Driving factors behind station-based car sharing adoption

Discovering distinct user profiles through a latent class cluster analysis

van der Linden, Hidde; Correia, Gonçalo; van Oort, Niels; Koster, Suze; Legêne, Martijn; Kroesen, Maarten

DOI
10.1016/j.tranpol.2024.12.001

Publication date
2024

Document Version
Final published version

Published in
Transport Policy

Transport Policy 162 (2025) 232–241

Contents lists available at ScienceDirect

Transport Policy

journal homepage: www.elsevier.com/locate/tranpol

Driving factors behind station-based car sharing adoption: Discovering distinct user profiles through a latent class cluster analysis

Hidde van der Linden [a], Gonçalo Correia [a], Niels van Oort [a], Suze Koster [b], Martijn Legêne [b], Maarten Kroesen [a,*]

[a] Delft University of Technology, Delft, the Netherlands
[b] Goudappel, The Hague, the Netherlands

ARTICLE INFO

Keywords:
Car sharing
Latent class cluster analysis
Motives
Travel behaviour

ABSTRACT

In light of growing environmental challenges, the need to reconsider how we approach personal transportation is becoming increasingly evident. A shift from a private car-focused mobility system towards a more sustainable and equitable transportation system is needed. Car sharing is considered a means to achieve this, however, its usage and its impact are not entirely understood, as many studies do not consider the motives of individuals to use this alternative, treating the population of users as a homogeneous group. This study aims to reveal distinct car sharing usage profiles to gain a thorough understanding of the various motivates behind car sharing and its relation with travel behaviour. Six user profiles are uncovered using a Latent Class Cluster Analysis (LCCA) based on station-based carsharing data of one company operating in the Netherlands gathered through an online survey (N = 1281). The results show significant diversity in car sharing motives. The identified user groups have different effects on travel behaviour. Environmentally motivated car sharers use the shared car as a complete replacement for their private car, causing a substantial decrease in car ownership and usage. For utilitarian car sharers, and especially formerly carless individuals, the decrease in car ownership is less substantial and even an increase in car use can be observed. Finally, it was found that car sharing is mostly complementary to public transport use. Ways to promote the use of both modes could be explored.

1. Introduction

In light of growing environmental challenges, the need to reconsider how we approach personal transportation is becoming increasingly evident. In the Netherlands, for example, private cars take up 55% of the available public street space in the 20 largest Dutch municipalities, while they remain parked 96% of the time on average (Jorritsma et al., 2021; van Liere et al., 2017). In addition, with many countries facing challenging sustainability goals and increasing issues regarding the liveability of cities, governments and institutions are acknowledging the need to shift from a private car-focused mobility system towards a more sustainable and equitable transportation system (Green Deal Autodelen II, 2022).

Shared cars might play an important role in this transition as their utilisation is often associated with a decrease in car ownership and use (Kolleck et al., 2021; Nijland and van Meerkerk, 2017). In addition, the use of shared cars is associated with a modal shift away from private cars towards more sustainable (active) modes (Becker et al., 2017). However, these positive influences are debated as some studies find smaller on even negative influences of car sharing use (Bucsky and Juhász, 2022; María Arbeláez Vélez et al., 2021; Nijland and van Meerkerk, 2017; Papu Carrone et al., 2020). Besides the influence on environmentally related aspects, car sharing may increase transportation equity as it enables formerly carless households to use a car when they need to (Shaheen et al., 2020).

As car sharing is associated with several beneficial effects, several studies have focused on revealing its potential by conducting stated preference studies on the general population regarding their intention to use car sharing services (see e.g. Montes et al., 2023). However, this approach overlooks the possible divergence between the behavior of actual car sharers and potential users. Moreover, focusing too heavily on stated preferences may lead to an over- or underestimation of car sharing's impact on individual travel behaviour. Therefore, it is important to study the behaviour of actual car sharers.

* Corresponding author.
E-mail addresses: Hiddelinden@hotmail.com (H. van der Linden), G.Correia@tudelft.nl (G. Correia), N.vanOort@tudelft.nl (N. van Oort), skoster@goudappel.nl (S. Koster), m.kroesen@tudelft.nl (M. Kroesen).

https://doi.org/10.1016/j.tranpol.2024.12.001
Received 17 May 2024; Received in revised form 29 November 2024; Accepted 1 December 2024
Available online 3 December 2024

Existing studies on car sharing adoption and use often portrayed a typical car sharer profile of someone who most likely is a male, young, highly educated and resides in dense urbanised area, in a small household with low car ownership (Aguilera-García et al., 2022; Becker et al., 2018; Burghard and Dütschke, 2019; Ceccato and Diana, 2021; Hjorteset and Böcker, 2020; Prieto et al., 2017). However, most studies did not consider psychological aspects such as individuals' motives for car sharing use (Ramos et al., 2020). This neglects the influence of personal motives on car sharing use and may unduly exaggerate the role of socio-demographic factors.

From studies that did consider personal motives for car sharing, three main categories of motives were identified: environmental-, cost- and utility-related motives (Mavlutova et al., 2021). However, studies differ on the exact influences of these motives, especially the environmentally related ones (Aguilera-García et al., 2022; Mattia et al., 2019; Münzel et al., 2019). While these differences might be attributed to the different study areas and datasets used, it is also notable that these studies treat the car sharing population as one homogeneous group, neglecting potential variations caused by individual differences. Moreover, this generalisation of the car sharing population overlooks the fact that varying motives for using car sharing may have different impacts on individuals' travel behaviour, which may lead to varying car sharing impacts.

Additionally, the interaction of shared mobility services, such as car sharing, with public transport is receiving more interest (Ceccato and Diana, 2021; Montes et al., 2023; Tarnovetckaia and Mostofi, 2022). More specifically, whether car sharing services are complimentary or competitive to public transport. Previous studies often include few to none actual car sharing users, which may lead to unjustified conclusions about the interaction between car sharing and public transport (Ceccato and Diana, 2021; Papu Carrone et al., 2020; Tarnovetckaia and Mostofi, 2022).

As illustrated, studies on car sharing use and its related impact provide contradictory results, often include very few actual car sharers, and overlook the influence of individual differences of car sharers. Because of the generalisation of the car sharing population and its related impacts, it remains difficult to develop effective car sharing strategies that stimulate sustainable travel behaviour and a decrease in car ownership. Therefore, this study focused on revealing distinct car sharing usage profiles to gain a thorough understanding of car sharing utilisation and its impact in terms of sustainability. To do so, a comprehensive approach towards usage has been adopted, including socio-demographic characteristics, spatial aspects, socio-psychological factors such as motives, and actual car sharing usage data. These data were gathered through a collaboration with the Dutch station-based car sharing company Greenwheels, which distributed an online survey among its members.

The remaining of this paper is structured as follows: Section 2 provides overview of the literature on car sharing and concludes with a conceptual model. Section 3 discusses the applied methodology, followed by Section 4, which presents the results of the LCCA. Section 5 offers a discussion of the results, and finally, Section 6 presents the conclusion of this study.

2. Background

2.1. Factors influencing car sharing use

To determine the factors that influence car sharing use, a literature review was conducted which considered both studies on the adoption of car sharing services and actual car sharing use (Van der Linden, 2023). In many studies, socio-demographic characteristics were found to significantly influence car sharing adoption or use. The main socio-demographic characteristics identified were factors such as age, gender, level of education, income, household size and occupation (Acheampong and Siiba, 2020; Aguilera-García et al., 2022; Becker et al., 2017; Burkhardt and Millard-Ball, 2006; Ceccato and Diana, 2021; Clewlow, 2016; Kim et al., 2015; Millard-Ball et al., 2005; Münzel et al., 2019; Prieto et al., 2017).

In addition to these socio-demographics, spatial characteristics such as the residential density of the area where car sharers reside and the availability of private parking were found to influence car sharing adoption (Ceccato and Diana, 2021; Prieto et al., 2017; Wang et al., 2021). Higher levels of residential density were found to have a positive influence on car sharing adoption while the presence of private parking was found to negatively influence car sharing adoption. Other factors that influence the adoption and use are related to the type of car sharing service provided. For instance, the car sharing costs, the proximity of a shared car and the availability of a shared car (Mattia et al., 2019; Papu Carrone et al., 2020; Schreier et al., 2018; Wang et al., 2021).

In addition to these characteristics, social-psychological factors such as users' attitudes have been shown to influence car sharing use. The environmental concern of individuals is often found to significantly influence car sharing use, while the exact nature of the impact remains debated (Aguilera-García et al., 2022; Becker et al., 2017; Mattia et al., 2019; Münzel et al., 2019; Ramos et al., 2020; Schaefers, 2013). Other relevant social-psychological factors are utilitarian motives, social motives, subjective norms, hedonic motivations and the effort expectancy of using a shared car (Aguilera-García et al., 2022; Curtale et al., 2021; Kim et al., 2015; Mattia et al., 2019; Mavlutova et al., 2021; Münzel et al., 2019).

A debated factor is the influence of environmental concerns. Some studies found environmental concerns to have a positive effect on the intention to use car sharing (Guglielmetti Mugion et al., 2019; Hjorteset and Böcker, 2020; Münzel et al., 2019; Li and Zhang, 2023), whereas others found no significant or even a negative effect (Aguilera-García et al., 2022; Becker et al., 2017; Kim et al., 2015). It should be noted here that the type of shared car, electric or conventional, available or presented in the questionnaire might have influenced the relation with environmental concerns. However, all these studies considered the car sharing population as a homogeneous group, which overlooks potential differences between individuals. Addressing this, Ramos et al. (2020) conducted a large European-wide study which identified different mobility styles through hierarchical cluster analysis. While differences regarding environmental concerns were found, it was not possible to determine a clear causal link between environmental concerns and the intention to use car sharing.

Lastly, with regard to personal characteristics, private car ownership is considered an important factor that negatively influences car sharing adoption and use (Aguilera-García et al., 2022; Becker et al., 2017; Mattia et al., 2019; Münzel et al., 2019; Ramos et al., 2020; Schaefers, 2013). Finally, having a public transport subscription, the type of trip purpose and prior experience with a service were found to have significant influences on car sharing use (Becker et al., 2017; Matowicki et al., 2021; Münzel et al., 2019; Venkatesh et al., 2012).

In addition to individual factors, car sharing use is also affected by attributes relating to the service. A recent stated preference study found that travel, access and parking time had strong negative effects on the probability of choosing car sharing (Carrone et al., 2020). In addition, frequency users of car sharing had a higher probability of choosing car sharing, indicating that prior experience plays a relevant role. The costs of the service (vis-à-vis alternative modes) was also found to significantly determine the car sharing alternative (De Luca and Di Pace, 2015; Carrone et al., 2020).

2.2. Impact of car sharing use on car ownership

One of the most mentioned and debated impacts of car sharing is the impact it has on private car ownership. For example, Nijland and van Meerkerk (2017) found that car ownership among car sharers in the Netherlands was 30% lower. This positive influence on car ownership reduction is also found in other studies, as in the Netherlands it was

found that every station-based shared car replaced 11 private cars (Oldenburger et al., 2019). Similar results were found in Bremen in Germany, where every shared car replaced 15 private cars (Schreier et al., 2018). In addition to this, in a questionnaire on free-floating car sharing in 11 European cities, the study of Jochem et al. (2020) showed that a single free-floating shared car could replace up to 20 private cars in an optimistic scenario.

On the contrary, Becker et al. (2018) found a much lower car ownership reduction of around 6%, for free-floating car sharing. Different from other studies, Becker et al. (2018) used a two-wave survey with a control group, one shortly after the start of a car sharing scheme and one a year later, to better assess the actual impact. Even less optimistic results of free-floating car data were found by Kolleck et al. (2021), who determined the substitution rate empirically by looking at data from 35 German cities. They concluded that free-floating car sharing did not lead to a difference in car ownership. However, for station-based car sharing, results were more positive, as they found that one station-based shared car replaced approximately nine private cars. Lastly, Bucsky and Juhász (2022), who compared the impact of 129 car sharing systems across Europe on overall car ownership levels, found only very minimal effects and stress that survey-based studies might overestimate the actual effect.

The ambiguous results on the impact of car sharing on car ownership make it difficult to determine whether car sharing services are actually beneficial in terms of public space usage namely through the reduction of parking pressure. This study extends the previous results by also studying the impact of station-based car sharing on car ownership in the Netherlands.

3. Method

3.1. Conceptual model

By combining the findings of the literature study with behavioural theories such as the Theory of Planned Behaviour (TPB) and the UTAUT2 model, a conceptual model for distinguishing diverse user profiles was constructed (Ajzen, 1991; Venkatesh et al., 2012). The conceptual model used in this study can be found in Fig. 1.

The model shows that different latent usage profiles, which represent the identified user groups, are based on a set of chosen indicators and covariates. For the indicators, individuals' actual car sharing use and their different motives for using car sharing are chosen. The most important types of motives for using car sharing identified in the previous section are included. These are the utilitarian, environmental and social motives and the experienced effort to use shared cars. The utilitarian motives capture how different perceived benefits motivate car sharing use. The environmental motives capture to what extent car sharing use is motivated by the individuals' belief that car sharing contributes to a better environment. Social motives are included to capture the influence of subjective norms, such as the opinion of others on an individual's choice to use shared cars, and the hedonic motivations to use shared cars, such as experiencing driving as fun or having a preference for sharing goods. The experienced effort to use shared cars is included to capture to what extent individuals feel they need to make an effort to use shared and if they are satisfied with the service. In addition to these motives that were identified in the literature, motives that account for the interaction between shared cars and public transport are included. Lastly, the actual car sharing frequency of an individual is included as an indicator.

On the left-hand side of the model (Fig. 1), the covariates that are assumed to influence class membership are displayed. Considering the likely direction of causation, it makes sense to incorporate individuals' motives and car sharing use as indicators of the model. This way, the model conceptually assumes that personal motivations to use car sharing and the amount of car sharing use are influenced by the covariates and not the other way around. In order to avoid endogeneity issues, where a covariate is dependent on the variable it is trying to predict, both car ownership and car sharing trip purpose are included as inactive covariates. This means that their conditional distributions will be calculated for the different classes in the model, but that they are not actually part of the model. This part of the model will shed light on the question whether the different motivational profiles also result in different impacts on car ownership and use.

3.2. Data collection

Data were collected via an online survey distributed among Dutch members of the station-based car-sharing company, Greenwheels. Founded in 1995, Greenwheels operates in the Netherlands and, at the time of the survey, had a fleet of 2600 cars spread across 185 Dutch cities. While most cars are stationed in large Dutch cities, they are also available in smaller cities.

Three criteria were used to select members for the survey: the member had used Greenwheels at least twice, their last ride was within

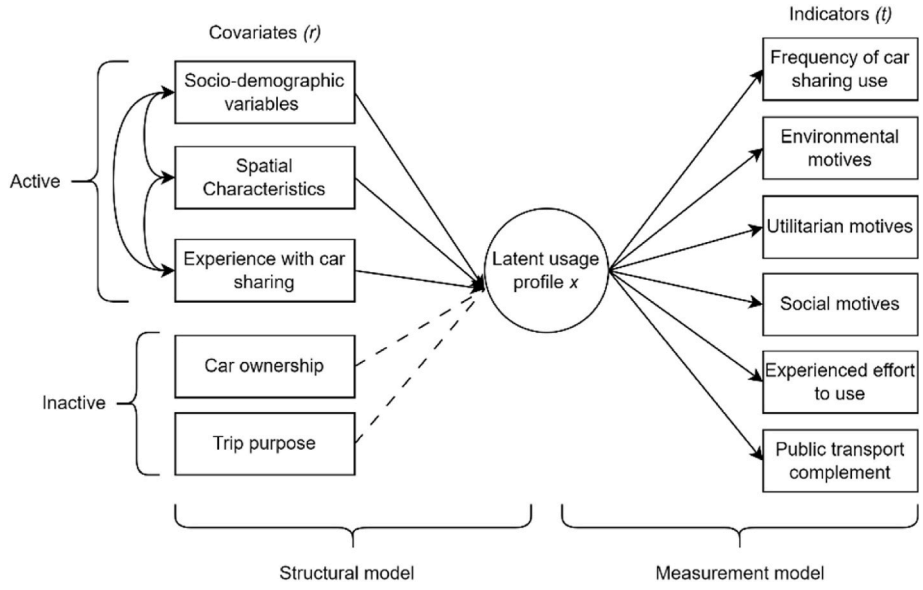

Fig. 1. Conceptual model for car sharing use.

the past six months, and they were Dutch-speaking, as the survey was conducted in Dutch. The survey was emailed to 13573 members between July 4th and 16th, 2023. To stimulate participation, respondents could voluntarily enter a raffle to win driving credits (10 prizes of €50 each). In total, 1393 responses were received, resulting in a response rate of 10.3%. After excluding incomplete and invalid responses, 1281 valid responses remained, yielding a final response rate of 9.4%.

3.3. Measures

Because it was not allowed to include questions regarding income, gender and occupation in the survey, these socio-demographic characteristics were not measured. The characteristics age, education level and household size were measured and included in the model as covariates. Furthermore, two spatial characteristics are included as covariates, namely residential density and available parking facilities. Lastly, trip purpose, car ownership and experience with car sharing are included as covariates. Experience with car sharing is included based on its presence in the UTAUT2 model and because its influence on car sharing usage has yet to be studied extensively. The inclusion of trip purpose reflects the notion that individuals may vary in their car sharing use and motives for use based on their car sharing travel purposes.

Data were gathered through the distribution of a survey among Dutch members of the station-based car sharing company Greenwheels. The survey was sent to 13,573 members between the 4th and July 16, 2023, and in total, 1393 responses were gathered, resulting in a response rate of 10.3%. After preparing the data by removing incomplete and invalid responses, 1281 valid responses remained.

To obtain measures for the indicators, the respondents' attitudes on various statements related to included motives were requested. All attitudes of the respondents were measured on a 5-point Likert scale from 1 (strongly disagree) to 5 (strongly agree). The car sharing frequency of the individuals was based on the number of reservations made from July 2022 to July 2023. Table 1 presents the 16 different indicators to measure the motives as well as the question related to the frequency of car sharing use.

3.4. Latent class cluster analysis

The next step is to perform a Latent Class Cluster Analysis (LCCA). LCCA is a model-based probabilistic clustering method aimed at revealing groups, in this case station-based car sharers, that are similar based on observed characteristics. The LCCA assumes that an underlying discrete latent class variable accounts for the correlations between a set of indicators and that, conditional on that latent class variable, the correlations between those indicators become insignificant (Magidson and Vermunt, 2004). The goal is to find the model with the smallest number of clusters that maximises the homogeneity within the clusters and heterogeneity between the clusters.

Unlike traditional deterministic clustering methods, such as K-means clustering, LCCA is a probabilistic clustering method. This means that individuals are assigned to different clusters with a certain probability of belonging to that cluster, rather than deterministic, to different clusters. Consequently, this is also one of the main advantages of LLCA compared to traditional deterministic clustering methods because it prevents biases in cluster centres due to the deterministic assignment of individuals to the different cluster centres (Magidson and Vermunt, 2002). Other advantages of LCCA are that it can handle variables of different scale types (nominal, ordinal, continuous and count) and that statistical criteria are available to determine the optimal number of classes (Magidson and Vermunt, 2002).

3.5. Model estimation and selection

The LCCA conducted in this study consists of two parts: 1) the estimation of the measurement model to determine the optimal number of classes and 2) the extension of the measurement model with a structural model by adding covariates that influence an individual's cluster membership. To perform the LCCA the software package Latent-GOLD®5.1 was used (Vermunt and Magidson, 2016). Commonly used statistical criteria to determine the optimal number of classes are the likelihood-ratio chi-square statistic L^2 and the Bayesian Information Criterion (BIC) (Magidson and Vermunt, 2004). The likelihood-ratio chi-squared statistic assesses to what extent the model-implied cell frequencies differ from the observed cell frequencies, with the null hypothesis that the difference is zero and, thus that model accurately reproduces the observed patterns. However, in the case of sparse data, L^2 statistic is does not follow a chi-squared distribution (Magidson and Vermunt, 2004). Since the estimated model included 16 variables, of which each had 5 categories, there were 5^{16} possible response patterns,

Table 1
Measured indicators.

Environmental motives
I use shared cars because they have lower emission compared to private cars
I use shared cars because by doing so, I contribute to the reduction of traffic in my city
I use shared cars because it contributes to creating extra space for other/enjoyable things in my city
Utilitarian motives
I use shared cars because it enables me to save money compared to owning a private car
I use shared cars because it is easier than owning a private car
I use shared cars because it improves the quality of my trip compared to the mode of transport I would have used otherwise
I use shared cars because it means I do not have to look for a parking place for my car
Social motives
People around me encourage me to use shared cars
I use shared cars because I enjoy driving in a car
I use car sharing services because sharing goods with others appeals to me
Experienced effort to use car sharing
I find it easy to use car sharing services
I am satisfied with the distance from my house to the shared cars I use
Shared cars are not always available when I intend to use them
Public transport complement
I use shared cars to travel from a train station to my final destination
I use car sharing for trips where public transport is insufficient
Frequency of car sharing use
1) 1–5 reservations (1–5 times per year)
2) 6–11 reservations (6–11 times per year)
3) 12–24 reservations (1–2 times per month)
4) 25–52 reservations (2–4 times per month)
5) >52 reservations (weekly or more often)

and thus many cells remained empty. Therefore the BIC was used, which is a global modal fit criterion that weighs both model fit (based on the log-likelihood) and model parsimony (the number of parameters). Besides this criterion, the theoretical interpretability of the clusters was taken into consideration to determine the optimal number of clusters. To ensure interpretability, usually cluster sizes of at least 5% are desired (Weller et al., 2020).

4. Results

4.1. Sample descriptives

Table 2 shows the sample descriptives regarding the socio-demographic characteristics and car ownership. Comparison with the population of Greenwheels' members showed that the sample can largely be considered representative. However, there were some discrepancies that should be noted. Specifically, the population of Greenwheel members consisted of a higher share of individuals aged 18–40 compared to the sample, and a smaller share of middle-aged (40–65) and old (65+) individuals. In addition, a larger share of single-person households and a smaller share of 2-person households was present among all Greenwheel members. Overall, these differences were rather small.

To provide some context on the users of shared cars in the Netherlands, Table 1 compares the sample with the general (adult) population in the Netherlands (presented in the last column). It can be observed that car sharing users are on average higher educated and living in more urbanised areas compared to the general population. In addition, car ownership is much lower, which is likely both a cause and an effect of their car sharing use.

Table 2
Sample descriptives.

Variable	Sample (%)	Population (%)[a]
Age		
18–30	7.5	15.9
30–40	14.8	16.2
40–65	56.0	44.8
65+	21.6	23.2
Education level		
None/Primary education	0.4	7.2
Secondary education & MBO1	6.5	29.1
MBO2-4	5.5	26.4
HBO/WO	83.8	36.6
I would rather not say/Unknown	3.9	0.7
Household size		
1	28.6	39.5
2	41.7	32.4
3	12.9	11.6
4	11.2	11.6
5+	5.7	5.0
Residential density		
Very highly urban	76.0	23.9
Highly urban	17.9	27.6
Moderately urban	4.2	17.4
Little urban	1.4	16.4
Non-urban	0.5	14.7
Household car ownership		
0	86.3	26.0
1	12.8	47.0
2+	0.9	27.0

[a] Data obtained from Statistics Netherlands.

4.2. Model fit and selection

Table 3 shows the model fit statistics of models with 1 through 10 latent classes. The lowest BIC value was found for the 7-cluster model. The smallest cluster size for the 7-cluster model was 2.3%, thus violating the rule of thumb of 5%. As the 6-cluster model proved to have sufficiently large cluster sizes and provided meaningful clusters for the interpretation, this model was selected.

After the optimal number of clusters was determined, the model was extended with a structural part by adding the covariates. To determine whether or not to include a covariate in the model, its significance was tested with the Wald-statistic (Vermunt and Magidson, 2016). Covariates with a Wald-statistic p-value <0.05 indicate statistical significance and thus were included in the model as active covariates. Non-significant covariates, however, could still be included in the model as inactive covariates. As explained above, inactive covariates do not influence class membership but can provide information about the distribution of that covariate within a cluster (Molin et al., 2016).

To extend the measurement model with a structural model, all initially selected active covariates present in Fig. 1 were added. Two covariates, education level and residential density, showed a p-value >0.05 based on the Wald-statistic, therefore the variable with the largest p-value, education level, was made inactive in a new model run. As residential density remained insignificant, with a p-value of 0.44, it was also made inactive. After re-estimating the model again, all covariates were significant with a p-value <0.05, indicating that they significantly influence class-membership. Lastly, the entropy R^2 of the total model was checked to assess to what extent the model accurately assigned the individual cases to the six clusters. The final latent class cluster model had an entropy R^2 of 0.77, which was slightly lower than the desired 0.80 but still sufficient. In addition, the standard R^2 for the covariates was 0.05, indicating that only a small portion of the variability in class membership was explained by the included covariates.

4.3. Parameter significance

Table 4 presents an overview of the significance of both the indicators and the covariates, as well as the factor loadings of the indicators. With the exception of two indicators, all are significant at the 0.001 level. The non-significant indicators consist of the usage frequency and the joy of riding. While there are differences in the car sharing use across the classes (see Table 5), these are non-significant, indicating that the different motivational profiles for car sharing usage, do not results in different frequencies of use. The factor loadings indicate that the classes differ most strongly with respect to the environmental motives, followed by the experienced effort of use, the utilitarian motivates and social motivates. The public transport motivates are least discriminatory.

Turning to the active covariates, the results indicate that the

Table 3
Model fit statistics.

No. of clusters	Npar	LL	BIC(LL)	Size of the smallest cluster
1	64	−27986.2	56430.4	100.0 %
2	81	−27240.2	55060.0	39.6%
3	98	−26899.0	54499.2	15.2%
4	115	−26719.7	54262.3	13.9%
5	132	−26580.0	54104.5	7.4%
6	149	−26483.5	54033.1	**6.6%**
7	166	−26406.8	**54001.3**	2.4%
8	183	−26356.6	54022.6	2.2%
9	200	−26307.2	54045.6	2.2%
10	217	−26257.1	54067.0	2.1%

Npar Number of parameters.
LL Log-likelihood.
BIC(LL) Bayesian Information Criterion (based on LL).

Table 4
Test statistics of the indicators and covariates.

Category	Indicator	Wald	p-value	Factor loading[a]
	Usage frequency	8.4	0.130	0.10
Environmental motives	Reduce emissions	185.7	0.000	0.61
	Reduce traffic	173.4	0.000	0.84
	Create public space	224.6	0.000	0.77
Utilitarian motives	Cheaper than a private car	78.8	0.000	0.40
	Easier than a private car	115.7	0.000	0.57
	Improves trip quality	75.6	0.000	0.32
	No parking search	119.5	0.000	0.44
Social motives	People around me encourage me	87.4	0.000	0.33
	Joy of driving	8.1	0.150	0.10
	Sharing of goods appeals to me	164.2	0.000	0.49
Experienced effort of use	Use is easy	178.4	0.000	0.53
	Proximity to shared car	75.3	0.000	0.48
	Shared car not available	101.0	0.000	0.36
Public transport motives	As last-mile solution for a train trip	38.6	0.000	0.20
	Instead of insufficient PT	42.4	0.000	0.22
	Active covariate	**Wald**	**p-value**	
	Age	22.8	0.000	
	Membership length in months	32.4	0.000	
	Household size	20.3	0.001	
	Parking facility available	61.3	0.000	

[a] The factor loadings are computed by a linear approximation of the logistic regression models for the indicators. The loadings output has an interpretation similar to factor loadings in a standard factor analysis (Vermunt and Magidson, 2005).

available parking facility (free on-street parking, paid/permit on-street parking or private parking) is most strongly associated with class membership. We will return to this finding in the discussion of the results.

4.4. Profile output

Table 5 presents the profile output of the final model, including both the indicators and covariates. Several additional variables are included as inactive covariates that were not present in the conceptual model as they provide additional information and context for the identified clusters. These variables are the number of disposed cars after starting car sharing, car sharing trip substitution and the driven car sharing kilometres. A description of the six distinct clusters can be found below.

Cluster 1: Moderately motivated car sharers [32%]

The first cluster, which is largest in size (32% of the sample), represents car sharers that do not distinguish themselves from the other clusters through specific high or low scores on the indicators, hence labelled as 'moderately motivated car sharers'. Regarding the environmental motives for using car sharing, the members of this cluster are rather indifferent and do neither agree nor fully disagree with the statements. While the members of this cluster rate the utility related statements slightly positive, their scores are rather low compared to the other clusters. The same applies to the statements related to the experienced effort to use shared cars.

With an average membership length of 66 months, members of this cluster are car sharing members for a shorter period than the members of most other clusters. Besides this, cluster 1 has the second highest car ownership, with 20% of its members owning at least one car. Compared to the other clusters, members of this cluster reside less in very highly urbanised areas and more often in highly urban urbanised areas.

Table 5
Class profiles of indicators and covariates of the 6-cluster model.

Class	1	2	3	4	5	6	Sample
Cluster size	32%	23%	19%	12%	7%	7%	
Indicators (mean)							
Usage frequency *Environmental motives*	2.52	2.62	2.79	2.62	2.55	2.29	2.59
Reduce emissions	2.97	3.20	3.98	4.15	1.50	1.55	3.15
Reduce traffic	3.34	3.78	4.55	4.95	1.40	1.41	3.59
Create public space	2.99	3.24	3.95	4.68	1.32	1.32	3.20
Utilitarian motives							
Cheaper than a private car	4.19	4.88	4.26	4.85	4.85	3.81	4.46
Easier than a private car	3.67	4.73	3.80	4.92	4.62	2.73	4.09
Improves trip quality	3.41	3.91	3.50	4.14	4.17	2.88	3.65
No parking search	2.81	3.49	2.94	4.15	2.81	1.68	3.07
Social motives							
People around me encourage me	2.77	3.20	2.80	3.71	2.80	2.01	2.94
Joy of driving	2.77	2.85	2.65	3.03	2.71	2.55	2.78
Sharing of goods appeals to me	3.25	3.69	4.16	4.41	2.80	2.37	3.57
Experienced effort to use							
Use is easy	3.87	4.72	4.34	4.82	4.64	3.67	4.31
Proximity to shared car	4.05	4.98	4.59	4.92	4.91	3.83	4.51
Shared car not available	3.23	2.13	2.84	2.46	2.22	3.24	2.74
Public transport motives							
As last-mile solution for a train trip	2.04	2.02	2.35	2.41	1.66	1.50	2.08
Instead of insufficient PT	4.27	4.52	4.59	4.75	4.44	3.95	4.44
Active covariates							
Age (mean) (Wald = 22.8, p < 0.001)	50	54	53	57	48	48	52
Membership length in months (mean) (Wald = 32.4, p < 0.001)	66	99	96	99	89	49	83
Household size (%)(Wald = 20.3, p = 0.001)							
1	27	36	19	29	33	32	29
2	40	45	42	44	40	37	42
3	15	12	12	11	12	14	13
4+	18	7	27	15	16	17	17
Mean	2.3	1.9	3.1	2.2	2.3	2.2	2.3
Parking facility available (%) (Wald = 61.3, p= < 0.001)							
Paid/permit on-street parking	50	74	52	78	71	38	60
Free on-street parking	33	17	26	18	15	32	25
Private parking spot	16	8	21	5	11	30	14
Other	1	2	1	0	2	0	1
Inactive covariates							
Car ownership (%)							
0	80	92	90	95	89	68	86
1	19	7	10	5	11	28	13
2+	1	1	1	1	0	3	1
Car disposed after car sharing (%)							
0	74	73	66	59	85	70	71
1	26	26	33	40	13	27	28
2 or more	0	1	1	1	1	3	1

(continued on next page)

Table 5 (*continued*)

Class	1	2	3	4	5	6	Sample
Level of education (%)							
None/primary education	0	0	1	1	0	0	0
Secondary education	7	7	5	5	8	8	6
Vocational education	5	6	5	6	5	5	5
College or university	82	84	86	85	87	79	84
I would rather not say	6	3	3	3	0	8	4
Residential Density (%)							
Very highly urban	67	85	73	85	86	66	76
Highly urban	25	11	19	11	9	23	18
Moderately urban	4	3	5	4	3	9	4
Little urban	2	1	2	0	2	0	1
Non-urban	1	0	0	0	0	2	1
Main car sharing trip purposes (% answered yes)							
Groceries/shopping	22	23	16	15	20	28	21
Visiting friends/ family	61	67	70	72	72	60	66
Sports/hobby/ entertainment	19	15	20	17	24	19	18
Vacation or weekend trip	32	28	30	33	20	11	25
Going from and to work or study	14	10	15	11	15	14	13
Picking-up/ dropping-off goods	55	58	30	56	54	50	56
(Health)care	4	5	3	6	4	4	4
Other	5	5	5	4	5	10	6
Car sharing trip substitution (%)							
Shared car from other company	8	10	8	8	8	10	9
Car from family/ friend/ acquaintance	11	8	10	7	8	12	10
Private car	25	19	31	24	17	32	25
Ride along with someone else	8	9	5	10	9	9	8
Public Transport	33	40	36	41	49	23	36
(E−)bike	7	5	3	5	2	8	5
I would not have made the trip	5	5	5	1	5	3	4
Other	3	4	2	3	1	3	3
Car use after car sharing (%)							
More	28	31	23	20	45	19	27
Equal	34	30	35	34	34	46	34
Less	38	40	42	46	21	35	39
Car sharing kilometres (One year mean)	877	940	1270	1146	1018	703	996
Number of reservations (One year mean)	18.8	20.5	23.3	22.6	20.4	17.7	20.6

Regarding the main car sharing trip purposes, members of this cluster use the shared car more often for a vacation or weekend trip compared to the other clusters. In addition, while visiting friends or family is the most reported trip purpose across all clusters, this trip purpose is reported relatively less often within this cluster.

Cluster 2: Experienced utilitarian car sharers [23%]

Members of this cluster rate the utility-related motives to use shared cars high and, in particular, the cost-related motive, which has the highest score of all clusters. In comparison to the other clusters, this cluster of users scores average on the three statements about the environment. Interesting to note is the very positive scores on the statements related to the experienced effort it takes to use shared cars. Furthermore, the members in the cluster are characterised by a long average car sharing membership duration (99 months) and by having the lowest average household size (1.9). The parking facilities available to the members of this cluster are predominantly paid or permit on-street parking (74%). Therefore, it might not be surprising that within this cluster 92% does not own a private car. Combined with the below-average percentage of people who disposed of their private car, this indicates that most members of this cluster did not own a car before they started car sharing. This may also explain the relatively low share of car substitution (19%) compared to the other clusters. It can be inferred that car sharing is used as an addition to their public transport-oriented travel behaviour.

Cluster 3: Environmentally motivated frequent car sharers [19%]

Members of the third cluster show the highest car sharing use of all clusters. Furthermore, this cluster distinguishes itself from the other clusters by scoring high on environmentally-related motives while scoring relatively lower on utility-related motives. This indicates that members of this cluster make a conscious choice, based on their attitudes related to the environment, to use shared cars. In addition, the low score on the joy of driving and the high score on the preference for sharing goods could support this.

The members of this cluster typically live in the largest households of the sample with an average size of 3.1 individuals. Furthermore, they have the highest car sharing use and relatively fewer members live in very highly urban areas (73%). It is worth mentioning that while members of this cluster have an above-average share of free on-street (26%) and private parking facilities (21%) available to them, car ownership within this cluster is very low (90% do not own a car). 34% of the members in this cluster have disposed of at least one private car since they started using Greenwheels, and they show a high car sharing trip substitution for the private car (31%). This indicates that members of this cluster use the shared car as a full replacement for a private car they would have used otherwise. This is also supported by the fact that members of this cluster use the shared car substantially less for occasional trips such as 'picking up or dropping off' goods.

Cluster 4: Highly conscious car sharers [12%]

The highly conscious car sharers make a very deliberate and motivated choice to use shared cars. This is exemplified by their high scores on all environmental and utility-related statements. This cluster distinguishes itself from the third cluster by the high values on the utility-related motives. Furthermore, members of this group have the highest score on the statement related to the sharing of goods, which supports the suggestion that they make a deliberate choice to use shared cars.

Members of this cluster are characterised by being the oldest of all clusters with an average age of 57, and together with the second clusters, they are on average Greenwheels members for the longest period (99 months). At the residential location of the members of this cluster, 78% have paid or permit on-street parking available to them, which is the highest percentage of all clusters. This may explain the fact that this cluster has the highest score on the indicator related to not having to search for a parking spot when using a (station-based) shared car. Furthermore, car ownership within the cluster is the lowest of all clusters, with only 6% owning a car. In addition, 41% of the members have disposed of at least one car after they start using car sharing, which is the highest percentage of all clusters. This highlights that, similar to the third cluster, members of this cluster have made a deliberate choice to replace their private cars by using shared cars.

Cluster 5: Environmentally-sceptical utilitarian car sharers [7%]

For the members of this cluster, the environmentally related statements are no motivation at all to use car sharing. However, the utility-related statements, except for not needing to search for a parking spot, are rated high by the members of this cluster. Compared to the other clusters, the members of this cluster do not like the idea of sharing goods as much. Reviewing all the scores on the indicators of this cluster suggests that its members mainly use the shared car because it benefits them

in terms of money, effort and trip quality.

Together with the sixth cluster, the members of this cluster are, on average, the youngest of all (48 years on average). However, different from cluster six, members of this cluster are, on average, car sharing members for a longer period (89 months compared to 49). When reviewing the level of car ownership, it is noticeable that while car ownership is low, the amount of disposed cars after starting using car sharing is the lowest of all clusters (14%). This shows that car ownership in this group was already low before using car sharing. Therefore, it is unsurprising that 49% of this cluster members indicates that they would have used public transport if they could not have used a Greenwheels shared car and that only 17% of this cluster indicates that they would have used a private car if they could not have used a Greenwheels shared car, which is the lowest of all clusters. Altogether, this suggests that members of this cluster were initially car-less individuals and that car sharing enabled them to use a car. This suggestion is also supported by the fact that this cluster is the only cluster in which more individuals (45%) indicate that their car usage has increased, instead of decreased (21%), after starting car sharing.

Cluster 6: Sceptical occasional car sharers [7%]

The sceptical occasional car sharers are found not to be particularly motivated to use shared cars. Besides the cost motive and the use of shared cars instead of insufficient public transport, members show no positive scores on the motives. Furthermore, members of this cluster have the lowest car sharing usage frequency.

Together with the fifth cluster, members of this cluster are the youngest car sharers and further distinguish themselves by being car sharing members for the shortest period of all clusters (49 months). Besides, they are slightly less highly educated and live less often in very highly urban areas than the other clusters. What further sets this cluster apart is that 62% of the members have either free on-street or private parking available to them. Therefore, it might not be surprising that car ownership is the highest of all clusters, with 32% owning at least one car. The higher car ownership might also explain the lower scores of these clusters on the utility and experienced effort related statements. Noticeable is that while car ownership is relatively high, 31% of the individuals in this cluster have disposed of a private car, which is the third highest of all clusters. This showcases that individuals do not need to be particularly motivated or use the shared car very often to dispose of a shared car. Together with the relatively high car ownership still present (31% owns a private car), the reduction in car ownership might indicate that members of this cluster have disposed of their second or third car since starting car sharing. Lastly, the high share of private cars as a substitution for the shared car, combined with the lowest share of public transport as a substitution, indicates that members in this cluster are less public transport oriented.

4.5. Effects on car ownership reduction

It was hypothesized that the reduction of car ownership (as a result of car sharing) would differ across the classes. This is indeed confirmed by the profile output (Table 5), which shows that the percentages of people that disposed 1 of more cars differ substantially across the classes (varying between 13% in class 5–40% in class 4). To assess whether this relationship is also statistically significant and control for potential confounding factors we ran an additional ordinal regression model using the number of disposed cars are the dependent variable. To this end, the so-called 3-step approach is used, in which car ownership reduction is treated as distal outcome of the latent classes (Asparouhov and Muthén, 2013). In this regression, the measurement error present in the latent classes is taken into account via the posterior membership probabilities (Asparouhov and Muthén, 2013).

Table 6 shows the parameter estimates of the model predicting car ownership reduction. The results show that belonging to the fourth class (the highly conscious car sharer) indeed significantly increases the probability that a person disposed a car, while membership of the fifth class (the environmentally sceptical car sharer) decreases this probability. Hence, people who engage in car sharing from a deliberate and strongly motivated perspective, are more likely to reduce their car ownership, as opposed to sceptical users. In addition to class membership, age and membership length also have significant effects on car ownership reduction. People tend to reduce car ownership with increasing age, which is an intuitively plausible effect. Finally, the length of membership has a negative effect on car ownership reduction. This suggests that more recent adopters of car sharing are more likely dispose a car after engaging in car sharing, compared to people who have been a member for a longer time. This suggests that people make the decision to dispose a car sooner rather than later (after adoption). Another possible explanation is that the cohort of current adopters (for some reason) is different from the group of earlier adopters, and that among the new adopters, car sharing is increasing seen as a means to dispose of a car. Of course, this would be a desirable trend from a policy perspective.

Table 6
Results of the ordinal regression model predicting car ownership reduction.

Variable	Category	Estimate[a]	p-value
Class membership	Class 1	−0.052	0.740
	Class 2	−0.240	0.180
	Class 3	0.254	0.160
	Class 4	0.505	0.004
	Class 5	−0.683	0.024
	Class 6	0.216	0.430
Age		0.053	0.000
Membership length in months		−0.003	0.002
Household size		−0.004	0.900
Parking facility available	Paid/permit on-street parking	−0.297	0.220
	Free on-street parking	0.023	0.930
	Private parking spot	0.116	0.650
	Other	0.157	0.820
Level of education		0.012	0.880
Residential density		−0.069	0.530
Treshold (0 cars disposed)		4.427	0.000
Treshold (1 car disposed)		1.071	0.000
Treshold (2 or more cars disposed)		−5.498	0.000

[a] Effect coding is used to ensure that the parameters are identifiable.

5. Discussion

The segmentation of station-based car sharers showed how six user groups differed in their motives for using car sharing and their related characteristics. Based on their motives, environmentally motivated frequent car sharers and highly conscious car sharers seem to make a deliberate choice to use car sharing services. Their relatively high level of car sharing use combined with the substantial reduction in car ownership indicate that these groups specifically use shared cars as a replacement for private car use. Therefore, station-based car sharing proves to be an effective way to reduce car ownership for these user groups. These user groups show that the high car ownership reductions found in other studies are indeed possible and can be explained through the distinct car sharer profiles (Jochem et al., 2020; Nijland and van Meerkerk, 2017; Schreier et al., 2018).

Conversely, environmentally-sceptical utility focused car sharers have a substantially lower impact on car ownership due to their already low initial car ownership. In fact, the results showed that car sharing led to a net increase in car use among the members of this cluster, which confirms that car sharing may also have a negative impact in terms of sustainability (María Arbeláez Vélez et al., 2021). However, as this cluster is rather small it could be argued that the improvement in terms

of transportation equity, as formerly carless people are enabled to use a car when they need one, outweigh the negative impacts on the environment. The other, more substantial, utilitarian group shares similarities with the environmentally-sceptical utilitarian car sharers. However, members of this group are less sceptical in regard to environmental motives, and more individuals in this group disposed of a car as their initial car ownership was higher. For both groups, the shared car is primarily a useful addition to their mobility options. This shows how car sharing impacts on mobility behaviour are very dependent on the individual, and it might explain why some studies find a small or even negative effect of car sharing on car ownership (Becker et al., 2018; Bucsky and Juhász, 2022; Kolleck et al., 2021).

Furthermore, the sceptical occasional car sharers demonstrated that cost benefits and perceived public transport insufficiency are enough to motivate those individuals to dispose of private cars, even with lower levels of car sharing use. Moreover, the relatively high level of car ownership still present in this group indicated that also second cars were disposed of, exemplifying an impact of car sharing, which was not found for the other user groups. These findings hold to a lesser degree also for the moderately motivated car sharers, in which similar patterns are found.

Considering the ongoing discussion on the impact of car sharing on private car ownership, this study provides a meaningful nuance by showing how car ownership reductions differ for different user groups. However, it also shows an average reduction of 30% for all users, which highlights the positive impact of station-based car sharing on private car ownership in the Netherlands. Combined with similar findings of studies conducted in the Netherlands, it can be concluded that station-based car sharing indeed has a positive impact on private car ownership (Nijland and van Meerkerk, 2017; Oldenburger et al., 2019).

Besides the impacts related to different user groups, this work provides some other new insights. First of all, we find that the subjective norm ‘people around me encourage me to use shared cars’ is not an important motive for most station-based car sharers. This statement received a neutral score on average in the sample and only one of the classes (class 4) agreed with this statement, and also not very strongly. This is quite a surprising finding given that multiple studies find this to be the most important predictor of the intention to use car sharing (Curtale et al., 2021; Mattia et al., 2019). This suggests that subjective norms are important when considering new ways of transportation, such as shared cars, but once a service is adopted, it is no longer regarded as an important aspect. Another interesting insight is the fact that the cluster with the highest car sharing use (the environmentally motivated frequent car sharers), also has the highest average household size (3.1). This shows that while smaller households are often associated with a greater intention to use shared cars, this does not always hold for the actual use (Amirnazmiafshar and Diana, 2022; Ceccato and Diana, 2021; Prieto et al., 2017). The disparities between findings on the intention to use car sharing and the actual use show how relying only on stated preferences may cause incorrect conclusions.

In addition, this study clarified the relationship between station-based car sharing and public transport. More specifically, it shows that car sharers are primarily public transport oriented but use a shared car when public transport is perceived insufficient for the intended trip. This highlights the complementary nature of station-based car sharing to public transport. Furthermore, when the hypothetical modal substitution of the shared cars was weighed for the carsharing use of the respondents, it turned out that the shared car substituted mostly private car trips. This differs from the study of (Nijland and van Meerkerk, 2017), which found that car sharing primarily substitutes public transport, and highlights the general positive influence of car sharing on sustainable travel behaviour.

Moreover, this study was among the first to include the influence of different parking facilities on car sharing use. While different parking facilities showed a significant influence on belonging to a distinct user group, it was not possible to determine whether strict parking facilities actually contributed to people’s decision to start car sharing. Clarifying the relations between stricter parking policies, the decision to become a car sharer and car ownership would provide valuable knowledge on the role of car sharing in reducing car ownership. To do so, future studies could consider estimating the impact of introducing stricter parking facilities alongside the introduction of car sharing services in that same area.

6. Conclusion

By the identification of six distinct station-based user profiles, this study showed that one specific type of car sharer does not exist and that implications of stimulating car sharing use differ per user group. From this segmentation, it can be concluded that the amount of car sharing usage is not the main determinant for the positive impacts related to car sharing, rather is the profile of the individual that uses the shared car. Therefore, car sharing companies and policymakers should recognise the identified differences between user groups when designing strategies to promote car sharing use or enhance sustainable transportation.

Considering the desire to reduce car ownership in urban areas, governmental institutions should focus on increasing the number of car sharers, rather than increasing the frequency of car sharing use. This is supported by substantial car ownership reduction for all users, even for more sceptical and occasional users. Additionally, it might be more effective to focus on areas with higher levels of car ownership, as addressing groups with already low car ownership might cause an increase in car use. However, as the need to reduce car ownership in very urbanised areas might be higher than the need to reduce car use, attracting more car sharers in highly urbanised areas would also be an effective strategy. Furthermore, as shared cars are found to be a useful but necessary supplement to public transport for car-less individuals, governments could explore ways to improve and stimulate the use of both modes next to each other, to satisfy the travel needs of car-less individuals. This particularly applies to public transport users who retain a car for occasional trips that could potentially be replaced by a shared car.

Car sharing companies could exploit the identified user groups by advertising the specific strengths and benefits of shared cars to the different (potential) user groups. For the utility-focussed groups, the perceived benefits in terms of convenience, costs and having an extra transportation option should be promoted, while for the environmental and highly conscious car sharers, the sustainable image should be highlighted. To the moderately motivated and sceptical car sharers, the possibility of disposing of a second car and the added value of a shared car as an additional travel option could specifically be promoted.

To indeed be able to target these specific groups, car sharing companies could focus on the availability of parking supply in different areas. The results show that the probabilities that a person belongs to one of the utilitarian classes (2 and 4) increase if one lives in an area with paid or permit on-street parking, while the probability that one belongs to the environmentally motivated class (3) increases in areas with free on-street parking. This is a relevant/actionable insight for operators. If parking supply is scarce, one is more likely to engage in car sharing for utilitarian reasons (shared car is cheaper), and if parking supply is abundant environmental reasons become more important. People in these areas seem to participate on a more voluntary basis, inspired by their concerns for the environment. The advertisement of the benefits of shared cars in specific areas can be tailored to these differences.

This research has certain limitations and suggestions for future research. A limitation is the fact that the impact of car sharing on car ownership found in this study is based on self-reported data of the respondents. Hence, the results entail some uncertainty as respondents might have provided incorrect data or unjustly attributed the disposal of their private cars to the use of car sharing services.

Including station-based car sharers of different companies or even other types of car sharing, such as zone-based or free-floating, would put

the results into a broader perspective. Furthermore, the underrepresentation of young people in the sample might have influenced the results as young people may have different motives for using shared cars, especially concerning the environmental and cost-related aspects. Lastly, a future study could also include different types of car sharing users to reveal if similar user groups exist among other station-based, zone-based or free-floating car sharers.

CRediT authorship contribution statement

Hidde van der Linden: Writing – original draft, Visualization, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Gonçalo Correia:** Writing – review & editing, Supervision. **Niels van Oort:** Writing – review & editing, Supervision. **Suze Koster:** Writing – review & editing, Supervision, Funding acquisition, Data curation. **Martijn Legêne:** Writing – review & editing, Supervision, Funding acquisition, Data curation. **Maarten Kroesen:** Writing – review & editing, Writing – original draft, Supervision, Methodology.

Data availability

The data that has been used is confidential.

References

Acheampong, R.A., Siiba, A., 2020. Modelling the determinants of car-sharing adoption intentions among young adults: the role of attitude, perceived benefits, travel expectations and socio-demographic factors. Transportation 47 (5), 2557–2580.

Aguilera-García, Á., Gomez, J., Antoniou, C., Vassallo, J.M., 2022. Behavioral factors impacting adoption and frequency of use of carsharing: a tale of two European cities. Transport Pol. 123, 55–72.

Ajzen, I., 1991. The theory of planned behavior. Organ. Behav. Hum. Decis. Process. 50 (2), 179–211.

Amirnazmiafshar, E., Diana, M., 2022. A review of the socio-demographic characteristics affecting the demand for different car-sharing operational schemes. Transp. Res. Interdiscip. Perspect. 14.

Asparouhov, T., Muthen, B., 2013. Auxiliary variables in mixture modeling: a 3-step approach using Mplus. Mplus web notes 15 (6), 1–39.

Becker, H., Ciari, F., Axhausen, K.W., 2017. Comparing car-sharing schemes in Switzerland: user groups and usage patterns. Transport. Res. Pol. Pract. 97, 17–29.

Becker, H., Ciari, F., Axhausen, K.W., 2018. Measuring the car ownership impact of free-floating car-sharing – a case study in Basel, Switzerland. Transport. Res. Transport Environ. 65, 51–62.

Bucsky, P., Juhász, M., 2022. Is car ownership reduction impact of car sharing lower than expected? A Europe wide empirical evidence. Case Studies on Transport Policy 10 (4), 2208–2217.

Burghard, U., Dütschke, E., 2019. Who wants shared mobility? Lessons from early adopters and mainstream drivers on electric carsharing in Germany. Transport. Res. Transport Environ. 71, 96–109.

Burkhardt, J.E., Millard-Ball, A., 2006. Who is attracted to carsharing? Transport. Res. Rec.: J. Transport. Res. Board 1986 (1), 98–105.

Carrone, A.P., Hoening, V.M., Jensen, A.F., Mabit, S.E., Rich, J., 2020. Understanding car sharing preferences and mode substitution patterns: a stated preference experiment. Transport Pol. 98, 139–147.

Ceccato, R., Diana, M., 2021. Substitution and complementarity patterns between traditional transport means and car sharing: a person and trip level analysis. Transportation 48 (4), 1523–1540.

Clewlow, R.R., 2016. Carsharing and sustainable travel behavior: results from the San Francisco bay area. Transport Pol. 51, 158–164.

Curtale, R., Liao, F., van der Waerden, P., 2021. User acceptance of electric car-sharing services: the case of The Netherlands. Transport. Res. Pol. Pract. 149, 266–282.

De Luca, S., Di Pace, R., 2015. Modelling users' behaviour in inter-urban carsharing program: a stated preference approach. Transport. Res. Pol. Pract. 71, 59–76.

Green Deal Autodelen II, 2022. Greendeals.nl.

Guglielmetti Mugion, R., Toni, M., Di Pietro, L., Pasca, M.G., Renzi, M.F., 2019. Understanding the antecedents of car sharing usage: an empirical study in Italy. International. Journal of Quality and Service Sciences 11 (4), 523–541.

Hjorteset, M.A., Böcker, L., 2020. Car sharing in Norwegian urban areas. Transport. Res. Transport Environ. 84, 102322.

Jochem, P., Frankenhauser, D., Ewald, L., Ensslen, A., Fromm, H., 2020. Does free-floating carsharing reduce private vehicle ownership? The case of SHARE NOW in European cities. Transport. Res. Pol. Pract. 141, 373–395.

Jorritsma, P., Witte, J.-J., Alonso González, M.J., Hamersma, M., 2021. Kennisinstituut voor Mobiliteitsbeleid | Deelauto- en deelfietsmobiliteit in Nederland.

Kim, D., Ko, J., Park, Y., 2015. Factors affecting electric vehicle sharing program participants' attitudes about car ownership and program participation. Transport. Res. Transport Environ. 36.

Kolleck, A., Olsson, L., Guyader, H., 2021. Does car-sharing reduce car ownership? Empirical evidence from Germany. Sustainability 13 (13), 7384.

Li, L., Zhang, Y., 2023. An extended theory of planned behavior to explain the intention to use carsharing: a multi-group analysis of different sociodemographic characteristics. Transportation 50 (1), 143–181.

Magidson, J., Vermunt, J.K., 2004. Latent class models. In: Kaplan, D. (Ed.), The Sage Handbook of Quantitative Methodology for the Social Sciences. Sage, pp. 175–798.

Magidson, Jay, Vermunt, J.K., 2002. Latent class models for clustering: a comparison with K-means. Canadian Journal of Marketing Research 20, 37–44.

María Arbeláez Vélez, A., Plepys, A., Olsson, L., Guyader, H., 2021. Car sharing as a strategy to address GHG emissions in the transport system: evaluation of effects of car sharing in amsterdam. Sustainability 13 (4), 2418.

Matowicki, M., Pribyl, O., Pecherkova, P., 2021. Carsharing in the Czech Republic: understanding why users chose this mode of travel for different purposes. Case Studies on Transport Policy 9 (2), 842–850.

Mattia, G., Guglielmetti Mugion, R., Principato, L., 2019. Shared mobility as a driver for sustainable consumptions: the intention to re-use free-floating car sharing. J. Clean. Prod. 237, 117404.

Mavlutova, I., Kuzmina, J., Uvarova, I., Atstaja, D., Lesinskis, K., Mikelsone, E., Brizga, J., 2021. Does car sharing contribute to urban sustainability from user-motivation perspectives? Sustainability 13 (19), 10588.

Millard-Ball, A., Burkhardt, J., Murray, G., Ter Schure, J., Fox, C., 2005. TRCP Report 108: Car-Sharing: where and How it Succeeds.

Molin, E., Mokhtarian, P., Kroesen, M., 2016. Multimodal travel groups and attitudes: a latent class cluster analysis of Dutch travelers. Transport. Res. Pol. Pract. 83, 14–29.

Montes, A., Geržinič, N., Veeneman, W., Van Oort, N., Hoogendoorn, S.P., 2023. Shared micromobility and public transport integration - a mode choice study using stated preference data. Res. Transport. Econ. 99, 101302.

Münzel, K., Piscicelli, L., Boon, W., Frenken, K., 2019. Different business models – different users? Uncovering the motives and characteristics of business-to-consumer and peer-to-peer carsharing adopters in The Netherlands. Transport. Res. Transport Environ. 73, 276–306.

Nijland, H., van Meerkerk, J., 2017. Mobility and environmental impacts of car sharing in The Netherlands. Environ. Innov. Soc. Transit. 23, 84–91.

Oldenburger, A., Olde Kalter, M., Timmermans, E., 2019. HOE GREENWHEELS STEDEN LEEFBAARDER MAAKT Studie Op Basis Van Een Representatieve Enquête Onder Gebruikers.

Papu Carrone, A., Hoening, V.M., Jensen, A.F., Mabit, S.E., Rich, J., 2020. Understanding car sharing preferences and mode substitution patterns: a stated preference experiment. Transport Pol. 98, 139–147.

Prieto, M., Baltas, G., Stan, V., 2017. Car sharing adoption intention in urban areas: what are the key sociodemographic drivers? Transport. Res. Pol. Pract. 101, 218–227.

Ramos, É.M.S., Bergstad, C.J., Chicco, A., Diana, M., 2020. Mobility styles and car sharing use in Europe: attitudes, behaviours, motives and sustainability. European Transport Research Review 12 (1), 1–12.

Schaefers, T., 2013. Exploring carsharing usage motives: a hierarchical means-end chain analysis. Transport. Res. Pol. Pract. 47, 69–77.

Schreier, H., Grimm, C., Kurz, U., Schwieger, B., Keßler, S., Möser, G., 2018. Analysis of the impacts of car-sharing in Bremen, Germany. www.team-red.net.

Shaheen, S., Cohen, A., Chan, N., Bansal, A., 2020. Sharing strategies: carsharing, shared micromobility (bikesharing and scooter sharing), transportation network companies, microtransit, and other innovative mobility modes. Transportation, Land Use, and Environmental Planning 237–262.

Tarnovetckaia, R., Mostofi, H., 2022. Impact of car-sharing and ridesourcing on public transport use: attitudes, preferences, and future intentions regarding sustainable urban mobility in the post-soviet city. Urban Science 6 (2), 33.

Van der Linden, H.H.M., 2023. Driving factors behind station-based car sharing use in The Netherlands. http://resolver.tudelft.nl/uuid:a1361f79-cff8-4aa3-be1d-24f427a5b238.

Van Liere, B., Beens, O., Knol, A., 2017. Van wie is de stad? https://milieudefensie.nl/actueel/van-wie-is-de-stad-pdf.

Venkatesh, V., Thong, J.Y.L., Xu, X., Walton, S.M., 2012. Consumer acceptance and use of information Technology: extending the unified theory of acceptance and use of Technology. Source: MIS Q. 36 (1), 157–178.

Vermunt, J.K., Magidson, J., 2005. Factor analysis with categorical indicators: a comparison between traditional and latent class approaches. In: New Developments in Categorical Data Analysis for the Social and Behavioral Sciences. Psychology Press, pp. 41–62.

Vermunt, J.K., Magidson, J., 2016. Technical guide for latent GOLD 5.1: basic, advanced, and syntax. Available at: http://www.statisticalinnovations.com.

Wang, J., Dane, G.Z., Timmermans, H.J.P., 2021. Carsharing-facilitating neighbourhood choice: a mixed logit model. J. Hous. Built Environ. 36 (3), 1033–1054.

Weller, B.E., Bowen, N.K., Faubert, S.J., 2020. Latent class analysis: a guide to best practice. J. Black Psychol. 46 (4), 287–311.