Designing MaaS Packages based on User Group Patterns

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SHORT SUMMARY

The advancement of technology and the introduction of shared mobility solutions enable the introduction of Mobility as a Service (MaaS), a solution integrating multiple transportation services into a single application. However, current methods for designing MaaS packages often overlook the diversity of traveler groups. This study addresses this research gap by analyzing MaaS adoption using a two-wave survey among university students in Budapest, Hungary, incorporating stated preference experiments. Participants expressed preferences for general or personalized packages, such as PT-micro packages. A mixed logit model was applied to examine choice behavior. The findings reveal that personalized packages significantly enhance MaaS adoption, with all transport modes in PT-micro packages positively influencing uptake. This approach highlights the value of considering traveler heterogeneity, providing useful insights for MaaS operators in designing tailored packages to meet diverse user needs.

Keywords: design; heterogeneity; Mobility as a Service; MaaS packages

1. INTRODUCTION

Travelers have various transportation options, and shared mobility services are getting popular in cities worldwide. While it might be true that shared mobility services can substitute the need to use private vehicles (Sopjani et al., 2020), provide first/last mile services (Wang et al., 2021), and decrease traffic congestion (Bösehans et al., 2023) as well as greenhouse gas emissions (Chen et al., 2020), travelers might find it challenging to use a wide range of transport opportunities in a city (Kamargianni et al., 2016) since each shared mobility has its exclusive functionalities (Esztergár-Kiss et al., 2020). Mobility as a Service (MaaS) is introduced to integrate various transportation services into one single service and provide seamless multimodal trips (Guidon et al., 2020). The mobility solutions propose that the integrated service should be accessible via a unified pricing system thus enabling customers to access all available modes by subscribing to predefined plans, a.k.a. MaaS packages (Reck et al., 2020). The packages can help intensify the use of less popular yet more environmentally friendly transport modes (e.g., e-scooter-sharing or bike-sharing) and decrease the use of private cars (Matyas & Kamargianni, 2019b).

Creating MaaS packages is challenging since they should fit the users' diversity and depend on their individual circumstances (Matyas & Kamargianni, 2019a). Respondents' travel patterns are generally used to design MaaS packages where the attribute levels are pivoted around the travelers' current travel records (Feneri et al., 2022; Ho et al., 2018; Kim et al., 2021; Matyas & Kamargianni, 2019b). Other studies (Caiati et al., 2020; Tsouros et al., 2021) let the participants create their MaaS packages based on given attributes, but this approach might result in high administrative costs due to managing several bundles.

Previous studies (Ho et al., 2018, 2020, 2021) identify some critical aspects of designing MaaS including tailoring MaaS bundles based on people's segment preferences. Therefore, current study builds further on preceding studies on MaaS bundles and their recommendations by creating packages based on the different patterns of user groups. This could be a useful strategy to boost the uptake of MaaS bundles without causing unnecessary administrative expenses.

Addressing the identified research gaps, this study proposes a novel approach to designing MaaS packages by conducting a two-wave survey with SP experiments and integrating clustering analysis with logit models. This method enables the development of more personalized mobility packages for specific groups while allowing for an analysis of the differences in uptake and preferences for services within MaaS packages.

2. METHODOLOGY

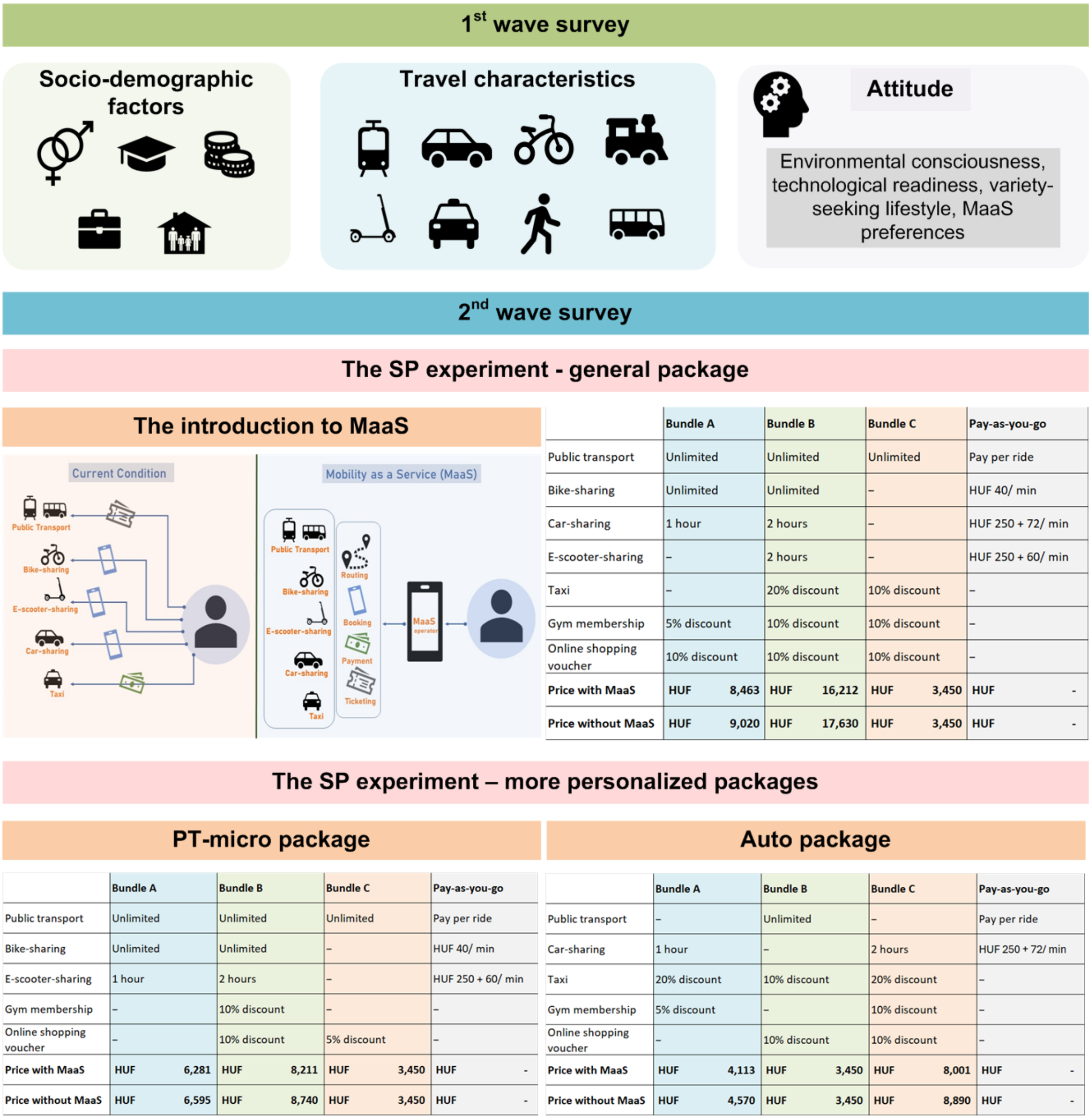
The study is conducted at Budapest University of Technology and Economics (BME), Hungary's largest technical university, located near the Danube River and within walking distance of the city center. The university is well-connected by multiple transport modes, with several bus stops, tram stops, and a metro station nearby. Shared micro-mobility options, including bike-sharing and e-scooter-sharing, have collection and drop-off points around the campus. Additionally, the university offers bicycle racks and car parking spaces conveniently located at the campus.

The overall design of the survey is presented in Figure 1. The first wave of the survey is distributed to college students via various university mailing lists. Students are invited to participate voluntarily. A total of 712 students completed the survey, with 687 responses deemed valid. In the second wave of the survey, the participants who agree to join are contacted via email. In the second wave, 181 respondents participated, with 127 valid responses after excluding incomplete entries. This survey focused on preferences for various MaaS bundles, featuring a stated choice experiment where participants evaluated six different scenarios. Table 1 outlines the mobility services included in the bundles and the attribute levels. The attributes are systematically varied across scenarios and respondents. The choice experiment is designed using the "rotation.design" function from the "support.CEs" package in R, which results in six questions for each block.

Table 1: The attributes and their levels

Mode	Attribute	Attribute level
Bike-sharing	Unlimited days of use	0 / 30
Car-sharing	Hours of car-sharing use	0 / 1 / 2
E-scooter-sharing	Hours of e-scooter-sharing use	0 / 1 / 2
Taxi	Discount per ride	0% / 10% / 20%
Add-ons:		
Online shopping voucher	Discount	0% / 5% / 10%
Gym membership	Discount	0% / 5% / 10%
Bundle price	Based on the attribute levels for each bundle	

The second round of the stated choice experiment consists of the MaaS bundles tailored based on the characteristics of each cluster. The heterogeneity analysis results in three traveler clusters named after the usage patterns of the transport modes: PTC (i.e., PT, train, and coach), PBS (i.e., PT, bike, and shared transport modes), and C (i.e., car). Figure 2 illustrates the features of the identified clusters. It is worth mentioning that the latent class cluster analysis is performed to identify the participants' heterogeneity. The detailed results of the clustering analysis are available in the paper of Kriswardhana and Esztergár-Kiss (2024a).



The SP experiment - general package

	Bundle A	Bundle B	Bundle C	Pay-as-you-go
Public transport	Unlimited	Unlimited	Unlimited	Pay per ride
Bike-sharing	Unlimited	Unlimited	–	HUF 40/ min
Car-sharing	1 hour	2 hours	–	HUF 250 + 72/ min
E-scooter-sharing	–	2 hours	–	HUF 250 + 60/ min
Taxi	–	20% discount	10% discount	–
Gym membership	5% discount	10% discount	10% discount	–
Online shopping voucher	10% discount	10% discount	10% discount	–
Price with MaaS	HUF 8,463	HUF 16,212	HUF 3,450	HUF -
Price without MaaS	HUF 9,020	HUF 17,630	HUF 3,450	HUF -

PT-micro package

	Bundle A	Bundle B	Bundle C	Pay-as-you-go
Public transport	Unlimited	Unlimited	Unlimited	Pay per ride
Bike-sharing	Unlimited	Unlimited	–	HUF 40/ min
E-scooter-sharing	1 hour	2 hours	–	HUF 250 + 60/ min
Gym membership	–	10% discount	–	–
Online shopping voucher	–	10% discount	5% discount	–
Price with MaaS	HUF 6,281	HUF 8,211	HUF 3,450	HUF -
Price without MaaS	HUF 6,595	HUF 8,740	HUF 3,450	HUF -

Auto package

	Bundle A	Bundle B	Bundle C	Pay-as-you-go
Public transport	–	Unlimited	–	Pay per ride
Car-sharing	1 hour	–	2 hours	HUF 250 + 72/ min
Taxi	20% discount	10% discount	20% discount	–
Gym membership	5% discount	–	10% discount	–
Online shopping voucher	–	10% discount	10% discount	–
Price with MaaS	HUF 4,113	HUF 3,450	HUF 8,001	HUF -
Price without MaaS	HUF 4,570	HUF 3,450	HUF 8,890	HUF -

Figure 1: The design of the survey

Cluster	Socio-demographic characteristics	Travel characteristics	Attitudinal characteristics
1. PT – train – coach (PTC)	Female students aged less than 23 from lower income households	**PT**: more than once a day **Train**: several times per month **Coach**: Once per month	Risk avoiders
2. PT – bike – shared transport modes (PBS)	Male undergraduate students having no cars	**PT**: more than once a day **Bike**: several times per month **Shared transport mode**: few times per year	Potential MaaS adopters with environmentally friendly and variety-loving behavior
3. Car (C)	Working male postgraduate students aged more than 23 with high income and having at least one car	**Car**: Once per day	MaaS sceptics with low environmental concerns and high technological readiness

Figure 2: The characteristics of the clusters

Figure 3 shows the steps of the analysis. Based on the characteristics of the clusters, two different bundles are constructed, i.e., PT-micro and Car bundles. The PT-micro bundle considers the characteristics of the PTC and PBS clusters. The clusters share similarities where the individuals are frequent PT users. However, since the mobility packages are valid in the urban area, trains and coaches are omitted.

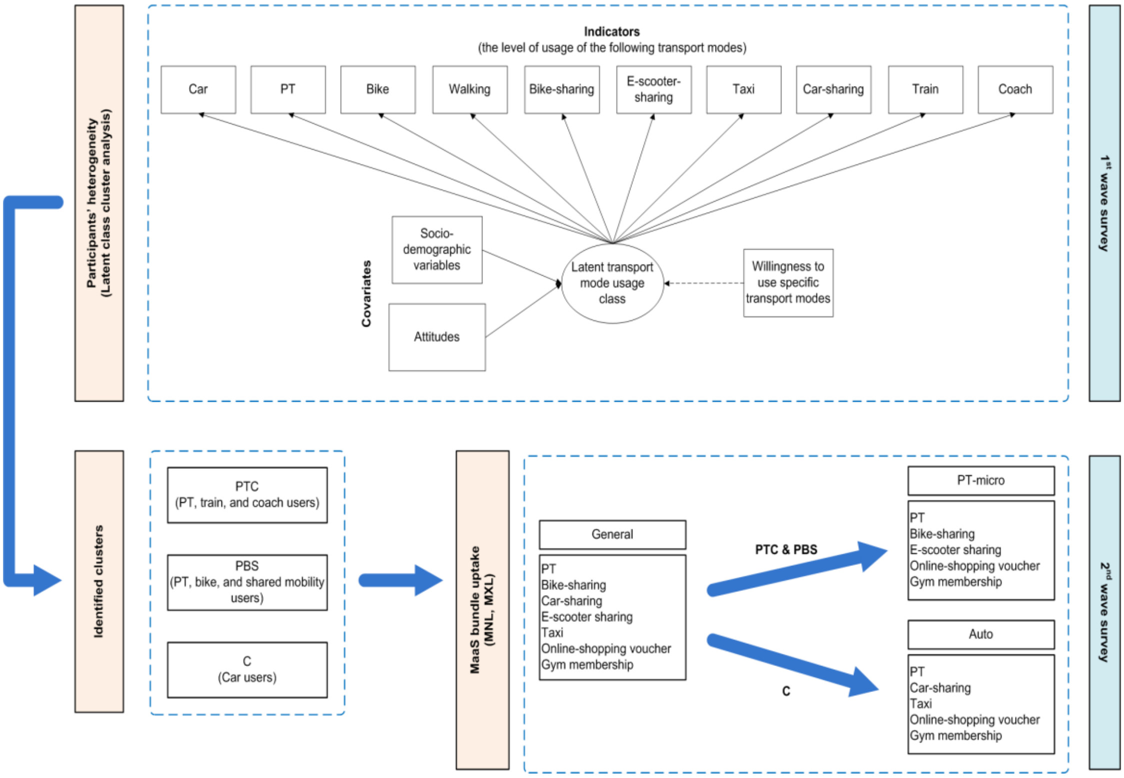


Figure 3: The analysis framework

Initially, the preferences for MaaS bundles are examined by using a standard multinomial logit model (MNL), which is followed by the application of a mixed logit model (MXL) to account for the random heterogeneity in the preferences. The models are estimated by using maximum likelihood with 1000 modified Latin hypercube sampling (MLHS) draws (Hess et al., 2006) in the R APOLLO package (Hess & Palma, 2019).

3. RESULTS AND DISCUSSION

In general, the respondents have similar characteristics in the first and the second surveys. The majority of the participants in both surveys are male (i.e., 68% and 66%, respectively) and undergraduate students (i.e., 65% and 68%, respectively) aged 23 or younger (i.e., 73% and 77%, respectively). This aligns with the BME Facts and Figures data (BME, 2021), which report that 69% and 61% of the students are male and undergraduate, respectively.

Table 2 illustrates the estimated coefficients where both the MNL and MXL modeling results are included for comparison. It is worth mentioning that the alternative specific constant (ASC) for PAYG is kept fixed as a base value. Two MXL models are estimated. The MXL-1 model includes the primary attributes, while the MXL-2 model extends the base model by including the interactions between socio-demographic factors and attributes related to transport modes.

The positive ASCs suggest unobserved tendencies toward the MaaS packages. Although MaaS packages are favored in general, the percentage of the PT-micro package chosen by the participants is higher than for the General package (i.e., 93.68% vs 89.92%), which means that among the respondents, the PT-micro package is more favorable than the General package. This means that mobility packages should be designed to accommodate the heterogeneity in the travelers' preferences thus improving the MaaS uptake.

Table 2: Estimation results

Variable	General		General		PT-micro		General		PT-micro	
	MNL		MXL-1A		MXL-1B		MXL-2A		MXL-2B	
	Estimate	Sig.	Estimate	Sig.	Estimate	Sig.	Estimate	Sig.	Estimate	Sig.
Bike sharing	0.612	***	0.755	***	1.985	***	0.249	*	1.028	***
Car sharing	−0.117		0.027		–		−0.318	*	–	
E-scooter-sharing	−0.396	**	−0.366	***	0.405	**	−0.417	***	0.408	*
Taxi (no disc.)	base		base		base		base		–	
Taxi (10% disc.)	−0.235	***	−0.187	*	–		−0.175	*	–	
Taxi (20% disc.)	0.197	**	0.210	*	–		0.238	**	–	
Gym (no disc.)	base		base		base		base		base	
Gym (5% disc.)	0.070		0.078		0.262	**	0.093		0.274	**
Gym (10% disc.)	0.164	**	0.132		0.766	***	0.146	*	0.766	***
Shop (no disc.)	base		base		base		base		base	
Shop (5% disc.)	0.321	***	0.338	***	0.271	***	0.354	***	0.283	***
Shop (10% disc.)	0.511	***	0.433	***	1.141	***	0.442	***	1.150	***
Plan price (μ)	−0.138	*	−1.795	***	−0.083		−1.967	***	−0.149	
Plan price (σ)	–		0.956	***	−0.592		0.956	***	0.658	***
Interactions										
Bike−sharing x male	–		–		–		0.570	***	0.886	***
Car−sharing x male	–		–		–		−0.126			
E−scooter−sharing x male	–		–		–		−0.227	***	−0.511	**
Bike−sharing x allowance	–		–		–		0.207		0.598	***
Car−sharing x allowance	–		–		–		0.486	***		
E−scooter−sharing x allowance	–		–		–		0.211	**	0.283	*
ASC bundle (μ)	2.216	***	4.812	***	10.950	***	5.622	***	7.916	***
ASC bundle (σ)			2.185	***	−3.896	***	2.282	***	−3.900	***
Adj. Rho-square	0.182		0.240		0.378		0.243		0.382	
LL(final)	−832		−770		−632		−762		−632	
AIC	1688		1568		1283		1562		1274	
BIC	1738		1628		1329		1649		1339	
% package chosen	89.92		89.92		93.68		89.92		93.68	

Note: statistically significant at 5% (***), 10% (**), and 15% (*).

The inclusion of bike-sharing positively impacts the adoption of MaaS packages. Similarly, discounts on gym memberships and online shopping vouchers significantly increase participants' willingness to purchase these packages. A key difference between the General and PT-micro packages lies in e-scooter-sharing. While e-scooter-sharing negatively affects the adoption of the General package, it has a positive influence when included in the PT-micro package. Participants also value larger discounts on taxi fares.

The study highlights that tailoring MaaS packages based on individual characteristics can shift preferences for shared modes within the packages. For instance, e-scooter-sharing, which deters adoption in the General package, becomes a driver of uptake in the PT-micro package. In the General package, participants prefer lower costs, as indicated by the negative price parameter. The General package reflects existing city transport options, whereas the PT-micro package is designed around participants' transport preferences. This approach is argued to be more effective for increasing MaaS adoption at a group level while minimizing time and administrative costs.

The findings suggest strategies for mobility package design, emphasizing personalization. The PT-micro package shows higher acceptance than the General package. Before offering packages, MaaS operators should collect socio-demographic and travel data to provide personalized options. However, allowing travelers to design their own packages could lead to overestimated needs, unused credits, and high administrative costs. Group-level personalization offers a practical solution to avoid these issues while increasing uptake.

The study's limitation lies in the representativeness of the data, as the sampling method may introduce bias. Thus, the results should be interpreted cautiously. This research serves as an initial effort to explore how personalized MaaS packages influence adoption and preferences for included services.

4. CONCLUSIONS

The primary objective of promoting MaaS bundles is to support the use of PT services and encourage sustainable travel behavior. However, the diverse travel characteristics might hinder the optimal adoption of MaaS packages as travelers are unlikely to purchase packages that are not suitable for them. Therefore, this study aims to provide insights into designing MaaS packages that travelers are more likely to accept. By drawing data from the students at a university while using a two-wave survey and two SP experiments, this study gives an initial look at a novel method to design mobility packages. The results demonstrate that a more personalized MaaS package is more preferred than the General package. Moreover, more personalized bundles could potentially alter the travelers' preferences for certain transport modes. Thus, current research underscores the importance of considering travelers' heterogeneity when creating MaaS packages. These insights can provide information on how to design future MaaS packages.

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