Car-Sharing Subscription Preferences: The Case of Copenhagen, Munich, and Tel Aviv-Yafo

Mayara Moraes Monteiro[a], Carlos M. Lima de Azevedo[a], Maria Kamargianni[b], Yoram Shiftan[c], Ayelet Gal-Tzur[c], Sharon Shoshany Tavory[c], Constantinos Antoniou[d], Guido Cantelmo[d]

[a]Technical University of Denmark, [b]University College London, [c]Technion, Israel Institute of Technology, [d]Technical University of Munich

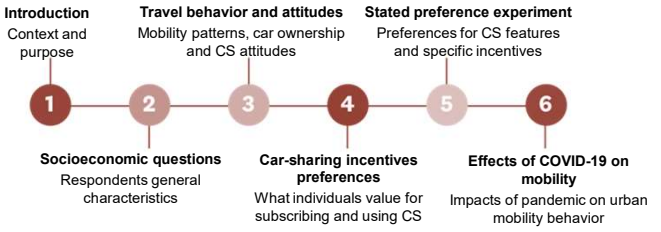
1. INTRODUCTION

Accumulating more than 32 million members, distributed across 47 countries and six continents (2018), car-sharing (CS) services have been providing short-term car access to their users [1]. Under the umbrella of sharing economy solutions, car-sharing aims at encouraging sustainable urban mobility, shifting the focus from personal ownership to demand-fulfillment shared use [2]. Yet, the analysis of how car-sharing service features affect car-sharing membership is limited, as previous studies have mainly focused on the influence of socio-demographic characteristics on it. Moreover, although recent literature has shown the potential of offering incentives to nudge individuals' towards more sustainable mobility patterns [3], to date, no study has explored whether incentives can increase the likelihood of subscribing to car-sharing services. Thus, the contribution of this paper is twofold: (i) further examining the impact of different business models on CS subscription in different contexts (cities); (ii) contribute to the literature of incentives for behavioral change by identifying relevant incentives to keep and attract CS members.

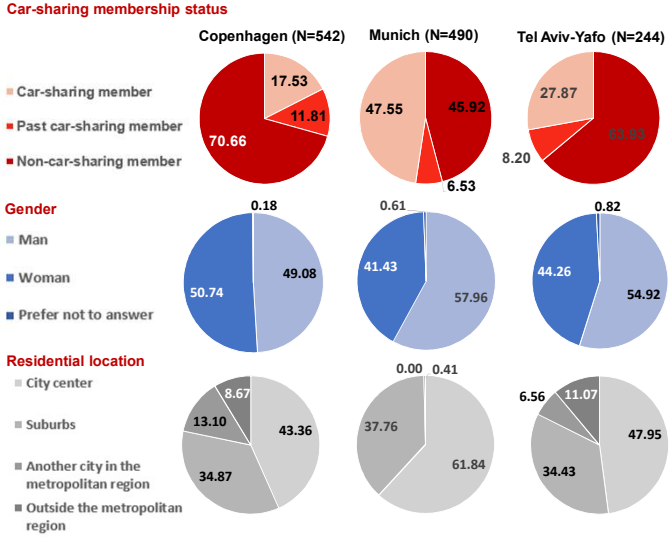
2. DATA

- Tailor-made online survey
- Simultaneous data collection (summer 2020): Copenhagen, Munich, and Tel Aviv-Yafo
- The cities were chosen due to their diverse transport systems, norms, and mobility cultures:
  - Copenhagen (CPH) has a strong bike culture [4];
  - Munich (MUN) has an extensive and well-developed public transport network [5];
  - Tel Aviv-Yafo (TLV) mobility relies on private cars and public buses [6].
- Stated-preference choice experiment
- COVID-19 related questions (During data collection, none of the cities was facing lockdown)

Online Survey



Sample characteristics



3. MODEL SPECIFICATION

The model estimated is a joint mixed logit model (PandasBiogeme [7]) with data from the three cities, accounting for correlation among choices of the same individual over the SP experiment (panel effect) [8]. As the variance of the error term (unobserved factors) is likely to vary among the three datasets (different cities) [8], we have set the overall scale of utility by normalizing Copenhagen and included scale parameters (θ^c) to allow for estimating the variances of Munich and Tel Aviv-Yafo relative to Copenhagen. The utility specification is defined in **Equation 1**:

$$U_{int}^c = \theta^c(ASC_i^c + \beta_{ix}^c X_{int} + \beta_z^c Z_n + \alpha_{in}^c + \sigma_{CSplans}^c + \varepsilon_{int}^c)$$
$$U_{0nt}^c = \theta^c(\varepsilon_{0nt}^c) \quad (1)$$

where:

U_{int}^c is the utility that each individual *n* from city c associate to alternative i in the choice situation *t*
ASC_i^c is the alternative specific constant, which captures the average effect on the utility of all factors not included in the model.
β_{ix}^c and β_z^c are the vectors of the coefficients associated with the impact of the service-related attributes included in the choice experiment (X_{int}) and the socioeconomic variables (Z_n) on the utility.
α_{in}^c are error components normally distributed across individuals, which capture the correlation among choices for the same individual (panel effect)
$\sigma_{CSplans}^c$ captures the magnitude of the correlation between the alternative car-sharing plans in each city
ε_{int}^c is the i.i.d. extreme value error component.

4. RESULTS

Coefficients were tested across cities for significant differences (likelihood ratio test and t-test)

	Copenhagen		Munich		Tel Aviv-Yafo	
Variable	Estimate	Rob. Std err	Estimate	Rob. Std err	Estimate	Rob. Std err
ASC – OWFF	4.96***	1.06	6.37***	1.24	1.66***	0.604
ASC – OWST	4.95***	1.06	5.8***	1.24	1.66***	0.593
ASC - P2P	5.65***	1.07	6.53***	1.34	1.5**	0.594
ASC – RT	5.06***	1.06	5.23***	1.23	1.47**	0.576
$\alpha_{\text{panel effect}}$ **– OWFF**	1***	0.189	1.97***	0.437	-0.159	0.249
$\alpha_{\text{panel effect}}$ **– OWST**	1.04***	0.218	1.17*	0.645	0.134	0.293
$\alpha_{\text{panel effect}}$ **- P2P**	0.818***	0.218	2***	0.489	0.612***	0.17
$\alpha_{\text{panel effect}}$ **– RT**	0.694***	0.25	2.91***	0.574	0.916***	0.204
$\beta_{\text{One time subscription cost}}$	-0.899***	0.101	-0.899***	0.101	-0.899***	0.101
$\beta_{\text{Usage cost (OWFF, OWST, RT)}}$	-0.092***	0.0246	-0.619***	0.106	-0.092***	0.0246
$\beta_{\text{Usage cost (P2P)}}$	-2.64***	0.33	-10.1***	1.98	-2.64***	0.33
$\beta_{\text{Usage cost per day}}$	-0.904***	0.148	-0.904***	0.148	-0.338***	0.0959
$\beta_{\text{Usage cost per hour}}$	-0.405***	0.146	-0.213***	0.079	-0.213***	0.079
$\beta_{\text{Only combustion cars}}$	-0.243***	0.0674	-1.17***	0.258	-0.243***	0.0674
$\beta_{\text{Only electric cars}}$	0.0069	0.0989	-0.123	0.202	-0.0708	0.0614
$\beta_{\text{Only small and sedan cars}}$	-0.0282	0.108	0.54**	0.225	0.0724	0.0715
$\beta_{\text{Small, sedan and SUV cars}}$	0.151	0.105	0.205	0.212	0.117*	0.0704
$\beta_{\text{Probability of finding a shared car}}$	0.935**	0.383	2.28***	0.745	0.374	0.228
$\beta_{\text{Walking time to access the vehicle}}$	-0.0101	0.0106	-0.0317***	0.00907	-0.0317***	0.00907
$\beta_{\text{Walking time from parking location to destination}}$	-0.0197***	0.00641	-0.078***	0.0226	-0.0197***	0.00641
$\beta_{\text{Incentive: Booking in advance}}$	0.226*	0.132	0.599**	0.262	0.000352	0.0784
$\beta_{\text{Incentive: Guaranteed child car seat availability}}$	0.469*	0.276	1.35***	0.517	0.108	0.138
$\beta_{\text{Incentive: Collect credits to redeem for goods (e.g., clothing and grocery discounts)}}$	0.16	0.131	0.0581	0.27	-0.0555	0.0851
$\beta_{\text{Incentive: Family/friends account with discounted rates}}$	0.19	0.134	0.75***	0.271	0.0124	0.0867
$\mu_{\text{Incentive: Plan including other modes for a seamless door to door trip}}$	0.3**	0.134	0.453*	0.268	0.0233	0.0917
$\sigma_{\text{Incentive: Plan including other modes for a seamless door to door trip}}$					0.366*	0.21
β_{Age}	-1.04***	0.163	-1.04***	0.163	-0.122	0.0744
$\beta_{\text{Car-sharing membership}}$	1.15*	0.682	2.2***	0.792	0.857***	0.27
$\beta_{\text{High income – household}}$	-0.48	0.64	-1.17	0.842	-0.608**	0.304
$\beta_{\text{Low income – household}}$	0.472	0.845	0.878	1.55	-0.816**	0.357
$\beta_{\text{Missing income – household}}$	-0.218	0.813	-2.33**	1.01	-0.858**	0.36
$\beta_{\text{Household with children up to 12 years}}$	1.66***	0.556	1.66***	0.556	-0.212	0.2
σ_{Csplans}	4.81***	0.443	5.8***	0.919	0.935***	0.223
Scale (Θ) [a]			0.543***	0.0746	2.31***	0.45

*** Significant at 1% level
** Significant at 5% level
* Significant at 10% level
[a] T-test against 1

	Goodness of fit
Number of observations	3737
Number of individuals	1276
Number of draws	5000
Number of estimated parameters	88
Log-likelihood	-4796.552
Null log-likelihood	-6014.469
Rho-square	0.202
Adjusted rho-square	0.188

Car-sharing plans features:

- The payment per minute (reference level) is preferred, followed by hourly thereafter daily rates
- More sensitivity in MUN to walking times and fleet engine-type (stronger environmental concern)
- Lower sensibility to walking times in CPH, which may be related to a stronger active mobility culture
- TLV's respondents prefer varied fleets with small, sedan, and SUV cars

Incentives (reference: business account with discounted rates):

- In CPH and MUN there is a preference for *booking in advance* and *guaranteed child car seat*
- CPH, MUN, and most respondents from TLV, prefer having a *plan including other modes (MaaS)*
- Having a *family/friends account with discounted rates* is preferred over the reference only in MUN

Socio-economic characteristics:

- Significant negative age parameters in CPH and MUN (older adults are less likely to subscribe)
- Income was only significant for TLV
- Individuals in CPH and MUN living with children up to 12 yrs. are more likely to subscribe

5 CONCLUSIONS

- Marketing campaigns focusing on positive environmental consequences of car-sharing usage should appeal highly in Munich, especially if supported by data/studies
- Special attention to the popularity of the location is needed when deciding on where to allocate reserved parking spaces for car-sharing, especially in CPH (parking at destination)
- For the TLV market, beyond providing a varied shared cars fleet (small, sedan, SUV cars), good parking conditions are highly appreciated to decrease the parking pressure and increase ridership
- The analysis of the socio-demographic variables reveals the potential of marketing campaigns targeting young individuals with children in CPH and MUN and mid-income individuals in TLV
- As for incentives, individuals in CPH and MUN prefer *booking in advance*, *guaranteed child car seat*, and *plans including other modes (MaaS)*, the latter being also preferred by most respondents in TLV
- Future research replicating the study in other cities (and continents) can expand our perspective on the differences and similarities of the car-sharing markets across the world

REFERENCES

[1] S. Shaheen, A. Cohen, and M. Jaffee, "Innovative Mobility: Carsharing Outlook - Worldwide carsharing growth," 2020. doi: 10.7922/G2125QWJ.

[2] Z. Mi and D. M. Coffman, "The sharing economy promotes sustainable societies," *Nat. Commun.*, vol. 10, no. 1, pp. 5–7, 2019, doi: 10.1038/s41467-019-09260-4.

[3] C. L. Azevedo *et al.*, "Tripod: Sustainable Travel Incentives with Prediction, Optimization, and Personalization," *97th Annu. Meet. Transp. Res. Board*, vol. 1, p. 19, 2018.

[4] Københavns Kommune, "City of Cyclists," 2020. https://urbandevelopmentcph.kk.dk/artikel/city-cyclists (accessed Apr. 30, 2020).

[5] Referat für Stadtplanung und Bauordnung - Landeshauptstadt München, "Mobilität in Deutschland - MiD," 2017. [Online]. Available: www.mobilitaet-in-deutschland.de.

[6] N. Sharav, M. Szeinuk, and Y. Shiftan, "Does your city need a metro? – A Tel Aviv case study," *Case Stud. Transp. Policy*, vol. 6, no. 4, pp. 537–553, 2018, doi: 10.1016/j.cstp.2018.07.002.

[7] M. Bierlaire, "A short introduction to PandasBiogeme," 2020.

[8] K. E. Train, "Discrete choice methods with simulation," Discrete. Choice Methods with Simulation., vol. 9780521816, pp. 1–334, 2003, doi: 10.1017/CBO9780511753930.

SPONSOR: eit Urban Mobility

Co-funded by the European Union