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Determinants of shared moped mode choice

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A R T I C L E I N F O

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A B S T R A C T

A plethora of shared fleet services have been introduced in cities worldwide. Despite their increased presence in urban areas, it is insofar unknown what are the main determinants of travellers' choices between the usage of shared-mopeds and cars and thereby the extent to which shared moped can substitute car travel. To this end, we design and conduct an SP choice model experiment. The estimated Panel Mixed Logit model is applied to explore the potential market share for shared moped, car and bike under several scenarios which are devised based on the expert interviews. Our findings demonstrate that the return availability of shared moped is the most influential travel time attribute. Walk time from home to the shared moped is an influential factor for people without moped experience. Moreover, model estimation results show that people who have used a shared moped before value the attributes differently than people without previous moped experience. We specifically focus on choice determinants and policy measures targeting car users to facilitate desirable behavioural changes. We present results from model application to demonstrate the effect of different policy packages on the market share of each mode, showing that certain policy interventions can attract car users to switch to shared moped while avoiding a strong reduction in bike use.

1. Introduction

Cities are constantly confronted with a pressing demand for mobility on one hand and scarcity of public space on the other. Shared mobility may play an instrumental role in reducing the demand for private vehicle short distance travel (Abduljabbar et al., 2021). Shared mobility enables users to gain short-term access to transport modes on an on-demand basis (Shaheen, 2019) and has the potential to fulfill some of their mobility needs.

The rapid deployment of shared mobility services has been accompanied by increased research attention in the past few years. Empirical research into user behaviour, traveller preferences and market segmentation has focused on carsharing and bikesharing. Users have been found to be primarily young, highly educated people with higher incomes, for bikesharing (Fishman, 2016), as well as carsharing services (Burghard and Dütschke, 2019; Clewlow, 2016; Winter et al., 2020), although a lower income user group for carsharing was also found (Lempert et al., 2019). Motivations to join a bikesharing (Fishman, 2016; Fishman et al., 2015) or carsharing (Lempert et al., 2019; Standing et al., 2019) system primarily relate to financial savings and convenience, with environmental motives also being identified as a driver for carsharing (Truffer, 2003). Ease-of-use and accessibility, defined in terms of sign-up procedures and walk time respectively, have been found to be important themes that can constitute a barrier to join in case a traveller has a negative perception of these elements, in particular for bikesharing services (Fishman, 2016; Fishman et al., 2012; 2015; Hess and Schubert, 2019; Whittle et al., 2019). Other factors, associated particularly with the attractiveness of carsharing services, are their compatibility with daily life, reliability, data privacy, convenience, and parking hassle (Burghard and Dütschke, 2019; Rahimi et al., 2020; Winter et al., 2020). There is empirical evidence in support of the proposition that shared-use vehicle systems have the potential to alter mobility behaviour. Carsharing in particular has been linked to higher modal shares for public transport, cycling, and walking and reduced private car use (Clewlow, 2016; Lempert et al., 2019; Zhou et al., 2020).

Next to carsharing and bikesharing, shared moped (or scooter) services have emerged over the last decade, and their uptake has strongly accelerated in recent years (Aguilera-García et al., 2020). Moped-sharing in its current form entails a fleet of free-floating vehicles that can be reserved, unlocked and locked via an app and charges users on a per minute basis, just as many currently operational bikesharing and carsharing systems (Namazu and Dowlatabadi, 2018). To the best of our knowledge, Aguilera-García et al. (2020) and Reck et al. (2022) are the only studies that have analysed usage patterns of shared-mopeds.

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They investigated users' characteristics as well as their motivations to use them. Shared moped users were found to be young and highly educated, although its use seems to penetrate also other age groups. The main stated reasons for using the shared mopeds were easy parking, no traffic jams, and a well-working service. Recent findings suggest that shared e-scooters may not necessarily contribute to urban mobility and climate goals. (Luo et al., 2021) conclude from their modelling results that e-scooters are likely to substitute bus trips and the empirical findings of Reck et al. (2022) show that the substitution effect of shared e-scooters (and e-bikes) results with a net increase in CO2 emissions.

Several governments have been operating pilot or full-scale shared e-mobility systems and are quickly expanding available services, including shared mopeds (Liao and Correia, 2020). Governments in the Netherlands are currently stimulating the use of micro-mobility, including shared e-mopeds, for short urban trips (two to five km), as just under half of short urban trips are made by car (Duursma, 2020). As there are multiple shared-moped operators currently present in the Netherlands, there is a particular need for quantitative-oriented research that offers insight into the trade-offs made in relation to shared-moped travel choices (Cherry and Pidgeon, 2018).

Despite their increased presence in urban areas, it is insofar unknown what are the main determinants of travellers' choices between shared moped fleets and car. Understanding the relevant trade-offs between the two modes will allow identifying the extent to which shared moped can substitute car travel. The latter is the prime objective of many urban mobility strategies. To this end, we conduct a mode choice experiment using Stated Preference (SP) data. Potential mode choice determinants are first explored by means of a focus group and are then specified in an SP experiment. Results from the SP experiment serve as input for expert interviews which are then used to formulate concrete policy measures. We specifically focus on choice determinants and policy measures targeting car users to facilitate desirable behavioural changes. We present results from model application to demonstrate the effect of different policy packages on the market share of each mode.

The remainder of this paper is structured as follows. The methodological specifications are presented in the following section. Next, we present the estimation results of a Panel Mixed Logit model. The implications of the model are then demonstrated using a scenario analysis. We conclude by discussing the key findings, study limitations and recommendations for further research.

2. Methodology

We design and conduct an SP choice experiment. Given the novelty of the mode under consideration, shared e-mopeds, little is known about the variety of potential mode choice determinants. We therefore start by exploring the determinants that are potentially relevant for (potential) moped users when making a mode choice involving a shared moped and car, by means of a focus group. The results are then used in designing a SP mode choice experiment. A choice model is estimated to quantify the impact of each attribute on mode choices. Results from this choice model are then used as input for expert interviews that are instrumental in formulating concrete policy measures. Furthermore, the model is applied to evaluate the impact of different policy packages on the market share of shared mopeds.

2.1. Pre-experiment focus group

A focus group is a qualitative research method involving a group of people who are asked to share their views, ideas and experience with (a) certain topic(s). The key characteristic which distinguishes focus groups is the insight and data produced by the interaction between participants (Gibbs, 1997). The interactions allow participants to build upon arguments of one another. Ideas may be revealed that otherwise might have remained unheard, and participants can correct each other's thinking errors and possibly respond with counter arguments. It is especially useful in helping participants develop an opinion on a topic that is relatively new, such as shared mopeds (Krabbenborg et al., 2020).

A focus group of five individuals has been composed, varying in gender, age, household structure and residence location. All group members have access to a private car. Due to COVID-19 regulations at the time of this study, the session took place via Zoom on October 12th 2020. A short introduction of the shared moped system in question was provided, explaining that all mopeds are electric; that the system is free-floating; finding, unlocking and locking a moped is done via a smartphone app; locking is only possible within the service area; same parking rules as for bicycles; vehicles have a speed limit of either 25 km/h or 45 km/h; there is a storage space under the seat. It was also explained that users are charged for use on a per minute basis and that insurance, maintenance and charging are the responsibility of the operator.

A thematic analysis in ATLAS.ti Windows (Version 8.4.24.0) (ATLAS.ti Scientific Software Development GmbH ATLAS.ti 8.4.24.0 Windows, 2021), a qualitative data analysis software, is conducted to identify important themes and other relevant information. The following key attributes emerged from the session in determining mode choice in the presence of shared mopeds:

- **Availability:** Access time to reach the moped, return trip availability of moped, presence of public transport alternatives;
- **Convenience:** Car parking effort, car parking cost, presence of timetable, ability to reach your destination, (im)possibility to drink alcohol;
- **Hygiene:** Mandatory helmet use for 45 km/h mopeds (shared helmet);[2]
- **Environment:** No emissions;
- **Moped price**;
- **Travel time:** Congestion discomfort, mode speed;
- **Safety**

An individual's perception of safety and context variables such as weather, luggage and trip length influence the valuation of the above-listed attributes.

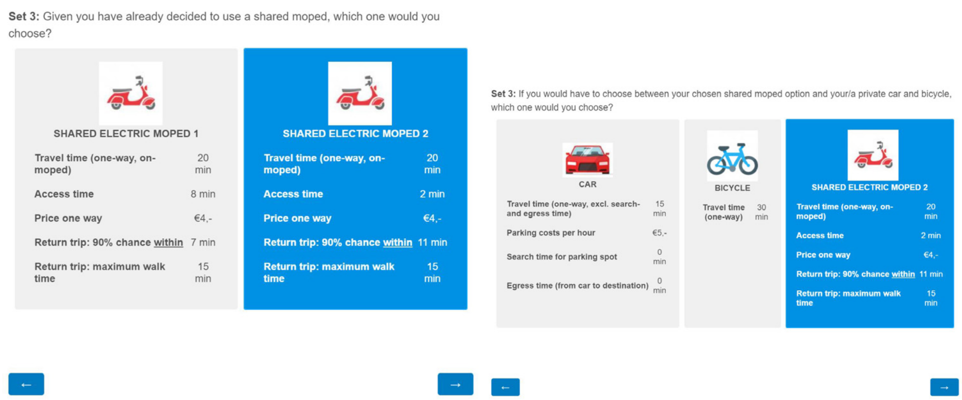
2.2. Survey design

An online survey is designed to collect stated choice data. This section explains the components included in the survey: the mode choice experiment and personal background variables. Data collection and sample characteristics are also discussed.

2.2.1. Mode choice experiment

The goal of the experiment is to quantify the trade-off in a mode choice between car and shared moped. As context, we ask respondents to consider trips that take 15 min by car, starting at home in a Dutch city. Additionally, respondents were asked to consider a trip purpose of running an (e.g. picking up a parcel), travelling alone and carrying a small bag (e.g. a backpack or shopping bag). The purpose of running an errand is chosen because those are on one hand considered occasional rather than habitual (as opposed to commuting trips), and on the other hand are still time-sensitive (as opposed to recreational trips). Weather conditions are kept as neutral as possible (19 °C, cloudy and dry), to avoid an advantage for either mode. A car trip of 15 min roughly equals a distance of 8 km, which is considered the upper limit of short-distance trips (Beckx et al., 2013). As the research objective is to determine what stimulates a car driver to use a shared moped instead of using their car, both car and shared moped are included as mode alternatives. Only the 25 km/h moped version is included for the sake of simplicity, as the helmet requirement for the 45 km/h moped has been identified in the focus group as an influential detractor. Including it would result in larger

[2] This study was conducted before the helmet obligation commencing on January 1st 2023 was announced



(a) Choice between two shared mopeds (b) Choice between car, bike and chosen moped

Fig. 1. Example of bi-level choice situation.

choice sets and therefore require more respondents. Bike is included as well, as it is a widely used mode in the Netherlands. Since the trip in this mode choice starts at home, it is assumed that respondents have a private bicycle at their disposal. Walking is not considered a viable option, as walking 8 km would take almost two hours. Included mode alternatives are thus the shared moped, private car and bike. Travel times for all modes are fixed. Attributes are chosen from the attributes generated by the focus group, based on their suitability (possibility to define levels) and relevance (does it make sense to include them, e.g. exclude attributes related to excluded modes). The bike alternative has no varying attributes, as no influential factors relating to bike emerged from the focus group. Levels for cost attributes were based on current pricing. Levels for time attributes were based on insights from the focus group: the lower levels represented the shortest time they had experienced, the higher levels represented the time they would be willing to spend on it. The following attributes and attribute levels are included:

- Access time: the walking time from the traveler's home to the shared moped position. Included levels are 2, 5 and 8 min;
- Moped costs: the total one-way trip price of the moped. Included levels: € 2, € 4, € 6, the latter is based on current pricing (± € 0,30 per minute);
- Return trip availability: represents the walking time range from the destination to a shared moped for the trip back home. Expressed as a 90% probability of a moped within X minutes. Included levels: 3, 7 and 11 min. A maximum walk time is provided for the remaining 10%, which is set to 15 min;
- Parking costs: costs for one hour of car parking, included levels are € 2, € 5 and € 8;
- Egress time: reflects the time needed to walk from the car parking spot to the destination. Included levels are 0, 5 and 10 min;
- Parking search time: the time needed to find a parking spot for the car. Included levels: 0, 5 and 10 min.

The final survey design is an efficient design created in Ngene. Ngene generated the choice sets with corresponding attribute levels. Such a design requires priors, which are obtained from the literature. The information gained in the focus group is used to improve or, in case no suitable value is found in the literature, estimate those. Respondents encountered nine choice sets of bi-level questions. First, they were asked to make a choice between two shared moped alternatives. In the subsequent question, their chosen moped alternative was put next to the car and bike. This construction is selected so as to elicit shared-moped preferences from all respondents, mitigating the risk of too few respondents choosing the moped option and thereby not receiving sufficient choice data pertaining to the shared moped service itself. An example of the bi-level question is shown in Fig. 1.

Table 1
Socioeconomic and demographic sample data.

Variable	Category	Sample proportion
Age	20–29	68%
	30–39	11%
	40–49	7%
	50–59	7%
	60–72	8%
Gender	Male	50%
	Female	50%
	Other	–
	Prefer not to say	–
Highest finished education	High school	3%
	MBO	3%
	HBO	10%
	University	85%
Household structure	Single no children	21%
	Single with children	2%
	With partner	34%
	With partner and children	9%
	Shared	36%
Household income	< € 10.000	25%
	€ 10.000–€ 40.000	30%
	€ 40.000–€ 70.000	19%
	€ 70.000 +	16%
	Prefer not to say	10%
Moped experience	Used	
	Heard of	
	Never heard of	

2.2.2. *Background variables*

In addition to the choice experiment, respondents were asked to provide some socio-economic and demographic information. The survey includes questions related to respondents' age, gender, household income, education level, household structure, travel frequency and shared moped experience.

2.2.3. *Data collection and sample characteristics*

The defined target group consists of individuals living in larger cities (100,000+ residents) with a valid car driver's licence (as a driver's licence is required for riding a shared e-moped) and access to a private car and bike. At the start of the survey, respondents were asked questions to determine whether they meet these requirements. Respondents who did not meet all requirements were excluded. Data was collected between December 7th 2020 and January 18th 2021 by distributing the survey via messaging apps, email and social media. This resulted in a convenience sample with a total of 191 complete and valid responses. Table 1 presents an overview of the sample characteristics for the collected background variables. The sample has equal shares of men and women and 56% have not yet made use of a shared moped service, allowing for the analysis of preferences amongst users and non-users. The majority of the respondents are younger than 30 years old and highly educated.

Note that the sample does not (intend to) represent the general population. Instead, the target group of our study constitutes a sub-population thereof consisting of individuals living in larger cities (100,000+ residents) with a valid car driver's license and access to a private car and bike. Since distributions of socio-demographic variables of members of this sub-population are not available, we cannot affirmatively assert whether the sample is representative of the target population or not.

This young, highly educated sample of 191 respondents, equally divided between men and women, is arguably likely to represent the segment of the population with a higher probability of using shared fleet services.

2.3. Model estimation

This subsection describes the procedure we undertake for choice model estimation. Since a sufficient number of respondents choose the moped option in the second mode choice situation, model estimation for this question was possible. The results of the experiment show that almost half (47%) of the respondents choose not to travel by moped under any realistic combination of travel attributes. For this group, there is no need to estimate a model to predict their choices for scenarios within the realistic range of attribute levels included in our survey. A subset of the data consisting of the respondents who chose the shared moped option at least once in the experiment, which amounted to 53% of the total sample or 101 respondents, was therefore created and provided as input for subsequent model estimation.

Three travel alternatives are included in the choice experiment: shared moped, car and bike. Bike is set as the reference alternative, because it has no associated attributes, and its utility is hence fixed to zero. The following models were estimated before selecting the most adequate model structure: a Multinomial Logit model, a Nested Logit model, a Panel Mixed Logit model with random parameters and a shared error component, and a Panel Mixed Logit model with random parameters, a shared error component and interaction effects. The final selected model is a Panel Mixed Logit model with random parameters, interaction effects and a shared error component. Model selection was based on the comparison of Log Likelihood values and model interpretability. Interaction effects are tested between moped experience and all parameters. The shared error component reflects the unobserved similarities between bike and moped. Each attribute is associated with two random parameters: one random parameter for the group with experience and one random parameter for the group without experience. Independent samples t-tests are used to determine whether the two separate parameters are significantly different, and if not, they were replaced by one generic parameter. Random parameters that obtained insignificant sigmas, i.e. the parameter capturing the unobserved heterogeneity for the respective attribute, were replaced by fixed parameters.

2.4. Post-experiment expert interviews

To formulate specific policy measures, expert interviews were conducted. Four interviews were carried out in March 2021 with different stakeholders to gain multiple and diverse perspectives. The stakeholders included a junior traffic engineer working for a large municipality, a mobility consultant working for a large consultancy firm, a mobility researcher working for an applied research institute and a founder and managing director of a shared moped company.

In these interviews, the results of the choice model estimation were discussed and used to come up with potential policies that can stimulate a behavioural switch from car to moped. The interviews were also used to construct relevant scenarios to be considered for further investigation in our model application.

Table 2
Results of the Panel Mixed Logit model with random parameters, shared error component and interaction.

Name	Unit	Value	Rob. *p* value
Generic parameters			
ASC_{moped}	[−]	0.690	0.389*
β_{AT}	[s]	−0.121	0.001
$\beta_{AV,lin}$	[s]	0.640	0.000
β_{PST}	[s]	−0.130	0.000
Parameters for experienced group			
$ASC_{car,E}$	[−]	2.330	0.000
$\beta_{AV,quad,E}$	[s]	−0.058	0.000
$\beta_{ET,E}$	[s]	−0.321	0.000
$\beta_{CPC,E}$	[Euro]	−0.742	0.000
$\beta_{SMC,E}$	[Euro]	−0.471	0.000
Parameters for inexperienced group			
ASC_{car}	[−]	1.680	0.000
$\beta_{AV,quad}$	[s]	−0.065	0.000
β_{ET}	[s]	−0.110	0.001
β_{CPC}	[Euro]	−0.410	0.000
β_{SMC}	[Euro]	−0.231	0.007
$v_{moped\,bike}$	[−]	−1.383	0.000
Initial loglikelihood		−998.639	
Final loglikelihood		−776.431	
Number of draws		1000	
Number of observations		909 (101*9)	

3. Choice model estimation results

The final model is a Panel ML model with generic as well as group-specific, and random as well as fixed parameters. In particular, it includes generic (and fixed) parameters for access time, park time, the linear component of return availability and the alternative specific constant for shared mopeds. All other parameters are group-specific, of which some are random and some are fixed.

A (random) shared error component (v), which is normally distributed, reflects the unobserved similarities between bike and moped. This model is the result of an iterative process, in which non-significant sigmas are excluded and parameter pairs that do not differ significantly are merged into one generic parameter. Models are estimated with PandasBiogeme (Bierlaire, 2020) using the following utility functions:

$$U_{moped} = ASC_{moped} + \beta_{AT} * AT + \beta_{SMC,E} * SMC + \beta_{AV,lin} * AV + \beta_{AV,quad,E} * AV^2 + v_{moped\,bike} + \epsilon_{moped} \quad (1)$$

$$U_{car} = ASC_{car,E} + \beta_{ET,E} * ET + \beta_{CPC,E} * CPC + \beta_{PST} * PST + \epsilon_{car} \quad (2)$$

$$U_{bike} = ASC_{bike,E} + v_{moped\,bike} + \epsilon_{bike} \quad (3)$$

In these equations, AT is the access time, SMC denominates the shared moped costs, AV represents the return availability, ET is the egress time, CPC corresponds to the car parking costs, and PST is the parking search time. Parameters with an E in the subscript vary based on previous moped experience. The shared error component, v, is a nesting parameter. Random parameters include ASC_{bike} (so for both groups), $ASC_{car,used}$, $\beta_{CPC,used}$ and $\beta_{SMC,used}$. Note that the return availability attribute is modelled as a combination of linear and quadratic components. This reflects the indication made by members of the focus group that with increasing return availability times the marginal increase in disutility, associated with this attribute, decreases. Furthermore, we find that the shared error component is significant for the inexperienced group.

The Rho^2 of the final model is 0.223. Model estimation results are shown in Table 2. Sigma parameters capture the unobserved heterogene-

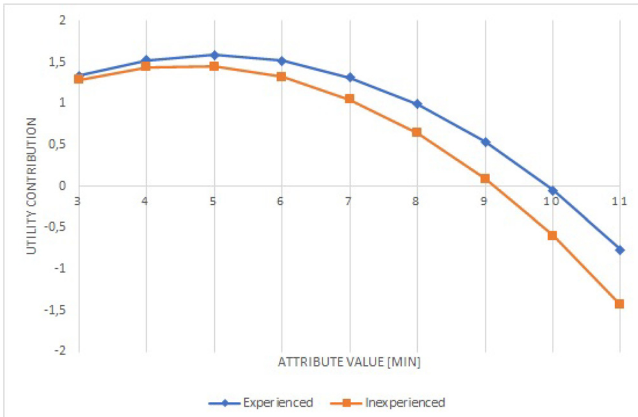


Fig. 2. The non-linear contribution of the availability parameter to travellers' disutility.

ity for the respective attribute. The Panel ML model converged using 1000 draws from a normal distribution.

All of the parameters included have the expected sign. The two return availability components cannot be evaluated individually, therefore a plot is added to illustrate the contribution of this attribute to disutility for both traveller groups (see Fig. 2). The slopes of the trendlines represent the change in utility with a one unit increase or decrease of the attribute. It can be seen that the utility for the inexperienced group is consistently lower than for the experienced one for the same attribute level. Regarding the cost attributes, car parking costs have a higher disutility than the shared moped service costs. This is true for both traveller groups.

Comparing the time attributes based on the disutility associated with one minute increase, egress time is the time attribute that is perceived most negatively by the experienced group. For the inexperienced group, the return availability is perceived most negatively. Access time and parking search time are roughly equal in this respect.

For some of the attributes, the standard deviations or sigma coefficients are also found significant. For the inexperienced group, no sigma related to a random parameter is found to be significant. This suggests that taste variation is not (widely) present in this group. Significant sigmas are found for the ASC for car and both cost attributes for the experienced group. Heterogeneity regarding car preference and taste for costs therefore is present in this group. A nest parameter is included to account for the unobserved similarities between shared moped and bike. This parameter is found to be significant for the inexperienced group. Respondents with no previous moped experience perceive hence similarities between shared moped and bike beyond the attributes explicitly accounted for in this experiment, e.g. lack of rain cover. For respondents with previous experience, this effect is not significant.

A comparison of the two groups shows that both cost parameters are higher for the experienced group. This group is thus more sensitive to a € 1 change in costs than the inexperienced group. With respect to the sensitivity to time attributes, the experienced group is most sensitive towards egress time as well as to return availability. The latter is also the attribute inexperienced group are most sensitive towards (see Fig. 2). We further investigate the differences between the two travellers groups and amongst different travel time attributes by investigating the Willingness to Pay (WtP) values for each time attribute. Table 3 presents the results, expressed in their value in hourly terms. An inspection of the share of respondents that have an experience with shared mopeds as a function of their household level does not reveal any clear relationship. Return availability is evidently an important factor for both groups, but especially for the inexperienced group. Egress time is more important for the experienced group than for the inexperienced travellers, whereas the opposite is true for Access time. The WtP for parking

Table 3
Calculated values of the willingness to pay (WtP) for a decrease of 1 h in travel time component for travellers experienced and inexperienced with shared moped services.

Value of travel time saving	Experienced	Inexperienced
Car: egress time	€ 25.95	€ 16.10
Car: parking search time	€ 10.54	€ 19.02
Moped: access time	€ 15.32	€ 31.30
Moped: return availability	€ 33.19	€ 88.70

search time amongst the inexperienced group is almost twice as much as the respective WtP for the experienced ones.

4. Model application

The estimated Panel ML model is applied to explore the potential market share for each mode under potential policy packages which are devised based on the expert interviews. A brief explanation of the scenarios, compared to the reference scenario is hereby provided:

- **Reduced city centre parking.** Parking spots are removed from the city centre; the fee for city centre parking is raised. Overall supply remains the same as (newly built) parking lots and garages outside the centre replace the removed spots.
- **Reduced overall parking.** City centre parking spots removed and increased parking fee, but no new parking locations to absorb parking demand.
- **Monetary incentives.** Parking costs are increased; moped costs are decreased.
- **Improved mopeds.** To make the moped more attractive, they become cheaper and are evenly distributed amongst clusters across the city.
- **Spatial redesign.** Car parking supply is reduced by removing parking spots from the centre. The shared mopeds are clustered and evenly distributed throughout the city.
- **Extended spatial redesign.** This scenario is similar to the previous one, supplemented with increased parking costs.
- **Masterplan.** All car attributes are set at their highest levels; all moped attributes are set at their lowest levels.

Sample enumeration is applied, which entails the construction of a synthetic population based on our sample. First, parameters were adjusted to account for unobserved heterogeneity by drawing from the estimated normal distribution. This was done for each random parameter included in the model. The final population consists of 30,941 synthetic individuals, which is an arbitrary number but considered sufficiently large to assure stable predictions. Choice probabilities per mode alternative are predicted for each synthetic traveller under each of the scenarios. The aggregate results when summed over the entire synthetic population are presented in Table 4. These numbers are interpreted as the market share per mode. Table 4 also displays the scenarios. In this model application exercise, the share of respondents that was excluded in the model estimation due to non-trading behaviour has been included again to obtain realistic market shares. The 'Ref' columns refers to the reference scenario. The reference scenario corresponds to the assumed baseline situation. Obviously, the parking situation differs per city and neighbourhood, but the chosen values are meant to reflect prevalent conditions. The same holds for access time and return availability. Moped costs are based on the current pricing level.

Simulations based on the estimated choice models indicate that making the car less attractive would have a larger influence on the market share of car than improving the attractiveness of the shared moped. Reducing the overall parking supply and raising parking fees (scenario 3) results in a substantial decrease in the market share of car from the level of 10,1% in the reference scenario down to 6,4% in the event of increased parking costs, egress time to parking and parking search time.

Table 4
Scenarios with attribute levels and market shares for all modes.

Scenario	1. Ref	2. Reduced city centre parking	3. Reduced overall parking	4. Monetary incentives	5. Improved mopeds	6. Spatial redesign	7. Extended spatial redesign	8. Master-plan
Moped costs	€ 6	€ 6	€ 6	€ 4	€ 4	€ 6	€ 6	€ 4
Access time	5 min	5 min	5 min	5 min	2 min	2 min	2 min	2 min
Return availability	7 min	7 min	7 min	7 min	3 min	3 min	3 min	3 min
Parking costs	€ 5	€ 8	€ 8	€ 8	€ 5	€ 5	€ 8	€ 8
Egress time	5 min	10 min	10 min	5 min	5 min	10 min	10 min	10 min
Parking search time	5 min	5 min	10 min	5 min	5 min	10 min	10 min	10 min
Market share								
Shared moped	20,2%	21,7%	21,9%	28,4%	30,4%	24,7%	25%	32%
Car	10,1%	6,7%	6,4%	7,1%	8,7%	6,9%	6,3%	6,3%
Bike	69,7%	71,5%	71,7%	64,4%	60,8%	68,4%	68,6%	61,8%

A small increase in bike market share is an unintended but desirable side effect. By limiting city centre parking (scenario 2), both these effects are achieved as well. A scenario that improves the shared moped offer by means of reduced costs, shorter access time and improved return availability (scenario 5: improved mopeds) is expected to decrease car market share to just under 9%. Moreover, in this scenario the predicted market share of bike decreases compared to the reference scenario, which is an undesired effect. Leaving both parking costs and moped costs unchanged but reducing parking supply and improving moped accessibility (scenario 6: spatial design) has quite a large effect as well, but mainly on the moped market share. The car market share is slightly lower than in the reference scenario, but the bike market share is lower as well. A combination of car-hindering and moped-stimulating measures (scenarios 7 and 8) leads to the lowest predicted market share for car. However, the market share for bike decreases compared to the reference alternative. This effect is stronger for scenario 8, which only differs from scenario 7 in moped costs.

5. Discussion and conclusion

We identify and quantify the role of determinants affecting a car driver's choice for a shared moped. Our analysis was guided by the goal of formulating policy measures to reduce the attraction of the car and make the shared moped an attractive alternative for it. A focus group was conducted to identify a set of potential choice determinants. We then devised a mode choice experiment to analyse and quantify the trade-offs exhibited by car users who are either experienced shared moped users or non-users. The mode choice experiment was part of an online survey which also included questions about socio-economic and demographic information. The results from the experiment were discussed in expert interviews to formulate policy measures to stimulate the switch from car to shared mopeds and those were specified and tested in model application.

People who have used a shared moped before value the attributes differently than people without any moped experience. A calculation of the Willingness to Pay (WtP) values shows that return availability of shared moped is the most influential time-related attribute for both groups. For people with moped experience, egress time is the second most important time attribute whereas for inexperienced travellers it is access time. Furthermore, travel costs, for parking as well as for moped, are important factors in explaining mode choices. Especially parking costs have a large influence on the attractiveness of the car. Raising the parking fee results in a low market share for the car and higher shares for moped as well as for bike. Lowering the moped costs makes the moped more attractive for car drivers, but also for cyclists.

Ideally, measures can be devised so as to attract car user to switch to shared moped while avoiding a strong reduction in bike use (for health and environmental reasons). To achieve that, it is advisable to focus on making car use more difficult. Raising parking fees is a good first step, which can be implemented fairly easily. A reduction of overall parking supply further enhances the negative effect on car attractiveness, while at the same time improving livability of the city. If desired, the freed-up space can be used to create moped parking spaces. Lowering moped costs is not advised, the model shows that this would primarily lead to a migration from bike to moped.

As this study is, to the best of our knowledge, a pioneering effort in conducting quantitative behavioural research in the context of shared moped services, there are hardly any comparable studies. A qualitative study investigating the shared moped is the one by Aguilera-García et al. (2020). They found that ease of parking was clearly the main reason for using shared mopeds. This is confirmed by our findings. Besides parking, they found that price, travel time and proximity to the final destination were important factors in the choice of means of transport. Apart from travel time, which was not included as an attribute in this study, their findings are endorsed by our choice modelling results.

It is important to stress that the results reported in this study are for a specific context, i.e. a 15 min car trip to run an errand, starting at home in a Dutch city (e.g. picking up a parcel), traveling alone and carrying a small bag and for a specific weather condition (19 °C, cloudy and dry) that we believe does not disadvantage either mode. Conclusions are only applicable to these specific situations. Hence, in bad weather conditions, the substitution of car travel by shared moped is likely lower than found in this study. Further research may explore the trade-off between moped and car under different trip circumstances. This can be done by extending the stated choice experiment by also varying context variables. This requires constructing context profiles that systematically vary the values of context variables. The mode choice sets then need to be nested under the context profiles to allow exploring to what extent choices change with changing trip circumstances (see van der Heijden et al. (2004) for an empirical application).

Our findings provide original insights into travellers' preferences in relation to shared moped, including for those that have not used them yet, thereby allowing to investigate the relevant determinants for both users and non-users and the extent to which they can become users-to-be under various circumstances.

Future studies might consider investigating other trip purposes and contexts. Another direction is to consider the 45 km/h moped, as this moped version has distinctive characteristics (e.g. helmet use and driving on the road) compared to the 25 km/h moped considered in this study. Future research may also examine the relationship between shared mopeds and public transport as well as walking.

Declaration of Competing Interest

Authors declare that they have no conflict of interest.

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