app, questionnaires and interviews. Additionally, IAG made available data from tracking devices deployed in cars of 33 MaaS trial participants who also subscribed to second trial program. The depth and variety of these datasets enabled first quantitative analyses of the impact of MaaS bundles on travel behavior. Perhaps the most encouraging finding is that the authors could quantitatively confirm earlier hypotheses that bundle uptake was indeed related to decreases in monthly car trips and kilometers (*23*). As the authors note, however, "with a relatively small number of participants, we can at best provide indications and possible triggers that do contribute to changing travel behavior patterns of mobility that might or might not achieve the sustainability objectives we aspired to when scaled up to a larger population" (*23*: p. 54).

While many lessons have been learnt from these two well-documented trials, several knowledge gaps remain to be closed. *First*, the impact of MaaS and MaaS bundles on travel behavior clearly needs to be further explored. To date, we have indications from two studies that MaaS bundles has the potential to reduce private car use. Both studies, however, have a relatively small number of participants and lack a control group to refute alternative exogenous explanations for the observed effects. We also do not have solid quantitative evidence on how MaaS bundles influence the usage of non-private car-based modes (e.g., carsharing, taxi, ridehailing). If their usage increased while private car usage decreased (of which there is some indication in (*22)*), sustainability impacts (and public investment into the MaaS ecosystem as a consequence) might be evaluated differently. *Second,* we do not know how budgets, in terms of monthly allowances or supscription fees, in MaaS bundles are being used (i.e., how many hours of carsharing expired each month?). From a commercial perspective, this knowledge is central to pricing MaaS bundles and to evaluating MaaS bundling as a potential business model. There is evidence for a 'flat rate effect' (i.e., some people prefer a subscription even though they would pay less under a pay-per-use scheme) in public transportation season tickets (*27-28*), but it is unclear if this holds for multimodal transportation plans as well.

THE AUGSBURG MAAS TRIAL

The launch of Germany's first commercial MaaS bundles in November 2019 received much attention from popular media, transport professionals and academics. How did the city of Augsburg, until then arguably not known by many outside of Germany, quietly manage to become a leading MaaS implementor in just one year at times when others struggle years after their first trial?

Many of the answers emerge from the city's long-term mobility strategy. Augsburg is a mid-sized German city with ~300,000 inhabitants. Public transportation is provided by the municipal public utilities company ('swa Augsburg'), which is common for German cities. swa Augsburg is structured in three branches (energy, water, public transportation) and its public transportation branch runs ~90 trams and ~80 busses with ~63 million passengers annually. However uncommon for German cities, swa Augsburg has a multimodal mobility strategy that is interlinked with its fare and sales strategy. Besides trams and buses, it also operates the sole local (free-floating and station-based) carsharing schemes (~180 vehicles and ~70 stations, since 2015) and bikesharing schemes (~150 vehicles and ~30 stations). While the step from offering the three modes as stand-alone services towards a MaaS bundle arguably is not as big as for many others, this 'institutional integration' allows swa Augsburg to position itself uniquely as the city's public transportation operator and mobility services broker (cf. *29*) simultaneously. A second aspect explaining swa Augsburg's quick progress in becoming a leading MaaS implementor is its pragmatic approach. While many are trying to achieve deep multimodal integration bottom-up (i.e., from level 0 to 4/5 in Sochor et al.'s (*11*) / Lyons et al.'s (*10*) terminology), swa Augsburg jump-started to offer MaaS bundles (Sochor et al.'s level 3) before offering a fully integrated mobility app (Sochor et al.'s level 1). As of July 2020, the different services were accessible through a single app with booking capability; however, no multimodal trip planner is available in the city yet.

Following swa Augsburg's long-term multi-modal mobility strategy, it started a MaaS project named 'Mobil-Flat' in November 2018. While the overall goal of its MaaS journey is customer retention, the goal of the trial was to learn about customer travel behavior under the influence of a bundle. 45 inhabitants of Augsburg subscribed to a first MaaS bundle for the year-long trial. It contained a monthly budget of 30 h of carsharing (any vehicle, unlimited km), an unrestrained number of 30 min rides of bikesharing and a city-wide public transportation pass (zones 10 and 20). The bundle was priced at 75 € which compared to a minimum price of 110.5 € for stand-alone services (52.5 € for the public transport pass, 48 € for carsharing without surcharges per km and 10 € for bikesharing).

As the overall reception was very positive and swa Augsburg certainly benefited from the nationwide recognition as an innovative public transportation provider, it refined its bundles based on the trial booking data and launched Germany's first commercial MaaS bundles in November 2019. The first 'second-generation' bundle ('swa Mobil-Flat S') was a smaller version of the originally trialed with 15 h of carsharing (compared to 30 h before, with the additional limitation of 150 km total distance), same public transport and bikesharing budgets, priced at 79 € per month. The second bundle ('swa Mobil-Flat M') essentially continued the originally trialed bundle at a price of 109 € per month. From January 2020, prices have increased to 83 € for the Mobil-Flat S and 115 € for the Mobil-Flat M. Table 1 provides an overview of the three bundles.

TABLE 1 MaaS bundles offered in Augsburg.

		Pilot	Mobil-Flat S	Mobil-Flat M
Dates	Start	11/2018	11/2019	11/2019
	End	10/2019	-	-
Modes and budgets	Public Transportation	Unlimited (zones 10 and 20)	Unlimited (zones 10 and 20)	Unlimited (zones 10 and 20)
	Carshare	30 h / unlimited km	15 h / 150 km	30 h / unlimited km
	Bikeshare	Unlimited <=30 min rides	Unlimited <=30 min rides	Unlimited <=30 min rides
Price	Start	75 € (2018)	79 € (2019)	79 € (2019 / 6 month offer) 109 € afterwards
	Current	-	83 € (2020)	115 € (2020)

The pilot phase was restricted to 45 customers between November 2018 and October 2019. The subsequent bundles (Mobil-Flat S and Mobil-Flat M) were offered from November 2019 onwards without any restrictions on customer numbers and with a substantial discount for everyone subscribing to Mobil-Flat M in the first two months. Correspondingly, 166 new customers subscribed in November and December 2019 with a large majority choosing Mobil-Flat

M. The subsequent months saw further increases in customer numbers with a peak of 282 active subscriptions in March 2020. Since then, active subscriptions have remained stable between 270 and 285 (Figure 1). While we discuss whether these are signs of market saturation or COVID-19 later (see Discussion), one notes that an increasing number of customers switched from the more expensive Mobil-Flat M to the less expensive Mobil-Flat S. One likely cause of this 'switching behavior' is the initial discount (Mobil-Flat M was sold at the same price as Mobil-Flat S for the first 6 months in November / December 2019).

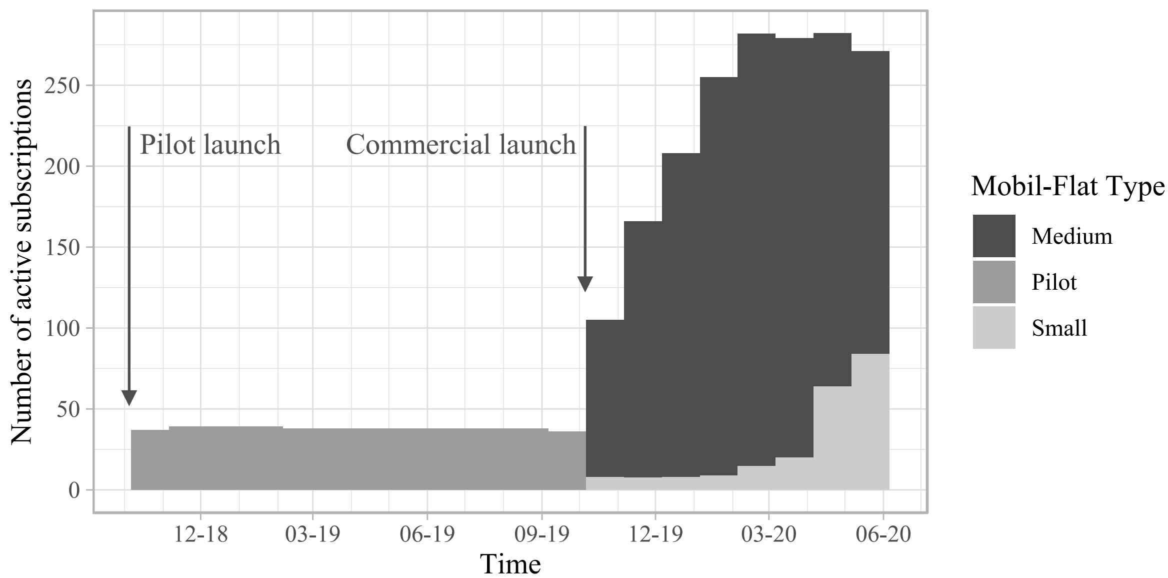

FIGURE 1 Number and type of active Mobil-Flat subscriptions over time.

Since the pilot launch in November 2018, a total of 341 customers have signed up for the Mobil-Flat (and partially cancelled after a few months), 168 of which are female and 169 male. Mobil-Flat subscribers mostly live in the city-center of Augsburg, where the density of carsharing and bikesharing stations is highest (Figure 2). In their mean, subscribers were 42 years of age (max: 81 years, 3rd quantile: 52 years, 1st quantile: 33 years, min: 19 years). Notably, 47 % of all Mobil-Flat customers were already members of the city's carsharing scheme before subscribing.

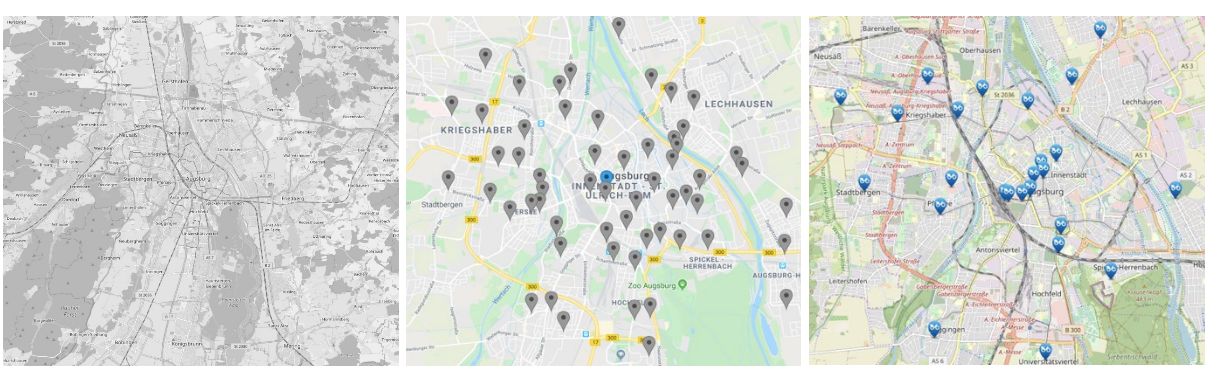

FIGURE 2 Frequency of Mobil-Flat subscribers by residential postcode (right), carsharing stations (middle) and bikesharing stations (right) in Augsburg.

DATA AND METHODS

Two datasets are combined to address the empirical research questions posed in the previous sections. Firstly, swa Augsburg provided the authors with a detailed registry of Mobil-Flat subscribers that includes Mobil-Flat subscription type (Pilot, M, S), start and end date of the subscription, residential postcode, gender, dates of birth and a membership ID. Secondly, we received trip-level booking data from their carsharing operations between October 2017 and June 2020 for all members (i.e., not only Mobil-Flat customers) that also included a membership ID. By matching membership IDs of both datasets, we obtain an unbalanced controlled panel with 3728 individuals (341 of which subscribed to a MaaS bundle during some months) and 48797 carsharing trips.

How are carsharing budgets in bundles being used?

We aggregate the trip-level carsharing booking data by month and membership ID and take the subsample of Mobil-Flat subscribers. We further filter the data for customers who have subscribed to a Mobil-Flat for at least 3 months and paid the regular amount (i.e., no pilot customers and discounted Mobil-Flat M customers) to avoid biases in bundle uptake towards larger budgets. The resulting dataset consists of 117 Mobil-Flat customers and their average monthly carsharing expenses. We first generate the distribution of average monthly carsharing consumptions for all customers. We then examine whether (and for whom) a flat rate effect can be observed by calculating for each customer:

(a) the mean carsharing expenses per month actually paid (i.e., after subtracting the Mobil-Flat budget of 15 h / 30 h for Mobil-Flat S / M, respectively), and add the costs for the respective Mobil-Flat (see Table 1), and
(b) the mean carsharing expenses per month the customer would have paid without the Mobil-Flat budget, and add the costs for the respective public transportation pass (50 € in 2018, 52.5 € in 2019, 55 € in 2020) and the bikesharing membership (10 € in all years)

Results are presented and discussed in the following sections.

How does bundle uptake affect carsharing usage?

We aggregate the trip-level carsharing booking data by month and membership ID (note that this sample includes both Mobil-Flat customers and the control group). We further filter the data for customers who have used carsharing for at least 6 months since becoming a member. The resulting dataset consists of 46,165 observations (monthly carsharing consumption) for our unbalanced panel of 2,504 carsharing customers of which 245 were also Mobil-Flat subscribers.

We analyze the effect of different Mobil-Flat subscriptions on travel behavior (i.e., carsharing consumption) by estimating a mixed effects regression model of type

$$\log(y) = X\beta + Zu + \epsilon$$

where

- y is a (transformed) vector of observations;
- β is a vector of fixed effects for variables in matrix X;
- u is a vector of random effects for variables in matrix Z;
- ϵ is a vector of random errors.

Here,

- y is the (log-transformed) monthly carsharing hours for each individual;
- X includes four binary variables indicating the type of Mobil-Flat subscription (*MF-M, MF-S, MF-P*), and the emergence of COVID-19 in Ausgburg (i.e., 1 from March – June 2020, 0 otherwise);
- Z includes two variables indicating the customer ID (to account for unobserved heterogeneity between customers, e.g. due to income and household structure) and the month of the observation (1 – 33) for random effects.

Figure 3 shows a histogram of the transformed monthly carsharing consumption observations in hours. The Shapiro-Wilk normality test (*30*) confirms that the sample comes from a normally distributed population ($p < 0.001$).

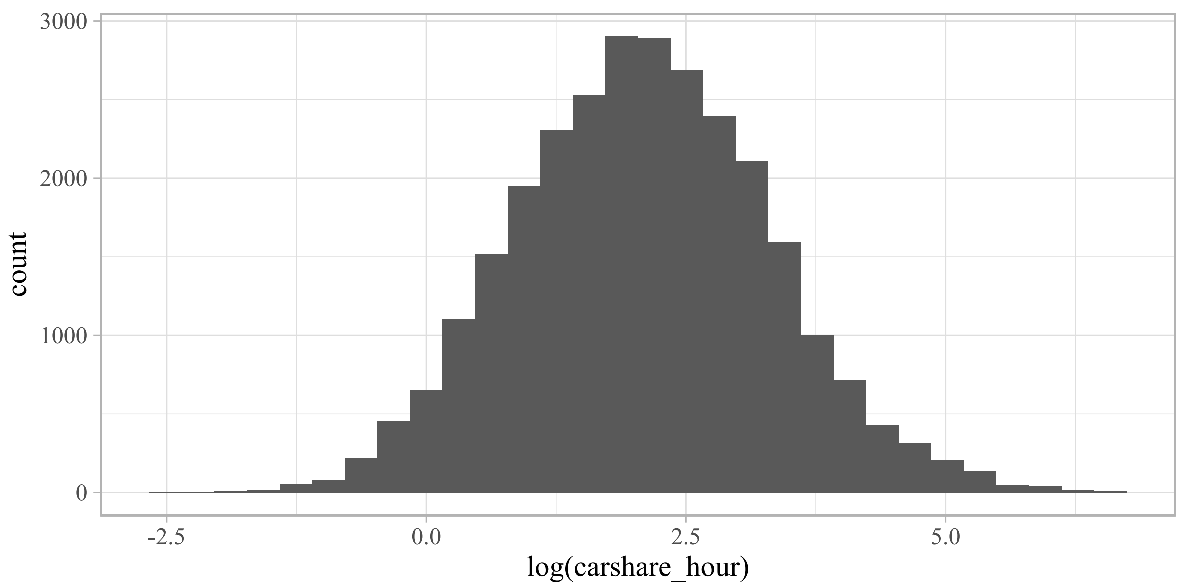

FIGURE 3 Distribution of dependent variable log(carshare_hour) for linear regression analysis.

RESULTS

How are carsharing budgets in bundles being used?

Figure 4 shows the overall distribution of mean carshare consumption (hours) per month. Mobil-Flat customers who paid the full price (i.e., no intial 6-month discount) for a 30 h monthly carsharing budget on average only used 19 h (1st quantile: 11 h, median: 17 h, 3rd quantile: 23 h). This suggests a substantial underutilization of available budgets.

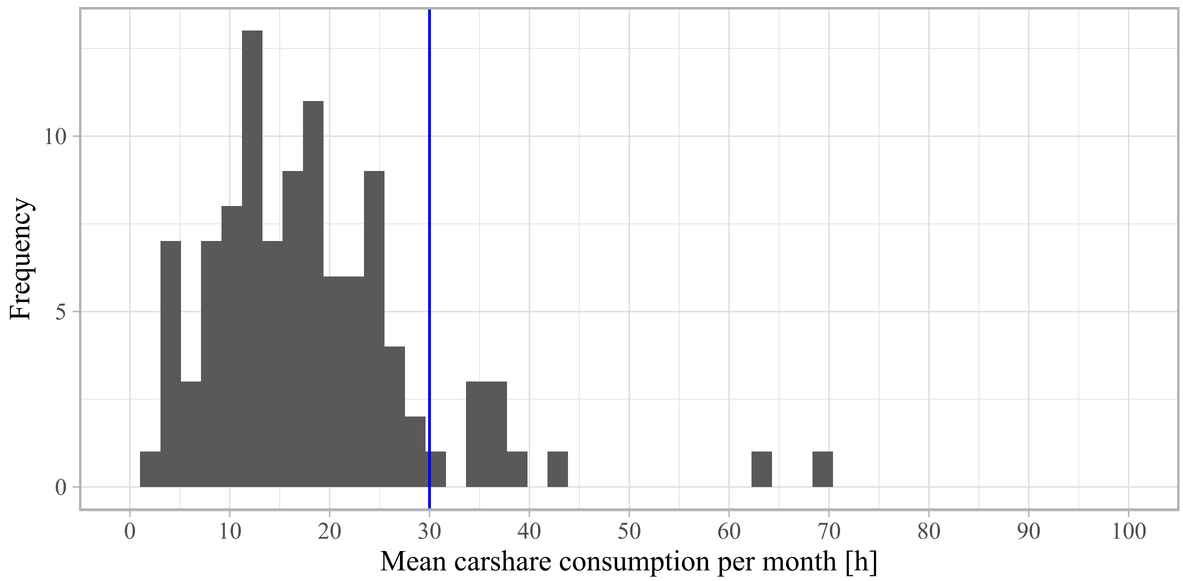

FIGURE 4 Distribution of mean carshare consumption (hours) for Mobil-Flat subscribers with a monthly carshare budget of 30 hours shows substantial underutilization of budgets.

Whether budget underutilization implies 'producer gain' (i.e., a customers would have paid less buying each mobility service separately instead of subscribing to a Mobil-Flat) or 'consumer gain' (i.e., customers still saved money by subscribing to a Mobil-Flat due to the discount given) is analyzed next. We calculate the difference between actual paid prices and hypothetical prices (without a Mobil-Flat subscription) for each customer and month, average all months per customer and display the results ordered by magnitude of prices difference in Figure 5. Negative values can be interpreted as producer gain and positive values can be interpreted as consumer gain. In sum, we observe that 37 customers (~32 %) on average paid more than they would have without a Mobil-Flat while 80 (~68 %) customers on average paid less than they would have without a Mobil-Flat. The median amount saved was substantial (~ 34 €) while the median amount of extra pay was muss less (~ –12 €). The total average consumer gain per month is equal to 4466 € while the total average producer gain per month is equal to 612 €.

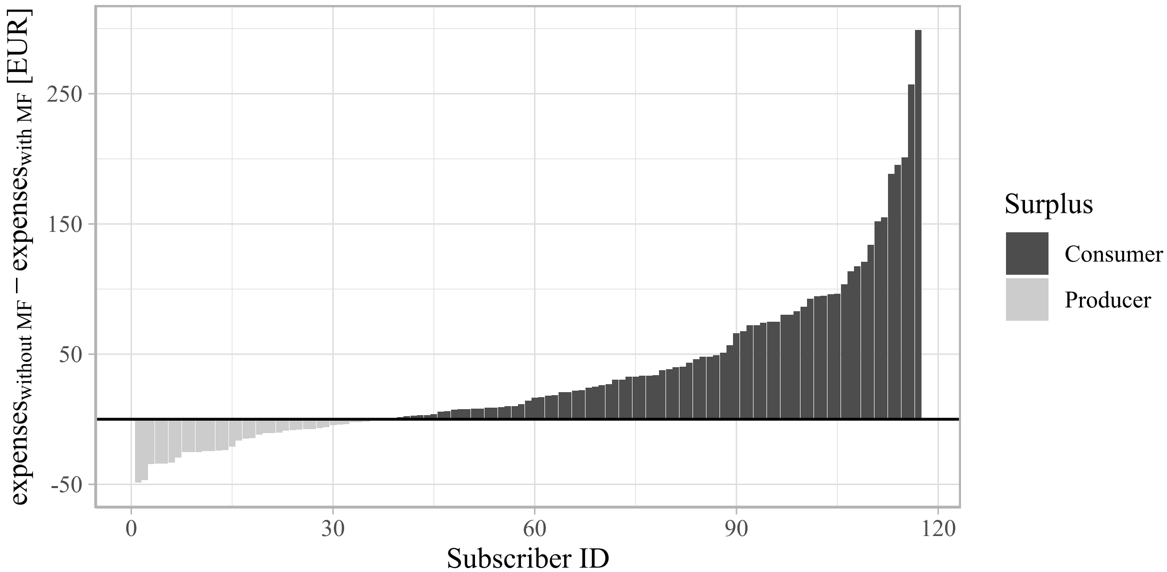

FIGURE 5 How much would Mobil-Flat customers have paid without a Mobil-Flat? Comparison of mean actual monthly expenses with a Mobil-Flat and hypothetical monthly expenses without a Mobil-Flat shows substantial consumer gain (i.e., most users saved money with a Mobil-Flat subscription).

How does bundle uptake affect carsharing usage?

Table 2 shows the estimation results for the mixed effects model. The overall model fit is good with a conditional R^2 of 0.4 and a root mean square error of 0.88. All tested fixed effects are highly significant and substantial. As the dependent variable is log-transformed, the estimates have to be exponentiated to be interpretable as changes in the ratio of the expected mean of the (untransformed) dependent variable. We find that the Mobil-Flat Pilot and the Mobil-Flat M subscriptions (each including a carsharing budget of 30 h) affect carsharing usage most substantially. On average, a Mobil-Flat Pilot subscription increased carsharing usage by 77% and a Mobil-Flat M subscription increased carsharing usage by 84% (i.e., exp(0.61) = 1.84). The smaller Mobil-Flat S subscription (carsharing budget of 15 h) also increased carsharing usage considerably, yet to a smaller degree (36%). The impact of COVID-19 is negative as expected, and led to an average decrease in carsharing usage of 24%.

TABLE 2 Estimation results for mixed effects model.

Fixed Effects		
	Estimate	t
(Intercept)	1.97	82.29***
Mobil-Flat Pilot	0.57	8.19***
Mobil-Flat M	0.61	16.17***
Mobil-Flat S	0.31	3.91***
COVID-19	–0.28	-5.34***
Random Effects		
	Type	Std. Dev.
ID	(Intercept)	0.72***
Month	(Intercept)	0.09***
N observations	28189	
N individuals	2504	
N months	33	
R^2	0.40	
RMSE	0.88	

*** : p < 0.001, ** : p < 0.01, * : p < 0.05

DISCUSSION

Our analyses offer evidence that bundles containing carsharing allowances increase carsharing usage of their subscribers substantially. While this effect in itself comes as no surprise and confirms earlier qualitative findings by Strömberg et al. (*22*), its quantification contextualizes the boundary conditions under which MaaS bundles can increase (or indeed decrease) the sustainability of transportation overall. We show that including higher carsharing allowances in MaaS bundles leads to higher increases in carsharing usage. In the most positive scenario, these increases could be offset by corresponding decreases in private car usage. In this scenario, the overall usage of car-based modes would remain stable and we would observe a *shift* rather than a *decrease* of car-based modes. In more pessimistic scenarios, the increase in carsharing usage could stem from decreases in public transportation usage and/or correspond to previously suppressed demand due to the high marginal costs of carsharing usage (which effectively drop to 0 for the allowance included in the bundle). While the (short-term) sustainability impact of including carsharing in MaaS bundles could still be positive in the first scenario due to a potentially higher fuel efficiency of the carsharing fleet, it would most likely be negative in the other two scenarios. The inclusion carsharing budgets in MaaS bundles and its implications for travel sustainability is thus more complex than previously acknowledged and should be evaluated with care. We recommend future studies to observe not the consumption of car-based modes (i.e., carsharing, ridehailing) within a bundle, but also the usage of car-based modes outside of the bundle (i.e., private cars) to adequately quantify the (short-term) sustainability impact of MaaS bundle components on travel behavior. Note that the long-term sustainability impacts of MaaS bundles might still be positive despite negative short-term impacts as it could lead to an overall reduction of car ownership. This relationship, though, also remains to be validated.

Our analyses offer first evidence on the actual market size for three trialed bundles. After an initial strong surge in demand, which was likely driven by initial rebates, the number of subscribers remained stable at ~280 active subscriptions. One reason could be that customers refrained from using shared modes (including public transportation and carsharing) due to the increased risk of a COVID-19 infection. Our model shows that COVID-19 had a substantial and negative effect on carsharing use. However, another reason could be that the bundles have already saturated market demand for these specific bundles. The latter hypothesis could imply that MaaS bundles might be substantially less appealing (at least for these specific bundles in Augsburg, Germany) than previous SP studies have found. The 280 active subscriptions compare to 7.5 % of the total number of active carsharing customers (3,728) and 0.1 % of the total number of active public transportation season ticket holders (292,247). This hypothesis is supported by evidence from WHIM, which has been unable to establish their bundles outside of Helsinki and Antwerp. Reasons for the difference between expectations stemming from SP studies and actual market uptake might be the hypothetical bias (*31*) or limitations of currently offered bundles when compared to portfolio-type SP studies (*14*).

Finally, driven by early expectations of the large size of the 'MaaS market', many are searching for a suitable business model (*32-34*). Here, we explored whether the flat rate effect (*35-36*) can be observed for MaaS bundles, too. We find that the flat rate effect can indeed be observed (i.e., 32 % of all customers on average paid more than they would have without a Mobil-Flat). However, 68 % of all customers paid less than they would have without a Mobil-Flat and overall consumer gain per month (4,466 €) was substantially more than overall producer gain per month (612 €). We expect the estimate for the producer gain to be a lower bound as one assumption we made is all customers use the other two components in a Mobil-Flat (public transportation and bikesharing) to their full extent in lack of data indicating otherwise. Thus, while the flat rate effect can be observed, it is unlikely that offering MaaS bundles per se could generate profit. However, the exact ratio of fixed vs variable costs for carsharing in this case and the usage of the other modes might change this first estimate.

CONCLUSION

In the outset of this paper, we noted that the US DoT described their vision of mobility integration as early as 1991. Despite several advances enabled by the digitization of planning, booking and payment processes, the mobility landscape still remains fairly disintegrated in many places with few organizations driving the cumbersome integration process. From a societal perspective, arguably the most relevant question is whether MaaS can deliver upon expectations to improve the sustainability of passenger transportation.

The three MaaS trials that have been independently evaluated and transparently documented so-far provide valuable early lessons. In Sweden (the UbiGo trial), researchers have found first evidence that MaaS can indeed shift mode use towards less car use and more walking (*22*). Evidence, however, is based on qualitative analyses of self-reported changes in travel behavior, which is known to be subject to response biases (i.e., social desirability bias, acquiescence bias). In Australia (the Tripi trial), researchers have shown first evidence of a relationship between bundle uptake and car use reduction based on unbiased booking and tracking data (*23*). The study, however, only included a small number of participants with both data sources. Here, we report on the first MaaS trial in Germany (the Augsburg trial). We find that uptake has been substantial (341 paying customers) yet first indications of market saturation suggest that (currently offered) MaaS bundles that include carsharing, bikesharing and public transportation might be more of a niche product than a 'game changer' in urban mobility[1]. We find evidence of a flat rate effect in carsharing allowances included in MaaS bundles, yet consumer gain is substantially higher than producer gain, dampening providers' hopes of a new business model. Last but not least, we find that carsharing allowances in bundles increased carsharing usage of subscribers. This effect suggests that reductions in private car use in the context of MaaS trials cannot be interpreted as sustainability increases per se, but interdependencies with other modes (of which we suggest three) have to be accounted for.

While many lessons have been learnt from the above trials, many open questions remain. Most importantly, the impact of MaaS and MaaS bundles on travel behavior clearly needs to be further explored. This concerns both the short-term effects on mode choice and the long-term effects on car ownership. One way to do so is to conduct a controlled before-after panel study which is currently underway in Switzerland (the Yumuv trial).

ACKNOWLEDGMENTS

The authors are very thankful to swa Augsburg for providing the data used in our analyses.

AUTHOR CONTRIBUTIONS

The authors confirm contribution to the paper as follows: study conception and design: D.J. Reck, K.W. Axhausen; data collection: D.J. Reck; analysis and interpretation of results: D.J. Reck, K.W. Axhausen, D.A. Hensher, C.Q. Ho; draft manuscript preparation: D.J. Reck; manuscript review: K.W. Axhausen, D.A. Hensher, C.Q. Ho. All authors reviewed the results and approved the final version of the manuscript.

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[1] In the Sydney trial, the authors found that carsharing played only a minor role in bundles. The most popular bundles were those that included large PT discounts.

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