Seamless Intermodality: Exploring Consumer Preferences for Public Transport and Shared Micromobility Bundles

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Abstract

Shared micromobility services, encompassing (e-)bike and e-scooter sharing, have a controversial space within urban mobility. While possessing the potential to reduce individual car usage, particularly as first/last mile solutions complementing public transport, they also pose a competitive challenge to the latter. Despite this inherent synergy, efforts to integrate ticketing systems and incentivize intermodal travel have been scarce. While a few studies have investigated the willingness to pay (WTP) for micromobility as a part of larger Mobility-as-a-Service (MaaS) bundles, little is known about preferences for different types of bundles. Addressing this gap, this study explores preferences for different bundle configurations combining micromobility and public transportation. A stated choice experiment was conducted with Swiss residents (n = 1,379) to compare market potential for three types of bundled subscriptions: 1) Flat rate offerings 2) a 50% discount pass and 3) minute packages. Additionally, bundles tailored for single journeys are investigated. A flexible mixed-logit model is used to analyze the impact of demographic factors and experience with micromobility on the willingness to buy the bundles. A flexible mixed-logit model analyzes the influence of demographic factors and prior micromobility experience on bundle purchase willingness. The results demonstrate substantial interest in both subscription and single-ride bundles, particularly when offered at discounted rates. Particular interest was found for the single-ride bundle during nighttime. These results can help practitioners to design attractive offers for their customers.

Keywords

micromobility; stated choice; bundling; consumer preferences; MaaS

1 Introduction

A controversial debate has evolved over the benefits and drawbacks of the rise of shared micromobility, which primarily includes (e-)bike sharing and e-scooter sharing. While companies promote their services as a sustainable alternative for car travel, the societal benefit is questionable. Reck *et al.* (2022) found that only a small fraction of shared micromobility trips replace car journeys and a larger share replaces walking or public transport.
One recommendation often proposed is a better integration of shared micromobility with public transport (PT) systems (Oeschger *et al.*, 2020). To leverage synergies and avoid cannibalization, "scoot-N-ride" bundles appear as a promising instrument to incentivize intermodality (Yan *et al.*, 2023). While a growing stream of literature has focused on broader Mobility-as-a-Service (MaaS) bundles (e.g. Ho *et al.* (2020)), little is known about consumer preferences for different micromobility and PT bundle designs.
This study aims to fill this gap in the literature and seeks to understand: How do different micromobility and public transport bundle designs influence consumer preferences? What is the potential adoption at certain price points? Who is the main target group for these bundles? A a stated-choice experiment among Swiss residents is used to evaluate three different subscription bundle designs: 1) Flat rates, 2) a 50% discount pass, and 3) minute packages. Additionally, this study is the first one to assess attractiveness of single-ride bundles in a European setting and also distinguishing daytime and nighttime. By elucidating preferences for these bundles, this study contributes to the development of more effective intermodal transport solutions that could enhance urban mobility and reduce reliance on private vehicles.

2 Literature

2.1 Shared micromobility and public transport

It is widely acknowledged that enhancing public transport systems and reducing reliance on private cars are essential for creating sustainable and livable cities (Sinha, 2003). A significant challenge in increasing public transport usage is the first/last mile problem, which refers to the often inconvenient and time-consuming segment of a journey from a public transport stop to the final destination (Park *et al.*, 2021). A frequently proposed solution to this issue is shared mobility, with shared micromobility emerging as a flexible and low-cost option (Shaheen and Chan, 2016). Shared micromobility encompasses both docked and dockless (e-)bike sharing systems, as well as the increasingly popular e-scooter sharing (Shaheen and Cohen, 2019).
However, While shared micromobility can be used as a solution for the first/last mile problem (Liu and Miller, 2022), Reck *et al.* (2022) found that trips frequently replace public transport journeys. They conclude that CO2 emissions of shared e-scooter and e-bike systems are greater than the

modes they replace. Shaheen and Martin (2015) also found this competition/complementation trade-off and identified that the role of bike sharing as a first/last mile solution is especially prevalent in areas with a low density public transport network.
To promote inter-modal trips combining public transport and micromobility, several measures have been proposed in the literature. As outlined in a literature review by Oeschger *et al.* (2020), it is widely established that infrastructure and the availability of shared micromobility at public transport stations is crucial for a seamless integration. Fewer research has been devoted to the benefits of integrated payment systems. Ghasri *et al.* (2024) found a willingess-to-pay of AUD 0.55 per ticket for an integrated payment solution. Montes *et al.* (2023) conclude that collaboration between public transport and micromobility operators could benefit both, as well as the customer.

2.2 Micromobility and public transport bundles

One way to collaborate rather than compete are bundle offerings for public transport and micromobility. Yan *et al.* (2023) found that single-journey "scoot-N-ride" bundles with discounted pricing can promote a modal shift from the private vehicle in the United States. Their results show that this discount needs to be rather substantial ($3 scooter credit or a half price discount for the scooter fare) to be effective.
In addition to these bundles combining solely public transport and micromobility, a growing literature has focused on a holistic solution for replacing private vehicle ownership: Mobility-as-a-service (MaaS). MaaS is a transportation model that usually integrates various transport modes (e.g. public transport, car sharing, ride-hailing and micromobility) into a single platform. Through this platform, users can plan, book, and pay for their multimodal trips, choosing between different packages and pricing models (Jittrapirom *et al.*, 2017). Several studies have included micromobility options when investigating interest and willingess-to-pay for broader MaaS bundles. The results are inconclusive: Ho *et al.* (2020) found no increased willingess-to-pay when including bike sharing into a MaaS plan. Caiati *et al.* (2020) identified positive utility contribution for e-bike sharing only with a two-part tariff (monthly fee and 50% discount on standard fare), but not for unlimited rides or 1 free hour per day. Polydoropoulou *et al.* (2020) and Tsouros *et al.* (2021) state a relatively high WTP for unlimited bike sharing with 41€ and 27€, respectively.
Only limited research has been conducted on the inclusion of shared e-scooters in MaaS bundles. Krauss *et al.* (2023) found a significant utility increase of MaaS bundles when e-scooter density is high, but only a non-significant utility contribution from shared e-scooter minutes included in a MaaS plan.

2.3 Literature gap and contribution

The literature review emphasizes the need for enhanced understanding of the integration between public transport and shared micromobility systems, especially with the advent of e-bike and e-scooter sharing platforms. To enable CO2 emissions reductions, these systems must collaborate rather than compete. However, existing research into the bundling of micromobility and public transport remains inconclusive, with little examination of diverse bundling strategies. To date, there has been no comparative analysis of different tariff structures that exclusively combine public transport with shared micromobility services.

This paper makes two contributions: Firstly, it addresses this gap in the literature by evaluating consumer preferences for different tariff structures. Secondly, it investigates these preferences within the context of Switzerland, known for its extensive public transport network and significant user base. So far, single-journey micromobility bundles have not been studied in a European context.

These findings offer valuable insights for practitioners in public transport and micromobility sectors, facilitating the design of attractive and effective service offerings.

3 Data

3.1 Sample description

The study was conducted in Switzerland, which provides an interesting case due to its dense public transport network with a comparatively high share in the modal split, but still a high car ownership rate (Bundesamt für Statistik, 2022).

Participants were recruited from German-speaking municipalities with a shared micromobility offering (bike sharing, e-bike sharing, or e-scooter sharing). This restriction was imposed to ensure that participants can relate to shared micromobility. Availability was determined with public data from the Swiss government (Swiss Federal Office of Energy, 2024) and includes most major cities, as well as some smaller villages in the agglomeration of those.

The data set is comprised of two sources, both collected in March and April 2024: An online panel with quotas on the gender and age structure of the Swiss population (n = 923) and a community sample comprised of subscription customers from a public transport association (n = 456). While both sources suffer from potential participation- and self-selection bias (Bethlehem, 2010), the community sample might be more prone to this bias, as participants are not directly rewarded for their participation. In the following section, characteristics of both samples will be compared.

To ensure data quality, the following measures were applied:

- The minimum completion time was set to 300 seconds, around 50% of the median completion time determined in a pilot.
- Participants who failed an attention check question "Please select fully approve" were screened out.
- Repeated participation from the same IP address was manually checked and removed when the covariates age and gender were identical.
- When the respondent stated to be not interested in shared micromobility, but selected a bundle in the choice experiment, they were asked whether they have changed their mind. In case they were still not interested, the answer was altered to the opt-out option.

The survey consists of three sections. In the first section, participants are asked about their mobility behavior and transportation preferences. The second section includes stated choice experiments on subscription- and single-ride bundles. The final section gathers information on socio-demographic characteristics. "Agglomeration City" refers to people living in the core cities ("Kernstadt") of the 52 agglomerations.

Table 1: Sample Description

	Online Panel		Community Panel		Census Statistics	
	N	Sample %	N	Sample %	N	Sample %
Sample size	923	100.00%	456	100.00%		
Female	448	48.50%	270	59.20%		50.30%
Age						
18-29	145	15.70%	109	23.90%		16.50%
29-49	436	47.20%	130	28.50%		34.40%
50-65	185	20.00%	143	31.40%		25.70%
65+	157	17.00%	74	16.20%		23.40%
Agglomeration City	372	40.30%	322	70.60%		28.10%
Public Transport	372	40.30%	431	94.50%		19.60%
Shared micro use						
1: >1x /week	70	7.60%	6	1.30%		
2: 1x /month	92	10.00%	29	6.40%		
3: 1x /year	94	10.20%	43	9.40%		
4: <1x /year	96	10.40%	31	6.80%		
5: Pot. intr.	203	22.00%	133	29.20%		
6: Not intr.	318	34.50%	214	47.00%		

Median completion time panel: 508.54 seconds

Median completion time community sample: 600.75 seconds

Table 1 compares the sample characteristics with statistics from the Swiss census (Bundesamt für Statistik, 2023). To simulate market penetration of the bundles, these distributions are used to generate a dataset.

3.2 Methods

This study employs the methodology of a stated choice experiment (A), a popular approach in transportation research (Schatzmann *et al.*, 2024). The method was chosen for this research question because it closely simulates real-world decision-making processes, i.e. whether or not to purchase a bundle at a specific price point. Furthermore, this methodology allows for the systematic variation and control of bundle attributes to isolate their effects on consumer choices. Similar studies on transport bundles have also utilized this methodology (e.g. Yan *et al.* (2023), Krauss *et al.* (2023), Ho *et al.* (2020)).

3.2.1 Subscription-Bundle Choice Experiment

The subscription-bundle choice experiment examines three distinct micromobility tariff structures, introduced to participants in the study's introduction: unlimited rides (flat rate), 50% discount on the standard per-minute price, and minute quotas with free unlocks. These alternatives are comparable to those investigated by Caiati *et al.* (2020). Participants were informed that the packages would encompass both e-scooters and e-bikes, catering to diverse preferences and a broader demographic than e-scooters alone (Reck and Axhausen, 2021). Both modes typically share similar market pricing, which significantly surpasses that of non-motorized bike sharing options. For reference, the actual pay-as-you-go market prices prevalent in St. Gallen during February 2024 were presented for the opt-out option.
The price for the public transport subscription was fixed and based on the individual value provided by the participant. This is to measure only the added willingness to pay for micromobility, not the valuation of public transport. While the research primarily focuses on micromobility offerings for public transport subscribers, respondents without a public transport subscription were not excluded from the experiment. Instead, they were instructed to assume the presence of a free public transport subscription. This approach ensured that willingness to pay for micromobility remained uninfluenced by the cost of a public transport subscription that might not be necessary for them.
To minimize cognitive burden, only two of the three alternatives were displayed in each choice task, along with an opt-out option. Participants completed a total of four choice tasks, encompassing all possible combinations of alternatives and one randomly generated combination. The order of alternatives was randomized.
Attribute levels were established within a range extending up to the prevailing market price. To maximize information gain, a D-efficient experimental design was generated using Ngene, incorporating priors derived from a pilot study involving 100 participants ChoiceMetrics (2018). Constraints were implemented to prevent strictly dominant options in scenarios where unlimited rides were priced at or below the other packages.

Table 2: Attribute Levels for Subscription Bundles

	Flat rate	50% discount	Minute quotas
Price (CHF)	10, 20, 30, 40, 50	1, 5, 10, 15, 20	5, 10, 15, 20, 25, 30
Minutes included	Unlimited	—	50, 100, 200

3.2.2 Single-Ride Choice Experiment

In the single-ride choice experiment, participants were presented with a binary choice: purchase the bundle or opt only for the public transport ticket and walk, considering varying parameters of bundle price, walking time, and time of day. The price of the public transport ticket was fixed to CHF 4, a typical price for a single-ride journey within a larger city. While substituting walking may not be the primary objective in terms of system optimization, this simplified choice scenario reveals general interest and willingness to pay for these bundles. Similar to the subscription-bundle experiment, a D-efficient design was generated using Ngene, based on the pilot study.

Table 3: Attribute Levels for Single-Ride Bundles

Price (CHF)	Micro travel time min. (walking time)	Time of day
1, 2, 3, 4, 5	2 (5), 4 (10), 6 (15), 8 (20), 10 (25), 12 (30), 14 (35)	day, night

3.2.3 Estimation

Both models were estimated as mixed logit models using Pandas Biogeme in Python (Bierlaire, 2020). This model type offers the advantage of capturing random taste variation and unrestricted substitution patterns (Train, 2003). In all models, the alternative specific constants (ASC) and the cost parameter are defined as random coefficients.

For comparison, one general model incorporating only socio-demographic characteristics (age, gender, agglomeration center, and public transport subscription) was fitted. Additionally, another model was fitted that included the use frequency of shared micromobility, as described in the data section.

4 Results

4.1 Subscription Models

The results presented in Appendix B.1 reveal the utility contribution for various bundle packages: flat rate (flat), 50% discount (disc), and the 200 minutes package (min). The analysis also considers interactions with socio-demographic variables, comparing these bundles to the pay-as-you-go option (opt-out). Notably, the alternative-specific constants demonstrate positive and statistically significant values, indicating a general preference for bundles over the opt-out option. Among the bundle options, the flat rate package has a higher valuation than the 200-minute package, which, in turn, surpasses the 50% discount package in perceived value. Interestingly, no significant difference is observed between the 200-minute and 100-minute packages, while a 50-minute package exhibits significantly lower value. As expected, the cost coefficient emerges as negative and highly significant, indicating that an increase in bundle price reduces its likelihood of selection.

Participants from the community sample are significantly less likely to choose a bundle option. Among the socio-demographic variables, the age coefficient consistently shows a negative and significant relationship across all packages. This suggests that younger individuals are more likely to subscribe to micromobility bundles compared to older individuals. The slightly higher value of the flat rate age coefficient could imply a greater preference among older individuals for bundles with lower commitment levels, such as the pay-as-you-go option.

A similar pattern emerges with regard to gender, where males exhibit a significantly higher propensity to subscribe to the flat rate and discount packages, with a positive trend also observed for the 200-minute package. As anticipated from the experimental design, the possession of a public transport subscription bears no significance, given the assumption that non-subscribers get a free subscription. Lastly, no significant difference is found between respondents residing in agglomeration core cities and those in other municipalities.

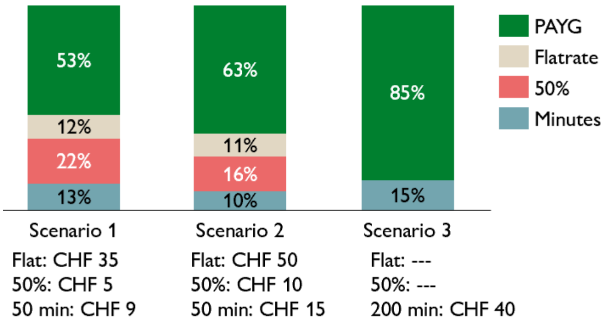
In model (1), which includes the use frequency of shared micromobility, the coefficients of this variable are predominantly highly significant, with one exception. Unsurprisingly, users who frequently utilize micromobility derive greater utility from a micromobility bundle compared to the reference category, which represents individuals not interested in using this mode of transportation. This confirms the intuitive expectation that existing users are more likely to see value in bundle offerings. However, both Rho-square and the Akaike Information Criterion show only marginal improvement in model (1) compared to the model without use frequency. Consequently, model (2) will be employed when simulating market penetration across the entire population, as there are no truly representative statistics on micromobility usage available.

The analysis also reveals considerable heterogeneity in preferences, indicated by the statistically significant sigma parameters for the alternative specific constants and the cost coefficient.

Simulation:

The choice probabilities for the different bundle packages were estimated with 5,000 individuals drawn from census data, as described in the Data section. For each individual a random beta was drawn from the distribution and the averages takes from 100 repetitions.

Figure 1: Scenario simulation

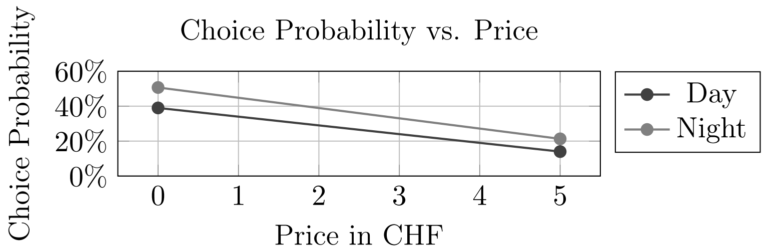


With an aggressive pricing, almost half (47%) of the individuals would select a bundle (1). Notably, the 50% discount package could achieve a high market penetration. At current market prices where only a 200 minutes package is offered at around CHF 40, the bundle would only be selected by 15%.

4.2 Single-Ride Models

The estimation results for the single-ride bundles (B.2) against the reference alternative walking show a very similar pattern as the subscription bundle. As with the subscription models, use frequency significantly increases the utility of the single-ride bundles.
Interestingly, purchase intention for bundles is notably higher at night. This could be due to safety concerns, convenience, or the desire for a faster travel option during late hours when public transport options might be limited. As expected, utility increases with travel time and decreases with cost, reflecting the trade-offs individuals make between time, money, and convenience.
Similar to the subscription model, there is significant heterogeneity in the preference for bundle purchasing and the sensibility for costs.
Simulation:
A simulation with 5,000 individuals drawn from census statistics as described in the Data Section and individual beta draws with 100 repetitions reveals a significant interest the the single-ride bundles (2). At a price point of CHF 2.50 and a micromobility travel time of 8 minutes (corresponding to a 20 minute walk), 26.6% would select the bundle during the day. This increases to 34.6% during the night.

Figure 2: Bundle selection (travel time = 8 min.)



5 Discussion and Conclusion

Bundled subscription models and single ride tickets may enhance the integration of shared micromobility with public transportation. They support the crucial first/last mile role of bike- and scooter-sharing systems without competing against or undermining public transport. Choice experiments have demonstrated significant interest in these options among Swiss residents when priced competitively. Switzerland as a country with a dense public transport network, but also high car ownership, seems to be open to intermodality. This aligns with Yan *et al.* (2023)'s findings and offers further insights into various bundle structures. Notably, there is substantial interest in the 50% discount "Halbtax"-style subscription, consistent with Caiati *et al.* (2020)'s observations on e-bike sharing. Many consumers would appreciate an affordable option to use shared micromobility, but hesitate to commit to more extensive packages, such as flat rates or large minute quotas. Nevertheless, these models also garner considerable interest. Single-ride options are especially attractive at night, highlighting their utility as a first/last mile solution when local public transport is scarce, and walking is either unpleasant or unsafe. Similar to the typical demographic of shared micromobility users (e.g., Reck and Axhausen (2021)), these bundles appeal predominantly to a younger, male audience. They seems to be similarly attractive for people living in the agglomeration core cities as well as their surroundings, possibly for commuting.

The substantial difference between the panel and community sample challenges the assumption of participation bias where more interested respondents engage in the survey. Conversely, panel participants may have exerted less effort in providing diligent responses, as suggested by shorter completion times.

Compared to the limited uptake for shared micromobility bundles in real-world pilots (e.g. Yumuv in Switzerland), the predicted willingness to buy seems to be overstated. A general problem of stated choice experiments is the hypothetical bias (e.g. Haghani *et al.* (2021)), which is likely also influencing this study. Still, the results are a promising indication for practitioners from public transport companies and shared micromobility providers to work on common offers that can benefit both by making intermodal travel more attractive. For a successful implementation, it is necessary to ensure a seamless infrastructure, both digitally and physically. Challenges also include a fragmented market with different micromobility providers and the question of financing bundle discounts. More real-world pilots could shed light on the actual acceptance of bundles.

6 Outlook & Future Research

This working paper for the STRC conference provides first insights into the study on shared micromobility and public transport bundling. Due to the limited scope, further additions will be made for the full paper.

Given the high hypothetical interest shown in this study, several approaches will be followed to gain a more realistic estimate of public interest.

After the stated choice experiments, participants were invited to take part in a lottery. They were asked whether they would choose a prize of CHF 30 as a voucher for shared micromobility, or a lower cash amount. Starting with CHF 1, the cash amount was increased until the respondent switched to cash. This revealed preference data on valuation of shared micromobility may help to correct for the hypothetical bias of the stated choice experiments and inform a more realistic estimate.

Over the course of the summer 2024, TIER and OSTWIND will offer the bundle packages outlined in this study. Purchase data of this pilot study will reveal general interest and relative preferences for the different packages.

Another research path might look into the mode split effects of the bundles. Are they contributing to increased use of public transport or are they merely replacing footpaths?

A Stated-Choice Experiment

Figure 3: DCE Subscription Bundle

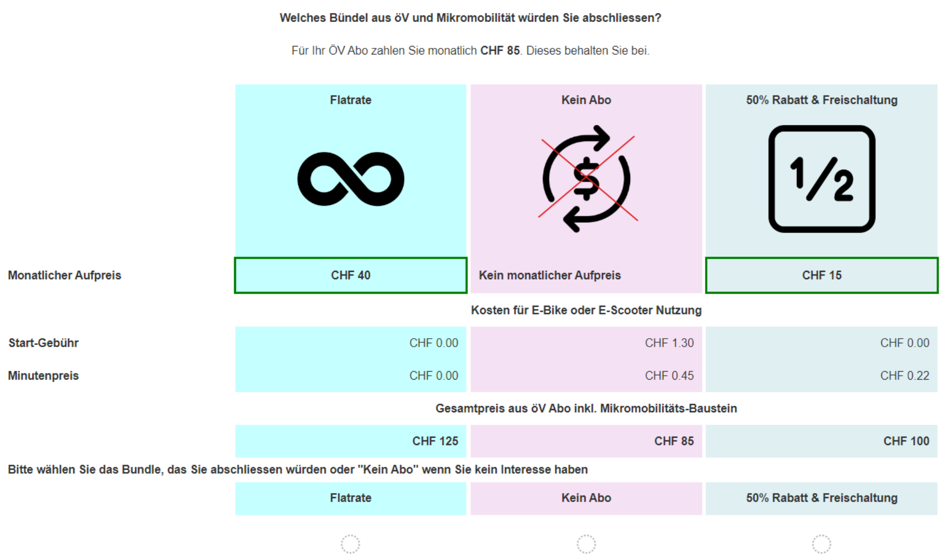
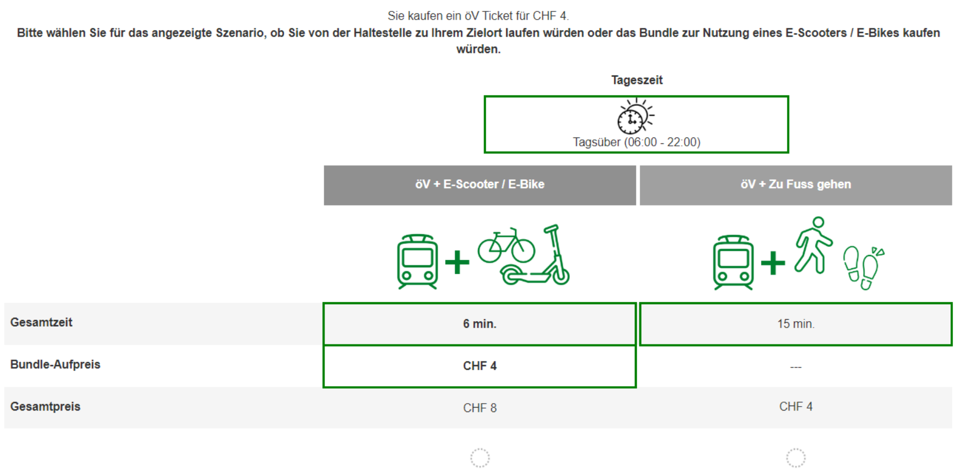


Figure 4: DCE Single Rides



B Model results

B.1 Subscription-bundles

Table 4: Model Fit Statistics for Subscription Bundle Models

Criterion	Model (1)	Model (2)
Sample size	1339	1339
Observations	5556	5556
Final log likelihood	-3858.04	-3994.56
Rho-square for the init. model	0.26	0.23
Rho-square-bar for the init. model	0.25	0.23
Akaike Information Criterion	7788.08	8031.11
Number of draws	3000	1000

Table 5: Parameter Estimates for Subscription Bundle Models

Parameter	Model (1)		Model (2)	
	Est.	Std. Err.	Est.	Std. Err.
cost	-0.15*	0.01	-0.17*	0.01
cost_sigma	0.14*	0.01	0.15*	0.01
community_sample	-5.44	0.58	-1.87*	0.24
agglo_center	0.15	0.21	0.04	0.22
asc_flat	4.92*	0.57	5.45*	0.56
asc_flat_sigma	2.05*	0.32	1.92*	0.29
male_flat	1.59*	0.33	1.60*	0.33
age_flat	-0.10*	0.01	-0.11*	0.01
ptsub_flat	-0.10	0.37	-0.49	0.36
flat_shift_freq1	4.36*	1.48		
flat_shift_freq2	5.44*	1.28		
flat_shift_freq3	2.14	1.13		
flat_shift_freq4	3.26*	1.21		
flat_shift_freq5	3.81*	0.76		
asc_disc	3.27*	0.40	3.93*	0.39
asc_disc_sigma	1.95*	0.14	2.02*	0.14
male_disc	0.55*	0.20	0.69*	0.20
age_disc	-0.08*	0.01	-0.09*	0.01
ptsub_disc	0.34	0.24	0.36	0.24
disc_shift_freq1	6.41*	1.36		
disc_shift_freq2	6.02*	0.87		
disc_shift_freq3	4.16*	0.73		
disc_shift_freq4	4.87*	0.79		
disc_shift_freq5	4.75*	0.63		
asc_min	4.26*	0.45	5.03*	0.45
asc_min_sigma	1.83*	0.16	2.01*	0.16
100min	0.14	0.18	0.16	0.18
50min	-0.60*	0.18	-0.63*	0.18
male_min	0.34	0.22	0.40	0.22
age_min	-0.09*	0.01	-0.10*	0.01
ptsub_min	-0.04	0.26	0.22	0.25
min_shift_freq1	4.46*	1.31		
min_shift_freq2	6.68*	0.95		
min_shift_freq3	5.44*	0.75		
min_shift_freq4	5.09*	0.82		
min_shift_freq5	5.05*	0.64		

* indicates significance at the 5% level

B.2 Single-ride bundles

Table 6: Model Fit Statistics for Single-Ride Bundle Models

Parameter	**Model (1)**	**Model (2)**
Sample size	1503	1503
Observations	4701	4701
Final log likelihood	-2029.52	-2284.85
Rho-square for the init. model	0.18	0.27
Rho-square-bar for the init. model	0.18	0.27
Akaike Information Criterion	4089.04	–
Number of draws	1500	1500

Table 7: Parameter Estimates for Single-Ride Bundle Models

Parameter	**Model (1)**		**Model (2)**	
	Est.	**Std. Err.**	**Est.**	**Std. Err.**
asc_bundle	-4.00*	0.50	0.99*	0.40
asc_bundle_sigma	1.96*	0.15	2.68	0.15
cost	-0.66*	0.05	-0.62*	0.05
cost_sigma	0.33*	0.07	0.14	0.15
night	1.14*	0.13	1.08*	0.13
traveltime	0.32*	0.02	0.31*	0.02
community_sample	-0.83*	0.25	-1.28*	0.28
age	-0.03*	0.01	-0.09*	0.01
agglo_center	-0.32	0.24	0.16	0.27
male	0.15	0.16	0.75*	0.18
asc_shift_freq1	5.16*	0.44		
asc_shift_freq2	5.50*	0.42		
asc_shift_freq3	4.33*	0.35		
asc_shift_freq4	3.37*	0.35		
asc_shift_freq5	3.85*	0.28		

* indicates significance at the 5% level

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Declaration: During the preparation of this work the author used ChatGPT 4 and Gemini 1.5 in order to improve the readability of this paper. After using these tools, the author reviewed and edited the content as needed and takes full responsibility for the content of the publication.

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