Hindawi
Journal of Advanced Transportation
Volume 2022, Article ID 4614848, 21 pages
https://doi.org/10.1155/2022/4614848

Research Article

Exploring Users' Preferences for Automated Minibuses and Their Service Type: A Stated Choice Experiment in the Netherlands

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Received 13 January 2022; Revised 14 June 2022; Accepted 17 June 2022; Published 6 October 2022

Academic Editor: Tiziana Campisi

In this paper, we study the deployment potential of automated minibuses (AmBs) on the first-mile part of public transport (PT) trips or short (sub)urban commutes by comparing "regular" (fixed route and fixed schedule) and "flexible" (door-to-door and on-demand) service types. For reaching that goal, we run a stated choice experiment in the Netherlands. The participants have assessed the referred two AmB alternatives compared to their current travel mode (car, PT, or active modes (AM) – bicycle and walking) used as the main mode for unimodal travellers or as access travel mode to transit lines for multimodal travellers. The results of a joint mixed logit model estimation based on data obtained from Dutch travellers show that there are similarities and differences in the preferences for the AmBs service type within and between the segments of travellers (car, PT, and AM) and that these are mostly in instrumental variables (cost and time) and attitudes. Current PT users prefer the flexible service to regular service based on their perception of in-vehicle travel time and waiting time, while current users of car and AM do not show a difference in preference between the two services concerning these variables. Moreover, their perception of in-vehicle travel time and waiting time is not significantly different from PT users' perception of those variables in the regular service. This may mean that for non-PT users (car and AM), AmB's flexibility of door-to-door transport is not seen as offering a significant advantage over what they think about public transport. When looking at the preferences of potential users explained by underlying psychological factors, we conclude that a positive attitude towards riding in AmBs is a significant factor in all three segments of travellers. Trust, usefulness, and enjoyment in using AmBs are important prerequisites for car and PT users to choose either service type. The experience with technology positively influences the preferences of current PT users for both AmB services.

1. Introduction

In the last several decades, urban mobility has undergone a fast transformation driven by the sharing economy, electrification, and automation. A variety of travel options that complement public transport (PT) systems is provided by vehicle-sharing (e.g., cars and micromobility modes such as scooters, and bicycles) and ride-sharing services (e.g., car or vanpooling, taxi-like services, and microtransit minibus shuttles). Nowadays, an increasing number of environmentally friendly electrical models are being deployed in these services, while potentially safer and more cost-efficient automated vehicles are expected to substitute human-driven ones in the near future [1–4].

In the present study, we focus on automated minibuses (AmBs) that are currently being introduced to the public around the world in pilot settings including in the Netherlands. Given the vehicle design characteristics (smaller size and low speed), prospective flexibility, and cost-efficiency of operations, the potential of AmBs' ride-sharing service to strengthen the underserved links of PT networks has attracted attention in both research and practice [5].

While automated driving technology is still undergoing tests and has to gain maturity, there is a need to understand in which application cases and contexts the AmBs' potential could be maximized so that it can serve the transport needs of the prospective end-users. Here, application cases can be defined as the area of service such as rural, (sub)urban areas, or city centres, and application contexts such as the type of service (scheduled or on-demand), the driving environment (in mixed traffic or on dedicated lanes), and the type of supervision and surveillance, etc.

So far, there is only one study in which researchers compared different application cases to determine how they influence the successful deployment of AmBs. It was conducted during the CityMobil2 project in 12 European cities [6]. The application cases were grouped into four categories, namely, "within city centre" (La Rochelle, Oristano, Reggio Calabria, and Trikala), "within a major facility (university campus, business district)" (Geneva, Lausanne, San Sebastian, and Sophia Antipolis), "from PT node to a major facility (hospital, exhibition centre)" (Brussels, León, and Milan), and "from PT node to the residential area" (Vantaa). At that time, researchers found a higher preference for AmBs than for conventional minibuses only in the cities with routes "within major facilities (university campus, business district)," which indicated that automated shuttles might not be attractive in all applications. Nevertheless, in the meantime, several years have passed and vehicle automation is becoming a more mainstream technology.

For understandable reasons, other studies evaluated people's experiences in a single-pilot application case and results should be interpreted bearing this limitation in mind. Among them, the application cases included city centres [7, 8], residential areas [9, 10], routes within business districts [11] and university campuses [12], the route from a PT station to a hospital [13] or an airport [14], the route from a parking area to an exhibition centre [15], and at a tourist location [16]. The overall impressions and intentions to use the AmBs in the future were estimated in those studies.

Apart from instrumental variables that characterize the mode of transport (travel time, travel distance, costs, and waiting and walking time), several context variables were also included such as time of day [15], weather [15, 16], driving environment (mixed vs dedicated lane) [17], supervision and surveillance [17, 18], trip purpose [19], and crowdedness [16]. The participants of these studies showed in general that they would prefer to travel in an AmB in the daytime, in rainy weather, in mixed traffic, and in a less crowded environment. The AmBs were found to be more attractive for long-distance trips, for leisure purposes, and were less favoured for regular commuting on short distances. Yet, preferences for supervision and surveillance had mixed results for example.

In the present study, we focus on one fundamental aspect of AmBs future integration into PT systems, that is, the type of service offered to the clients. The on-demand and flexible features of AmB's service are frequently mentioned as an advantage of this new transport mode [9]. The flexible service (on-demand, door-to-door) can be introduced as an alternative to or operating jointly with regular (fixed route, scheduled) service. Another option is to provide a hybrid service where the AmBs follow a fixed route but can be called on-demand.

To date, there are only a few studies that focus on the type of service. The studies by Badia and Jenelius [20] and Calabrò et al. [21] showed that both service types could find appropriate application cases, depending on the size of the operational area, travel demand, and the length of the trips and users' value of travel time.

The travellers' perception of service types was hitherto evaluated in two stated choice studies. In the last-mile application case, from a metro station to the business park Rivium (Capelle-aan-den-IJssel, the Netherlands), respondents were given a choice between an AmB operating in a dedicated lane, an AmB driving in mixed traffic, or selecting another travel mode [17]. The type of service, namely, fixed one with fixed stops (regular service) or offering on-demand door-to-door trips (flexible service), was included as an attribute of the AmBs in the experiment. The preference for the latter type was found to be higher. In [18], respondents were asked to choose between an AmB, a conventional bus, or another travel option. A conventional bus followed a fixed route and a fixed schedule (regular service). For an AmB operating on a fixed route as well, the respondents could select the fixed-schedule operations or call an AmB on-demand (hybrid service). It appeared that partial flexibility offered by on-demand operations in a hybrid service was not more attractive to potential users in the application case of short trips in (sub)urban areas.

From these two studies, we have initial indications that flexible service is more appreciated than a regular one, but a hybrid service (on-demand, fixed-route) does not look like an appealing solution. Nevertheless, more insights are needed to understand the decision-making process behind the preferences for the AmBs and their service type.

An additional aspect that we look at in the present study is the influence of the users' current travel mode. In other words, finding out if the travellers grouped according to their current travel mode (car, PT, or active modes (AM) - bicycle and walking), the AmBs and their service type were perceived differently. As Roche-Cerasi [22] showed, car users may not perceive any additional value of AmBs in the application case of first-mile connection to public transit. The participants of the cited study stated that it would not make their travel by PT easier and more attractive. On the contrary, 37.5% of car users living in rural areas with low PT network coverage expressed their intention to switch to AmBs operating as an access mode to conventional bus stops [23]. In the segment of current PT users, it appeared that 16 to 23% of travellers would use PT more often with the introduction of AmBs [23]. Likewise, a positive correlation with the intention to use AmBs was found for frequent PT and AM commuters on the last-mile part of their trip [24]. However, the results of the study by [25] showed that car and PT users may not differ in their intention to use automated PT such as automated trains, trams, or buses.

From earlier studies, we see that the intention to use the AmBs in the future varies between current travellers' segments when classified by their main current mode of transport. Therefore, accounting for it is important when evaluating the potential of the AmBs and their service type.

Aiming to contribute to the further understanding of the prospects of AmBs' integration into PT systems from the users' perspective, we can formulate the main objective of the present study: to explore the preferences for AmBs with respect to the service type (regular and flexible), which might be provided for the first-mile part of the trips or short (sub) urban commutes, and in comparison to the travellers' current mode (car, PT, or AM).

Therefore, we designed a stated choice experiment for a hypothetical application case of first-mile (access) connection to transit lines or short (sub)urban commuting trips in the Netherlands. We use two types of service, one being on-demand and door-to-door, called "flexible service," and the other a fixed-route and fixed-schedule service, called "regular service." Their introduction as two separate alternatives in the choice sets allows the explicit evaluation of each service type. We asked the participants to assess the two AmB alternatives compared to their current travel mode (car, PT, or AM), which was obtained in the earlier part of the survey. This disaggregated approach also allows us to evaluate the differences and similarities in the preferences between the AmB service types among the different user segments according to their current travel mode.

The paper is organized as follows. In the next section, we give a brief overview of the expectations and doubts that prospective users have about AmBs. The methodology of the research is described in Section 3; the collected survey data are analysed in Section 4. We explain the modelling approach in Section 5. In Sections 6 and 7, respectively, we discuss the results and finalize the paper with general conclusions and future research directions.

2. Literature Overview on Users' Expectations and Doubts regarding AmBs

The potential users of these services have started to form their initial opinions about AmBs following news about them in the media, observing demonstration drives (without passengers) or taking test rides during pilot projects. There is a common expectation that the introduction of AmBs can lead to social, economic, and environmental benefits. However, their launching has also attracted some concerns.

From a positive perspective, the users see the AmBs as part of PT systems and look forward to the improvement that can be brought upon in terms of flexibility, frequency, personalisation of the trip preferences, and better network coverage [25–28]. They expect an increase in the accessibility for older, disabled people, in particular when a door-to-door service is introduced [22]. AmBs are seen to even replace private vehicles and, therefore, reduce congestion [29]. The environmental benefits are in saving energy and using clean energy sources [11].

From a negative perspective, the concerns are mainly about privacy and security from hacking or terrorist attacks, safety in traffic in general and because of the possibility of a technology failure [8, 30–32]. The question about the ethical reasoning of AmBs in case of an unavoidable accident is frequently raised, i.e., "run over a child or crash the vehicle" type of issue [10]. Prospective users are hesitant about relying on technology, communicating their needs as passengers, and interpreting the behaviour of AmBs when driving or passing by as they do not yet have enough experience [25, 29, 33, 34]. Therefore, people do not expect faster journeys and fewer traffic accidents [22]. The increase in vehicle and infrastructure costs is of concern as well [35].

The absence of a driver has two main consequences according to the prospective users' view. On one hand, it might save the expenditure on salaries and thus make the flexible, on-demand, door-to-door service feasible [29, 32]. However, opinions on a possible travel cost reduction are not consensual. As opposed to the usually expected decrease [27], the participants of another study [10] were unsure if this will be a reality in the future. They would prefer the costs to be used to improve the service quality, i.e., having frequent, on-demand, round-the-clock operations. Other foreseen advantages include improved safety in traffic due to elimination of drivers' mistakes, less rude behaviour, or reduction of unpleasant driving style, and also a more stable service as buses will not be cancelled when staff are not available [27]. On the other hand, travellers realize that the deployment of technology will cause the loss of jobs [35]. Not having a driver or another supervisory person onboard also raises concerns about late-night safety and security, prevention of vandalism, and compliance with paying for the trip. Problems might arise too with regards to access inside the bus for disabled and older people and the provision of first aid [36, 37].

It is important that the influence of this mix of advantages and disadvantages, envisaged by the participants of the abovementioned studies, is addressed and continuously monitored for changes. Therefore, in addition to the stated choice experiment that focuses on the users' preferences for the AmBs' service type in comparison to their current travel mode, we include in the survey more aspects. Among them are the influence of the belief that AmBs would reduce the number of traffic accidents and lower the environmental impact of transport; trust in technology to drive the passengers safely; knowledge and experience with AmBs; and preferred type of supervision that would substitute the driver.

3. Methodology

An online stated preference survey was designed that comprised four sections. The questionnaire started by collecting the information on the respondent's current travel behaviour to be used in the stated choice experiment, which is in the second section. The third section included Likert scale indicators of attitudes for different aspects related directly or indirectly to AmBs. Finally, in the last part, respondents were asked to provide information about their socioeconomic background.

3.1. Stated Choice Experiment. If a new alternative (e.g., travel mode, route, etc.) is offered to travellers, a stated choice (SC) experiment is often used [38]. This is a data collection technique that originated in the fields of transport and market research [39]. The respondents are given several sets of choices, with several alternatives that differ in their attributes and attribute levels. In its most standard configuration, they are asked to choose one of the options in the given hypothetical situation [40]. Further analysis of the data with discrete choice models allows us to evaluate the prospects of new alternatives and establish the trade-offs that respondents make [41].

The usage of such surveys is not free of debate. The main concern is about the hypothetical nature of the choice situation, its representation of reality, and, consequently, the reliability of stated choices. To ensure realistic responses, in Sections 3.1.1–3.1.4, we address the issue of the realism of the SC experiment by using a reference alternative and providing a clear description of AmBs and their service types, by including relevant indicators of service quality in the choice tasks as attributes and by carefully selecting the attribute levels to represent the choice context.

3.1.1. Reference Alternative. As mentioned above, the hypothetical essence of the choice situations that respondents face in an SC experiment has raised concerns as to whether a respondent would make the same choice in reality. Therefore, the quality of the collected data is in question. To increase the realism of an SC experiment, it is advised to use a reference point from which the respondent starts the evaluation of potential options (see Starmer as cited in [42]).

In the first section of the survey, the participants were asked to provide information about their current travel behaviour, which was used to create a reference alternative for the SC experiment. From the question about the current occupation status of the respondents, the trip purpose was assumed and was taken as a context in the choice sets. The respondents were referred to a trip from home to work (for employed or self-employed individuals), study (for students), or any frequently visited destination (for unemployed or retired individuals). Depending on the respondents' travel pattern for the reported trip, the main transport mode for unimodal travellers or access transport mode for multimodal travellers (the main transport mode for them was in most cases the train) was used as a label for the reference alternative in the SC experiment. According to this travel mode, we grouped the respondents into three segments of travellers: the car users, the PT users (bus or tram), and the AM users (cycling or walking).

It is important to note that travellers have different perceptions of access and egress parts of multimodal trips; users tend to pay more attention to the characteristics of the access part as was shown in [43]. Therefore, we specifically asked multimodal travellers only to think about the access part of the trip and used it in the choice situations instead of generalizing to first-/last-mile connections.

An additional precaution was taken to avoid the misperception that the AmBs might substitute high passenger capacity transit modes or private cars for relatively longer commuting trips. For example, in the case when in real life the respondent commutes from home to work by car for 45 min, this is probably not a trip that should be replaced by an AmB. We thus limit the application of the AmBs to a first-mile trip or a short (sub)urban trip in the Dutch context by assigning the invariant "standard" trip duration of 20 min with "standard" travel costs concerning the current travel mode (further explained in Section 3.1.3).

Another rationale for using a reference alternative in this SC experiment is that we can look into similarities and differences in the preferences for the AmBs and their service type between the mentioned three segments of travellers (car, PT, and AM users).

3.1.2. Alternatives and Their Description. Aiming to explore the potential of two service types that the AmBs might offer in the future, we included them as two separate alternatives to the choice sets. They were designated "self-driving bus (regular service)" which follows a fixed route and has a fixed schedule, and "self-driving bus (flexible service)" which operates on-demand and picks up and drops off passengers at their requested locations.

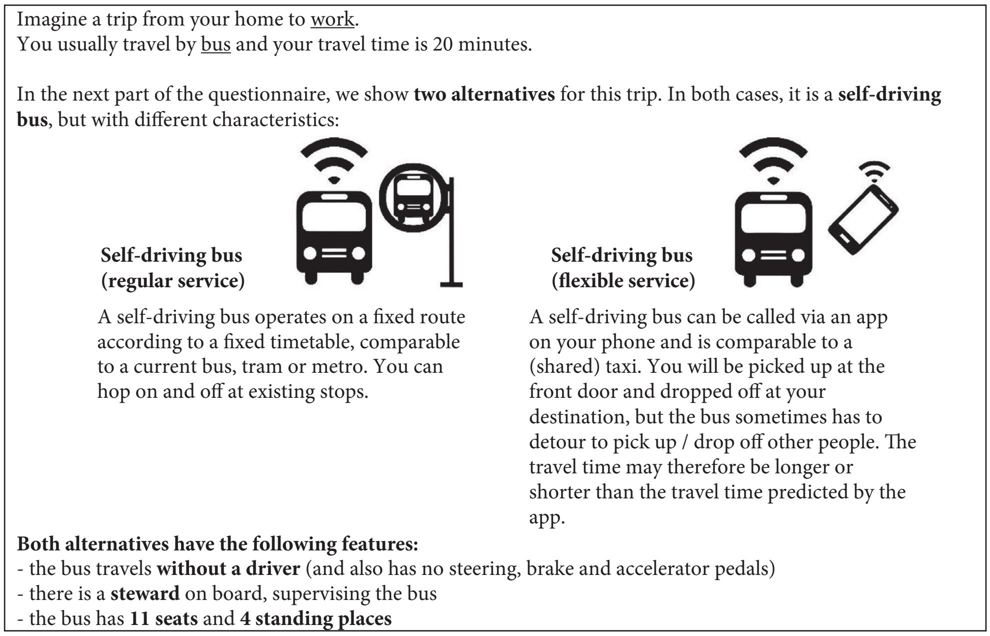
To help the respondents to imagine an AmB with the service type that it might provide in the context of their daily trips, we gave them a clear description of two main AmB alternatives (Figure 1).

3.1.3. Attributes and Attribute Levels. To evaluate the deployment potential of the two types of services provided by AmBs from the users' perspective, we include four instrumental variables in the SC experiment that are key attributes of service quality as shown in previous studies [44, 45]. For PT and the two AmB alternatives, the instrumental variables are in-vehicle travel time, travel costs, waiting time at the stop or doorstep, and walking time to the stop (only for "regular service"). The car trip has attributes of in-vehicle travel time and costs. We assume that the car is parked next to the respondent's home; so, the walking time for the car users is negligible. Cycling or walking time is shown for AM users.

Travel time of the reference alternative (car, PT, and AM) is fixed at 20 min to limit the application case of the AmBs to a first-mile part of the trip or a short (sub)urban trip in the Dutch context. This figure is assumed based on the average trip length of 40–45 km per day for people in the 18–65 years age range [46].

The calculation of travel costs for car users is based on the cost per km for owning and running a vehicle. It includes fuel, insurance, maintenance costs, and tax payments for an average car excluding parking costs [47]. Travel costs for PT are taken from trip planning apps.

The attribute levels for the AmBs are pivoted around attributes of the reference trip if this is done in PT; e.g., in-vehicle travel time in the AmB (regular service) is 10 min shorter, the same or 10 min longer than in PT (Table 1). The attribute levels of travel time and costs for the AmB (flexible service) are assumed to be higher than those of the AmB (regular service), considering possible longer trips with detours for picking up and dropping off passengers. All alternatives, their attributes, and attribute levels are shown in Table 1.


Imagine a trip from your home to work.
You usually travel by bus and your travel time is 20 minutes.

In the next part of the questionnaire, we show **two alternatives** for this trip. In both cases, it is a **self-driving bus**, but with different characteristics:

Self-driving bus (regular service)

A self-driving bus operates on a fixed route according to a fixed timetable, comparable to a current bus, tram or metro. You can hop on and off at existing stops.

Self-driving bus (flexible service)

A self-driving bus can be called via an app on your phone and is comparable to a (shared) taxi. You will be picked up at the front door and dropped off at your destination, but the bus sometimes has to detour to pick up / drop off other people. The travel time may therefore be longer or shorter than the travel time predicted by the app.

Both alternatives have the following features:
- the bus travels **without a driver** (and also has no steering, brake and accelerator pedals)
- there is a **steward** on board, supervising the bus
- the bus has **11 seats** and **4 standing places**

Figure 1: Example of the description of two AmB alternatives (for an employed respondent who travels from home to work by bus).

Table 1: Alternatives, attributes, and attribute levels in the SC experiment.

	Alternative 1 Current travel mode			Alternative 2 Automated minibus (regular service)	Alternative 3 Automated minibus (flexible service)
	CAR	PT	AM		
In-vehicle travel time (min)	20	20	20	10/20/30 (−10/0/+10)*	15/25/35 (−5/+5/+15)*
Travel costs (€)	5.00	2.50	—	2.00/2.50/3.00 (−0.50/0/+0.50)*	2.50/3.25/4.00 (0/+0.75/+1.50)*
Waiting time (min)	—	5	—	2/5/8 (−3/0/+3)*	2/5/8 (−3/0/+3)*
Walking time (min)	—	8	—	4/8/12 (−4/0/+4)*	—

CAR: reference alternative (car users); PT: reference alternative (PT users); AM: reference alternative (AM users). * Applied pivot values are in parenthesis.

3.1.4. Choice Sets. The fractional factorial orthogonal design of 12 choice sets is generated in Ngene software [48]. With the relatively low complexity of the choice tasks in our SC experiment, a full number of situations (12 choice sets) is presented to each respondent (see Figure 2 for an example).

3.2. Socioeconomic Characteristics of the Respondents and Attitudinal Indicators. The influence of attitudes and perceptions in an individual's decision-making process can be captured by measuring the agreement or disagreement with indicators on a Likert scale. In previous research, it was shown that the inclusion of these latent variables in discrete choice models increases their explanatory power [49, 50]. Another argument for the attitudinal indicators is that little is known so far about what might motivate people to use the AmBs in the future; therefore, we included this component in the survey as well.

The selection of the indicator statements is based on earlier studies where researchers showed a significant effect on the acceptance of AmBs (Table 2). Among them are perceived usefulness (S15, 21, 22), ease of use (S14), safety (S11, 13), enjoyment (S18, 19), intention to use (S16), environmental benefits (S20), and future applications (S12).

Additionally, we asked respondents to rate their general opinion about self-driving transport (S1), experience with technology (S6-10), and comfort of riding backwards (S17) as the AmB does not have a front or back end and can travel in both directions. We include a block that assesses sensation-seeking or risk-taking behaviour that is not yet well studied but shows high loadings on the intention to use the AmBs in the future [28]. The indicators are adapted from the psychometric Domain-Specific Risk-Taking scale (DOSPERT) [51].

The last section of the survey contains questions about the socioeconomic background of the respondents such as gender, age, educational level, occupation, annual gross household income, region of residence in the Netherlands, possession of a driving licence and PT pass, possession of different types of vehicles, having a traffic accident in the past, having disability or motion sickness, use of car- or ride-sharing services (such as Uber and GreenWheels), having knowledge about automated driving and experience with it, and preference for the type of supervision that would substitute a driver in an AmB.

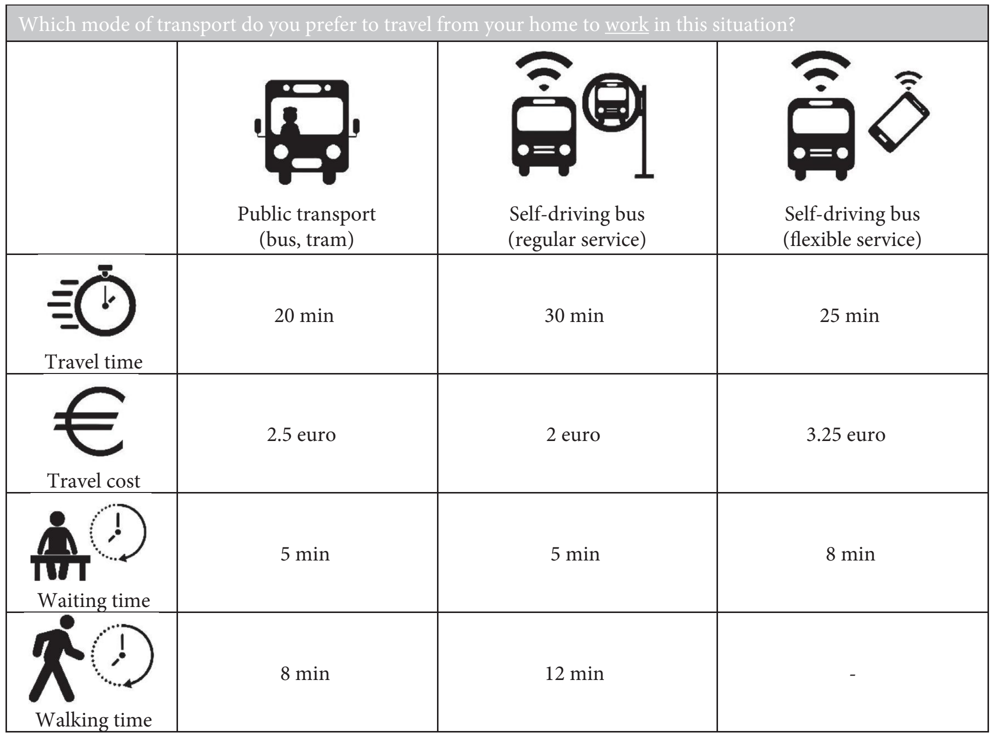


Figure 2: Example of a choice set with PT as reference alternative.

4. Data Analysis of Survey Sample

4.1. Data. The online survey was distributed in the Netherlands in March 2020 by an external panel company. The original version was in Dutch and is shown in this paper in its translated version. Only respondents over 18 years of age were invited to take part in the research.

The total number of participants who joined the survey was 1685. Ninety respondents did not complete it, and for 230 respondents, it took less than 5 min to answer all questions. Considering the length of the survey, their answers were excluded. The resulting number of valid responses is 1365 (81.0%). The majority of the respondents (67.5%) spent 5–10 min, while it took 10–20 min for 28.3% of the sample and more than 20 min for the remaining 4.2% of the participants.

Furthermore, an analysis of the data on nontrading and lexicographic behaviour was conducted. As it is shown by Hess et al. [55], sometimes participants have a strong preference for one of the alternatives, response fatigue, or just trying to influence a policy decision. Another type of selection strategy is choosing the cheapest or the fastest option and ignoring other attributes. Unfortunately, we cannot learn much from these responses because it is not possible to establish trade-offs between the attributes.

We excluded the nontraders who selected only one of the alternatives in all the 12 choice tasks, in most cases this was their current travel mode. Notice that we are not aiming at estimating mode shares as a result of this study. Afterwards, we looked for the lexicographic choice patterns and removed those responses from the dataset. In the end, the sample consisted of 520 car users, 153 PT commuters, and 160 AM travellers. The remaining 833 responses were further analysed using discrete choice models, and in total $833 * 12 = 9996$ observations were collected from the SC experiment.

Table 3 shows the distribution of socioeconomic characteristics (SEC) in the sample (in total and separately for car, PT, and AM segments of travellers) and the population of the Netherlands. The categories of the SEC such as gender, age, education level, occupation, and the province of residence are slightly over- or undersampled in the whole sample and each segment but can be considered representative of the Dutch population. In terms of annual household income, the sample cannot be considered representative as the percentages of below-average and middle-income (1-2*x* average) categories are just opposite to the distribution in the population. Due to the sensitivity of the question about income, almost 16% of respondents preferred not to answer, so the true representation is hard to establish. We have decided not to apply weights to correct the income distribution in the sample as this would bias the choices for AmBs and their service type (checked with cross-tabulation) and because we are not aiming to estimate mode shares with this study.

The data on the daily travel behaviour of the respondents are of interest as well. The distribution of main transport modes and the trip purposes is summarized in Table 4. Comparing to the population, it can be seen that in the sample of 520 car users, 153 PT users, and 160 AM users, there are approximately 6% fewer car users (drivers and passengers), 4% more PT users, and 8% more AM users than the population according to [46]. Therefore, we can consider that the sample is sufficiently representative of the population.

Table 2: Attitudinal indicators.

	Indicators	Source	Likert scale
S1	What is your general opinion about self-driving transport?	This study	1 = very poor, 7 = very good
	How likely is it that you will show the following behaviour if the opportunity arises?		
S2	Drive (yourself or as a passenger) without wearing your seat belt	Adapted from [51]	1 = very unlikely, 7 = very likely
S3	Get into someone's car when you know that the driver has drunk more than two glasses of alcohol		
S4	Cycle or walk across the street while the traffic light is on red		
S5	Exceed the speed limit		
S6	I have a lot of experience with the use of "adaptive cruise control" in the car (automatically keeping a distance from the vehicle ahead)	This study	1 = strongly disagree, 7 = strongly agree
S7	I have a lot of experience with using "cruise control" in the car (driving automatically at a fixed speed)		
S8	I regularly use a parking assistance system in the car		
S9	I regularly have my navigation system switched on in the car		
S10	I regularly use a travel planner to plan my public transport journey		
S11	Self-driving buses without a driver are safe	Adapted from [28]	
S12	I think that in 30 years only self-driving vehicles will be on the roads	Adapted from [52]	
S13	Thanks to self-driving vehicles, there will be fewer fatal road accidents in the future		
S14	I think it takes a lot of time to learn how a self-driving bus works	Adapted from [53] (reversed)	
S15	The use of a self-driving bus is comparable to the use of current public transport (bus, tram, and metro)	Adapted from [28]	
S16	In the future, I will use self-driving transportation for my daily trips		
S17	Riding backwards in a self-driving bus (seats facing the opposite direction of travel) is not an option for me	This study	
	A ride on a self-driving bus		
S18	is fun	Adapted from [54]	Score from 1 to 7
S19	is relaxing		
S20	is better for the environment		
S21	is flexible		
S22	saves time		

Additionally, we have found that 89.3% of the sample of respondents have a driving licence and 66.6% have a PT pass; 80% of the participants have a private or leased vehicle, and 80.6% have a scooter or bicycle; 42.7% of the sample have been in a traffic accident. Car- and ride-sharing services are popular with 10.7% of the respondents; 14.9% have some disability, and 13.6% suffer from motion sickness in one or more transport modes. The distribution of the aforementioned characteristics per segment of users is given in Table 5.

One of the most noteworthy findings is that 65.2% of the sample already knew about automated driving, namely, 62.7% of car users, 69.9% of PT users, and 68.8% of AM users. Meanwhile, 46.5% of the respondents in the sample used driving assistance technology and, most important, 14.4% had experienced a test ride in an AmB or automated vehicle (respectively, 48.8% and 13.7% of car users, 45.8% and 19.6% of PT users, and 39.4% and 11.9% of AM users).

4.2. Missing Data. Respondents had the option not to provide any of their personal information. From Table 3, we can see that there are missing data on education level (0.1%) and annual gross household income (15.8%).

The most common approach for handling missing data is a listwise deletion of the responses from the dataset. However, it is known that this might affect the size and representativeness of the sample and bias the outcomes of the models [60]. In the present study, the deleted responses would negatively influence the representativeness of the car segment of travellers. For this reason, it is useful to have a closer look at the data before deciding whether to delete the incomplete responses or impute them using one of the state-of-the-art available methods.

The proportion of missing data is of importance. The education level falls below the benchmark of 3%. As the variable is categorical, the imputation of the most frequent category is used as recommended by Harrell [60]. With the proportion of over 3% of the missing values in income data, imputation methods can be applied [60]. We deploy the nonparametric k-nearest neighbours (kNN) method that can be used for numerical (continuous) and categorical data. It is a hot deck imputation method for cases where both the recipient variable (income) and donor variables (age, gender, education level, and occupation) are in one dataset. The advantage of this method is that instead of a predictive model that might be misspecified, the distance metric is applied to

Table 3: Overview of the sample and comparison with the distribution in the Dutch population.

Variable	Category	Car users (520 respondents), in %	PT users (153 respondents), in %	AM users (160 respondents), in %	Sample (833 respondents), in %	Population [56, 57, 58, 59], in %
Gender	Male	52.1	45.1	51.9	50.8	49.7
	Female	47.9	54.9	48.1	49.2	50.3
Age	18–24	3.3	24.2	15.6	9.5	14.6*
	25–34	17.3	22.2	13.8	17.5	15.1
	35–44	16.0	15.0	10.6	14.8	14.1
	45–54	19.6	9.8	15.0	16.9	17.2
	55–64	24.0	13.1	21.3	21.5	16.0
	65–74	16.5	14.4	21.9	17.2	13.1
	75–84	3.3	1.3	1.3	2.5	7.1
	>85	—	—	0.5	0.1	2.8
Education level	No education	0.4	—	0.6	0.4	—
	Primary education	0.6	0.7	5.0	1.5	9.4
	Secondary education	19.2	17.5	25.0	20.1	20.1
	Higher national diploma	34.2	23.6	25.6	49.3	36.7
	Undergraduate degree (bachelor's degree)	39.0	47.1	39.4	21.8	20.5
	Postgraduate degree or higher (master's degree, PhD, etc.)	6.4	11.1	4.4	6.8	11.8
	I do not know, prefer not to say	0.2	—	—	0.1	1.5
Occupation	Employed or self-employed	67.9	56.9	41.8	60.9	68.9
	Retired	8.7	3.9	15.0	13.9	11.6
	Student or intern	14.0	10.5	16.8	7.4	3.7
	Unemployed or (partially) incapacitated	1.5	23.5	11.2	9.0	
	Housewife/houseman	5.2	4.6	10.6	6.1	15.8 (including the last 3 categories)
	Volunteer	2.1	0.6	2.9	2.0	
	Others	0.6	-	1.7	0.7	
Annual gross household income	Minimum (less than €12,500)	2.1	9.2	7.5	4.4 (5.3)**	6.4
	Below average (€12,500 - €36,000)	26.5	28.1	32.5	28.0 (33.2)	69.4
	1-2*x* average (€36,000 - €72,000)	48.3	34.0	33.8	42.9 (50.9)	22.3
	More than 2x average (more than €72,000)	9.8	12.4	2.4	7.8 (10.6)	1.9
	I do not know/prefer not to saydsb	13.3	16.3	23.8	15.8	—
Provinces	North Holland	10.6	20.9	16.2	13.6	16.5
	South Holland	18.8	28.8	16.9	20.3	21.3
	Utrecht	5.4	5.2	11.2	6.5	7.8
	Zeeland	3.7	1.3	2.5	3.0	2.2
	North Brabant	14.8	8.5	13.8	13.4	14.7
	Limburg	11.0	8.5	5.0	9.4	6.4
	Gelderland	14.0	7.2	16.2	13.2	12.0
	Overijssel	6.5	5.9	5.0	6.1	6.7
	Flevoland	3.8	2.0	5.0	3.7	2.4
	Drenthe	3.7	1.3	2.5	3.0	2.8
	Friesland	3.7	5.9	4.4	4.2	3.7
	Groningen	4.0	4.5	1.3	3.6	3.5

* This category starts from the age of 15 in the data from CBS. ** Percentages in parenthesis are recalculated excluding missing data in income for comparison with the distribution in the population.

Table 4: Distribution of main transport modes according to the trip purpose in the sample and the population.

Transport mode/Trip purpose (%)	Work (60.9%)	Study (7.4%)	Recreational (31.7%)	Total in the sample	Distribution in the population [46]
Car (as a driver)	40.4	0.7	11.7	52.8	50.9
Car (as a passenger)	2.0	0.2	7.4	9.6	18.5
Train	5.5	2.3	1.6	9.4	11.3
Bus, tram, metro	4.9	2.0	2.0	8.9	2.9
Bicycle	5.2	2.2	3.7	15.4	8.4
Electric bicycle	1.2	—	3.1		
Scooter	1.0	—	0.7	1.7	—
Walk	0.7	—	1.5	2.2	2.5
Other*	—	—	—	—	6.4

Table 5: Distribution of additional characteristics per segment of travellers (car, PT, and AM users).

Variable	Category	Car users (520 respondents), in %	PT users (153 respondents), in %	AM users (160 respondents), in %
Driving licence	Yes (any type of driving licence)	96.5	81.0	73.8
Vehicle in possession	Private or company (lease) auto	92.9	56.9	60.0
	Scooter, bicycle or electric bicycle	76.5	84.3	90.0
PT pass	Yes	57.1	96.7	68.8
Traffic accident	Yes	44.4	43.1	36.9
Disability	Yes (any type of disability)	13.5	15.7	18.8
Motion sickness	Yes (in any type of vehicle)	13.5	16.3	11.3
Use of car- or ride-sharing services (such as Uber and GreenWheels)	Yes	9.8	16.3	8.1

define the connection between recipient and donors [61, 62]. We fill in the missing values in the income variable by KNN Imputer from Scikit-Learn [63] with the mean value of 5 nearest neighbours from age, gender, education level, and occupation donor variables.

5. Discrete Choice Modelling

5.1. Model Specification. Discrete choice models are applied for the analysis of collected data from the SC experiment. Essentially, these models try to explain and describe the decision-making process of the respondent based on the utility maximization principle [38, 41, 64]. In other words, it is thought that the individual n chooses the alternative i among the presented finite or discrete number of alternatives I. She or he is assumed to try to maximize her or his utility (benefit) when stating their preference in $t \in \{1, \ldots T\}$ choice sets. These choices are further combined into a utility U_{in} associated with each alternative.

In the present study, we use the utility function of the alternative i in the linear-additive form:

$$U_{\text{in}} = V_{\text{in}} + \varepsilon_{\text{in}}, \tag{1}$$

where V_{in} is observed or measured by the researcher, and ε_{in} contains all unobserved variables and measurement errors.

The observable or systematic part V_{in} consists of three components. The first is the vector of instrumental variables x_{ikn} and vector of their coefficients β_{ik}. From the SC experiment, these are in-vehicle travel time, travel costs, waiting time at the stop or doorstep, and walking time to the PT stop, as in Table 1. The measured part of the utility V_{in} is extended with the second term comprising the respondents' socioeconomic characteristics x_{isn} with a related vector of coefficients β_{is}. The socioeconomic data are categorized and dummy coded before entering into the models. The vector of latent variables η_{iln} with a corresponding vector of coefficients β_{il} represents the respondents' subjective perceptions and attitudes and is the third component. The inclusion of the last one is of the so-called hybrid choice models formulation that incorporates the latent constructs either sequentially or simultaneously. Even though the simultaneous way can outperform the sequential, we use the last one for its practical simplicity and clarity which is sufficient for this exploratory study.

Equation (1) can be rewritten as follows:

$$U_{\text{in}} = \sum_k \beta_{ik} x_{ikn} + \sum_s \beta_{is} x_{isn} + \sum_l \beta_{il} \eta_{iln} + \varepsilon_{\text{in}}. \tag{2}$$

The assumptions about the form of the distribution of the unobserved part ε_{in} of the utility function lead to different discrete choice model specifications. The error term ε_{in} is independently and identically distributed extreme value type 1 for all alternatives in a Multinomial Logit (MNL) model formulation. If the unobserved factors in the utilities are correlated over the alternatives, the distribution

Table 6: Estimation results of exploratory factor analysis.

Indicators	Factors			
	Trust, usefulness, and enjoyment of AmB	Positive attitude towards riding in AmBs	Technology experience	Risk-taking behaviour
S11: self-driving buses without a driver are safe	0.714			
S13: thanks to self-driving vehicles, there will be fewer fatal road accidents in the future	0.694			
S16: in the future, I will use self-driving transportation for my daily trips	0.632			
S15: the use of a self-driving bus is comparable to the use of the current public transport (bus, tram, and metro)	0.591			
S12: I think that in 30 years, only self-driving vehicles will be on the roads	0.533			
S1: what is your general opinion about self-driving transport?	0.527	0.492		
S21: a ride on a self-driving bus is flexible		0.803		
S22: a ride on a self-driving bus saves time		0.776		
S19: a ride on a self-driving bus is relaxing	0.519	0.636		
S18: a ride on a self-driving bus is fun	0.504	0.627		
S20: a ride on a self-driving bus is better for the environment		0.600		
S7: I have a lot of experience with using "cruise control" in the car (driving automatically at a fixed speed)			0.715	
S6: I have a lot of experience with the use of "adaptive cruise control" in the car (automatically keeping a distance from the vehicle in front)			0.646	
S8: I regularly use a parking assistance system in the car			0.639	
S9: I regularly have my navigation system switched on in the car			0.518	
S3: how likely would you be to get into someone's car when you know that the driver has drunk more than two glasses of alcohol?				0.709
S4: how likely would you be to cycle or walk across the street while the traffic light is on red?				0.676
S5: how likely would you be to exceed the speed limit?				0.652
S2: how likely would you be to travel (as driver or passenger) without wearing your seat belt?				0.593

with generalized extreme value can capture this correlation in the most commonly used nested logit models.

The family of mixed logit models can be specified either by using (a) random coefficients β accounting for taste heterogeneity among individuals or (b) by adding a random error component that might capture the correlation in unobserved factors over time or alternatives. Mixed logit models can also take into consideration the intrarespondent heterogeneity or the correlation of the responses of the same person across the given number of choice sets.

Different model specifications are tested in this study in a search for a final model with the highest statistical significance in explaining our sample of choices.

5.2. Exploratory Factor Analysis. The exploratory factor analysis is performed in the SPSS software package to construct the latent attitudinal variables from indicator statements in Table 2 [65]. As its name indicates, this statistical technique explores and groups the attitudinal indicators into common factors without a prior hypothesis about correlations between measured indicators.

The principal axis factoring model is applied as the primary goal is to capture the latent dimensions. For ease of interpretation, a simple structure is achieved with orthogonal varimax rotation. The indicators with communalities lower than 0.25 and factor loading lower than 0.4 are excluded from the exploratory factor analysis. Subsequently, 19 out of 22 statements are grouped into four factors that account for 65.1% of the variance in the data and have an eigenvalue greater than 1. That is considered sufficient with the explained variance of over 60% [66]. These 4 factors correspond to trust, usefulness, and enjoyment of AmB; positive attitude towards riding in AmBs; technology experience; and risk-taking behaviour (Table 6). Computed factor scores for each respondent are further included in the discrete choice models.

5.3. Models' Estimation Process. We deploy a five-stage modelling strategy to explore if there are similarities (taste homogeneity) in the preferences for the AmB service types (regular and flexible) within and between the segments of travellers (car, PT, and AM) (Figure 3). Even though full taste homogeneity (in all parameters included in a discrete choice

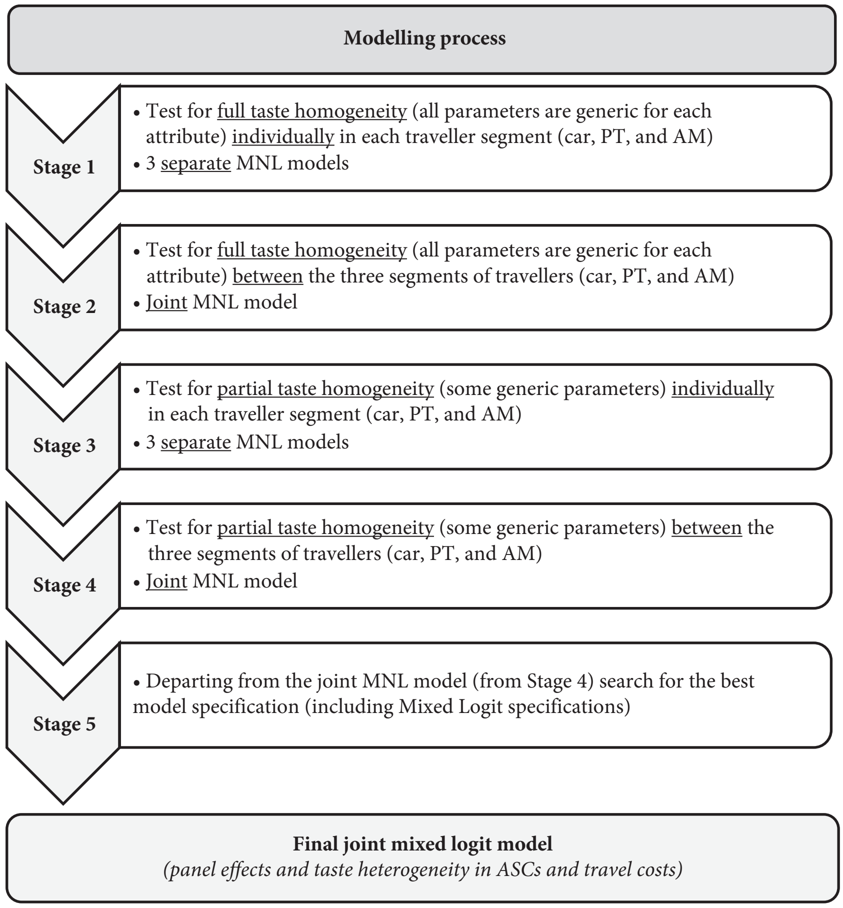


Figure 3: Five-stage modelling process.

model) is rare, as a matter of statistical evidence we start with testing whether it exists in the preferences for the AmB service type within each traveller segment (Stage 1) and between the segments (Stage 2). Once the presence of full taste homogeneity is rejected, we proceed with allocating the sources of partial taste homogeneity (in some parameters) in preferences for the AmB service type, starting from within each traveller segment (Stage 3) and then between the traveller segments (Stage 4). MNL models are used for the tests of full and partial taste homogeneity in the initial four stages. Proceeding with the resulting MNL model from Stage 4, we search for the best model specification (including mixed logit) that explains the observed choices in the collected datasets and present the results of a final model at Stage 5. PythonBiogeme software package is used for the estimation of all tested discrete choice model specifications [67].

5.3.1. Stage 1: Full Taste Homogeneity in the Preferences for the AmB Service Type in the Car, PT, and AM Traveller Segments Individually. We start with base MNL models with instrumental, socioeconomic, and latent variables and estimate them for each segment of travellers independently (car, PT, or AM). The reference alternative has invariant attribute levels and remains constant in each choice set and across respondents within the segment of travellers. To account for the reference trip, the pivoted attribute levels of two AmB alternatives enter the discrete choice models as a difference (absolute deviation) from the reference alternative. All parameters are included as alternative-specific in the base MNL models.

To test whether the potential users do not distinguish the service types (regular and flexible), we estimate three general (restricted) MNL models with almost all parameters for the AmB (regular service) and the AmB (flexible service) being generic instead of alternative-specific. As the walking time to the bus stop is only given for the AmB (regular service) in the SC experiment, it remains alternative-specific. The correctness of the specification of the general (restricted) models is verified by the likelihood ratio test [38]:

$$LRS = -2\left\{L\left(\beta_g\right) - L(\beta)\right\}, \quad (3)$$

where $L(\beta_g)$ and $L(\beta)$ are the final log-likelihood of the general (restricted) model with 34 generic parameters and the base model with 67 alternative-specific parameters, respectively.

Comparing the likelihood ratio statistics for car, PT, and AM segments, respectively, $LRS_{CAR} = 163.308, LRS_{PT} = 242.878, LRS_{AM} = 90.326$ with the critical value of $\chi^2 = 47.400$ for 33 degrees of freedom at the 95% significance level, we can conclude that full taste homogeneity for two AmBs' service types is not present in the car, PT, and AM traveller segments.

5.3.2. Stage 2: Full Taste Homogeneity for the AmB (Regular Service) and the AmB (Flexible Service) between Three Segments of Travellers (Car, PT, and AM) in the Joint Model. To allow for the direct comparison of preferences for two AmB alternatives between the three segments of travellers (car, PT, and AM), we create an artificial nested structure of a joint MNL model following the methodology suggested by Swait and Bernardino [68]. Three base (alternative-specific) MNL models are placed as separate nests under one root. The difference in the variance σ of error terms ε in three traveller segments (car, PT, and AM) is accounted for by the relative scale parameters μ. The scale parameter for the car users' nest is normalized to one $\mu_{CAR} = 1$, and the scale parameters for PT μ_{PT} and AM μ_{AM} nests are estimated relative to it.

From (2), we can rewrite the joint model that accounts for the differences in the scales:

$$\begin{aligned} U_{\mathrm{CAR}} &= \sum_k \beta_{\mathrm{CAR}\,k} \cdot x_{\mathrm{CAR}\,k} + \sum_s \beta_{\mathrm{CAR}\,s} \cdot x_{\mathrm{CAR}\,s} + \sum_l \beta_{\mathrm{CAR}\,l} \cdot \eta_{\mathrm{CAR}\,l} + \varepsilon_{\mathrm{CAR}}, \\ U_{PT} &= \mu_{PT}\left(\sum_k \beta_{PT\,k} \cdot x_{PT\,k} + \sum_s \beta_{PT\,s} \cdot x_{PT\,s} + \sum_l \beta_{PT\,l} \cdot \eta_{PT\,l} + \varepsilon_{PT} \right), \\ U_{AM} &= \mu_{AM}\left(\sum_k \beta_{AM\,k} \cdot x_{AM\,k} + \sum_s \beta_{AM\,s} \cdot x_{AM\,s} + \sum_l \beta_{AM\,l} \cdot \eta_{AM\,l} + \varepsilon_{AM} \right). \end{aligned} \tag{4}$$

Full taste homogeneity is tested under the assumption that tastes are the same in all parameters $\beta_{\mathrm{CAR}\,k} = \beta_{PT\,k} = \beta_{AM\,k}$, $\beta_{\mathrm{CAR}s} = \beta_{PT\,s} = \beta_{AM\,s}$, $\beta_{\mathrm{CAR}\,l} = \beta_{PT\,l} = \beta_{AM\,l}$ and the only difference between the three segments exists in scales $\mu_{\mathrm{CAR}} \neq \mu_{PT} \neq \mu_{AM}$. The sum of the final log-likelihoods of the base (alternative-specific) MNL models estimated independently is −8646.54 with a total of 201 parameters (67 in each). The final log-likelihood of the joint restricted MNL model with 67 generic parameters and 2 scale parameters is −9056.411. The likelihood ratio statistics of 819.742 is much higher than the χ^2 critical value of 159.814 for 132 degrees of freedom at a 95% significance level. Therefore, we conclude that there is no full taste homogeneity present between the segments of car, PT, and AM users.

5.3.3. Stage 3. Partial Taste Homogeneity in the Preferences for the AmB Service Type within Each Traveller Segment (Car, PT, and AM) Separately. Having proved that full taste homogeneity (in all parameters) is not present, in the third stage, we check whether partial taste homogeneity (in some parameters) exists in the preferences for the AmB type of service within each segment of travellers independently (car, PT, and AM users). Here, we return to the three base MNL models for car, PT, and AM users' segments with all parameters included as alternative-specific for the AmB (regular service) and the AmB (flexible service).

In the previous Stages 1 and 2, the full set of 67 parameters (including the nonsignificant ones) has been used for testing the hypothesis of full taste homogeneity (in all parameters). At this stage, we at first exclude nonsignificant parameters from the base (alternative-specific) MNL models. The remaining parameters have a p value $p > 0.1$. A lower level of 10% rather than 5% is applied due to the exploratory purpose of the study.

Candidate parameters (in which taste homogeneity might be present and these should be restricted to having the same value) are identified from covariance/correlation analysis of pairs of β s based on t-test values that are less than a critical threshold of 1.96 for a 95% significance level [38]. The output file of PythonBiogeme [67] contains this analysis. 8, 5, and 4 generic parameters are introduced in the MNL models for car, PT, and AM travellers' segments.

As in Stage 1, the restricted models with introduced generic parameters (designated as partially restricted) are tested for the correctness of the specification using the likelihood ratio test. At a 95% significance level, the likelihood ratio statistics between base (alternative-specific) models and partially restricted models for car, PT, and AM segments of travellers, respectively, $LRS_{CAR} = 36.376$, $LRS_{PT} = 3.842$, $LRS_{AM} = 3.22$ are lower than the χ^2 critical values $\chi^2_{\mathrm{CAR}} = 50.998$ (36 df), $\chi^2_{PT} = 53.384$ (38 df), and $\chi^2_{AM} = 62.830$ (46 df). Therefore, we can conclude that the partially restricted models are of the correct specification.

5.3.4. Stage 4. Partial Taste Homogeneity between Segments of Travellers (Car, PT, and AM) in the Joint Model. We proceed with the identification of the candidate parameters that might be the source of partial taste homogeneity between the segments of travellers (car, PT, and AM) in their choices in a unified model. Following the methodology explained in Stage 2 and 3, we put three partially restricted MNL models (from Stage 3) in a joint partially restricted MNL model and introduce 7 generic parameters between the segments of travellers identified from the covariance/correlation analysis.

The likelihood ratio statistics of 7.05 between three partially restricted MNL models (estimated jointly as if there is no partial taste homogeneity between segments of travellers) and the joint partially restricted MNL model is less than the χ^2 critical value of 16.919 for 9 degrees of freedom (2 scale parameters and 7 generic parameters). From this, we can conclude that indeed car, PT, and AM users have partial homogeneity in tastes while other parameters remain heterogeneous across the segments.

5.3.5. Stage 5. Search for the Best Model Specification. In the last stage, we search for the best model specification that explains the observed choices in the collected datasets. Proceeding with the joint partially restricted MNL model from Stage 4 that contains restricted parameters representing taste homogeneity in the preferences for the AmB service type within and between the segments of travellers (car, PT, and AM), we test different model specifications. These include nested logit, mixed logit with random error component or random parameters (travel time, travel costs, and alternative-specific constants (ASCs)), and mixed logit with panel effects. The panel mixed logit model with taste heterogeneity in travel costs parameters and ASCs explains the data best considering the main goodness-of-fit indicators, i.e., adjusted Rho-squared, Akaike, and Bayesian information criteria.

The results of the final joint model with socioeconomic and latent variables are given in Table 7. The estimated parameters are placed in columns named "CAR," "PT," and "AM" for car, PT, and AM segments of travellers, respectively. The name of each parameter in the table ends with a subscript of "BR" or "BF" indicating that it belongs to the AmB (regular service) or the AmB (flexible service) utility function. The combined "BR-BF" subscript denotes a generic parameter for the AmBs regardless of the service type. The generic parameter coefficients for the revealed similarities between the segments of travellers are in bold (e.g., $\beta_{BR\_BF\_TT}$ generic parameter for car and PT segments of travellers has a coefficient of **−0.122 (−31.1)*****).

The final joint mixed logit model includes 57 parameters. It was estimated on 10000 Halton draws from a normal distribution and showed stable results. It took 12 days and 7.5 hours for the model to converge on a computer with a 3.6 GHz frequency processor and 32 GB RAM. The goodness of fit (adjusted Rho-squared) of the final model is 0.287. A value between 0.2 and 0.4 indicates a good model fit to the sample data [40].

The scale parameters for PT and AM segments of travellers are both significantly different from 1. This shows that the difference in variance in the error terms is present. It is 22% higher in the PT users' segment than in the car segment, and 39.2% lower in the AM than in the car segment.

6. Discussion of Results

From the final joint mixed logit model (Table 7), we discuss the results from the perspective of revealed similarities and differences in preferences for the AmB service type within and then between the segments of travellers (car, PT, and AM users). We go through the findings following all components of the utility functions. We start with instrumental variables, continue with latent and socioeconomic variables, and, in the end, interpret the mean of the unobserved part of utility, ASC. We finalize this section by mentioning the limitations of the present study.

6.1. Instrumental Variables. Looking at the preferences for the type of service provided by AmBs within each segment of travellers (car, PT, and AM), we see that the AM users do not significantly prefer one service type over another in all instrumental variables (travel time, travel costs, and waiting time). Car users perceive the difference only in costs spent for travelling in the regular service, while PT users are the only segment that distinguishes and appreciates AmB's flexible service in terms of in-vehicle travel time and waiting time at the doorstep.

Notably, there are important similarities and differences between the segments of travellers. The in-vehicle travel time is associated with similar disutility regardless of the service type for car and AM users and in the AmB (regular service) for PT users. Only the latter demand segment of travellers (PT users) has a better perception of the in-vehicle travel time in the AmB with flexible service. The same pattern holds for the waiting time marginal values, although the disutility of the waiting time for the flexible service loses its significance for PT users. No need to walk to the bus stop and the possibility to wait for the AmB in the comfort of your home are known reasons for opting for on-demand services [69, 70]. That is why PT users might prefer to spend their travel time in the AmB operating as a flexible service rather than a regular one. Whilst car and AM users already do not need to spend time waiting and walking, therefore, that is probably the reason why the in-vehicle travel time in the AmBs with flexible service is not preferred.

Car users perceive the travel costs for the regular service less negatively than the costs of the flexible service. The explanation for the latter might be that the on-demand and door-to-door features are not something the car users would prefer to pay for at the cost of following an uncertain route due to other travellers' pick-ups and drop-offs versus a predefined route of more conventional regular service. In fact, car users are known to value independence, convenience, and control over their travels [71, 72]. A significant taste heterogeneity for the travel costs parameter has been detected in all segments of users, which goes to show the uncertainty that exists regarding the sensitivity of travellers towards transport prices.

Walking time to the bus stop is statistically speaking of less concern for AM users than for the other two segments (car and PT users). This might be connected to them being inclined to more physically demanding modes of transport (so-called active) than the other user segments are.

6.2. Latent Attitudinal Variables. The results also indicate the importance of psychological factors when explaining the preferences for the AmBs and their service type. One out of four constructs, risk-taking behaviour, does not show a significant influence in all segments of travellers, which might be explained by the self-reporting nature of the

Table 7: Results of the final mixed logit model.

Parameter	Description of the corresponding variable	Traveller segments CAR	PT	AM
ASC		0	0	0
ASCBR	Alternative-specific constant of reference alternative and two automated minibus alternatives	0.493 (1.48)	—	—
ASCBF		−1.55 (−6.62) ***	—	—
ASCBR_BF		—	−0.0169 (−0.0899)	3.32 (8.06) ***
σASC_BR	Standard deviation of alternative-specific constant distribution (normal distribution)	1.38 (6.55) ***	—	—
σASC_BF		1.28 (10.3) ***	—	—
σASC_BR_BF		—	0.582 (6.69) ***	0.853 (1.91) *
βik Instrumental variables				
βBR_TT		—	−0.127 (−11.3) ***a	—
βBF_TT	In-vehicle travel time in minutes	—	−0.0859 (−8.14) ***	—
βBR_BF_TT		−0.122 (−31.1) ***a	—	−0.122 (−31.1) ***a
βBR_TC		−0.487 (−4.69) ***	—	—
βBF_TC	Travel costs in euros	−1.12 (−15.6) ***b	—	—
βBR_BF_TC		—	−1.36 (−10.7) ***b	−1.36 (−10.7) ***b
σBR_TC	Standard deviation of travel costs distribution in euros (normal distribution)	0.535 (6.23) ***	—	—
σBF_TC		0.672 (10.2) ***	—	—
σBR_BF_TC		—	0.844 (9.92) ***	0.844 (9.92) ***
βBR_WAITT		—	−0.135 (−5.82) ***c	—
βBF_WAITT	Waiting time at a bus stop in minutes	—	−0.0411 (−1.36)	—
βBR_BF_WAITT		−0.115 (−10.5) ***c	—	−0.115 (−10.5) ***c
βBR_WALKT	Walking time to a bus stop in minutes	−0.214 (−17.3) ***	−0.214 (−17.3) ***	−0.124 (−4.58) ***
$\beta$is Socioeconomic variables				
Age (reference: old):				
βBR_AGE1	Young	−0.608 (−2.51) **	—	—
βBF_AGE1		—	1.02 (5.13) ***	—
βBF_AGE2	Middle	—	1.29 (5.91) ***	—
Education level (reference: low):				
βBR_EDU1	Medium		0.414 (3.06) ***	−0.499 (−1.89) *
βBR_EDU2	High		0.528 (2.46) **	−2.73 (−3.17) ***
Occupation (reference: unemployed or retired):				
βBR_WORK1	Study	—	—	−1.05 (−2.29) **
βBR_WORK2	Employed	—	—	−0.601 (−2.32) **
βBR_BF_WORK2		−0.554 (−3.64) ***	—	—
Income (reference: low):				
βBR_INCOME1	Middle	−0.397 (−1.9) *	—	—
βBR_INCOME2	High	−0.566 (−1.65) *	—	—
βBF_INCOME2		—	0.662 (3.09) ***	0.662 (3.09) ***

Table 7: Continued.

Parameter	Description of the corresponding variable	Traveller segments CAR	PT	AM
Region (reference: north):				
βBF_REGION2	East	—	0.508 (2.41) **	—
Driving licence (reference: no):				
βBR_DR_LICENCE	Yes	—	—	0.956 (3.75) ***
Vehicle in possession (reference: no vehicles):				
βBF_VEHICLE1	Auto	—	−0.517 (−3.48) ***	—
βBR_VEHICLE2	Scooter, bicycle	—	−0.454 (−3.0) ***	—
PT pass (reference: no):				
βBR_PT_CARD	Yes	1.04 (5.23) ***	—	—
βBF_PT_CARD		0.478 (2.68) ***	—	−1.28 (−4.28) ***
Traffic accident (reference: no):				
βBR_TR_ACCIDENT	Yes	—	—	−0.466 (−1.91) *
βBF_TR_ACCIDENT		—	−0.796 (−4.98) ***	—
Knowledge about automated driving (reference: no):				
βBR_BF_KNOW_AD_PT	Yes	—	−0.322 (−2.11) **	—
Experience with automated driving (reference: no):				
βBR_EXP_AD1	Yes (driving assistance)	−0.322 (−2.1) **	—	−0.322 (−2.1) **
βBF_EXP_AD2	Yes (automated vehicle or minibus)	−0.45 (−1.75) *	—	—
βBR_BF_EXP_AD2		—	0.399 (2.2) **	—
Supervision (reference: no supervision):				
βBR_BF_SUPERVISION2	Remotely by operator	0.377 (2.57) ***	—	—
βil latent variables				
βBR_ATT_BUS	Positive attitude towards riding in an automated minibus	—	—	0.454 (2.06) **
βBF_ATT_BUS		—	—	1.15 (4.09) ***
βBR_BF_ATT_BUS		0.645 (8.31) ***	0.222 (2.73) ***	—
βBR_BF_TRUST	Trust, usefulness and enjoyment of automated minibuses	0.424 (6.89) ***	0.424 (6.89) ***	—
βBR_BF_TECH	Technology experience	—	0.22 (2.49) **	—
μd				
μ_CAR	Scale parameters	1	—	—
μ_PT		—	1.22 (11.7) ***	—
μ_AM		—	—	0.608 (11.7) ***
Number of parameters			57	
Null log-likelihood			−10981.73	
Final log-likelihood			−7827.029	
Adjusted Rho-squared			0.287	
Akaike information criterion			15768.06	
Bayesian information criterion			16037.39	
Number of Halton draws from a normal distribution			10000	

*** = significant at a 99% confidence interval. ** = significant at a 95%. * = significant at a 90%. Not significant values are in italics. a, in-vehicle travel time: the values are not significantly different from each other. b, travel costs: the values are not significantly different from each other. c, waiting time: the values are not significantly different from each other d *t*-test against 1.

answers. The respondents might be concerned with sharing their misbehaviour [73]. The average score for the four statements that formed the risk-taking factor varied from 1.74 to 3.17 points on a 1 (no risk) to 7 (high risk) scale.

Three other attitudinal constructs, i.e., positive attitude towards riding in AmBs; trust, usefulness, and enjoyment; and experience with technology, have a positive influence on the preference for AmBs. Besides, in most cases, there is no significant preference for one service type over another. The AM users are the only traveller segment for which a positive attitude towards riding in AmBs is of more importance when choosing flexible service.

Again, there are some similarities and differences in the attitudes between traveller segments. The positive attitude towards riding in AmBs (the perception of the ride in the minibus as being flexible, saving time, relaxing, fun, and eco-friendly) plays a significant role in the choices for the minibuses in all segments. However, no taste homogeneity is found for this variable in three segments of travellers. The flexible service preference as explained by the positive attitude towards riding in AmBs is highest in the AM segment, whereas the preference for regular service is more modest. The car and PT users do not distinguish their preference for AmBs depending on the offered service but differ in magnitude. Regardless of the service type preference, the results reflect potential users' expectations from the deployment of AmBs to improve the quality of PT service in terms of convenience and comfort and reduce environmental impact as expressed in previous studies [10, 11, 26–28]. We were able to confirm that having a positive image of future trips in AmBs is an important determinant of preference for AmBs.

The joint construct of trust, usefulness, and enjoyment of the AmB has a positive effect on the preference for both types of service with no difference between car and PT commuters. Initial trust in the capabilities of AmBs to drive safely without a driver, recognizing the usefulness for daily trips, the pleasure of commutes, and being driven are some of the most important predictors of prospective use of AmBs [11, 17, 18, 30], though not for AM users in the present study. It cannot be said with certainty why AM users do not assign importance to these constructs. The possible reasons might lie in their socioeconomic characteristics and personality traits.

For the PT segment, the experience with technology (namely, driving and parking assistance and route-planning apps) positively influence the preference for AmBs offering both services but does not affect car and AM travellers' choices. It appears that PT users might be more concerned than car and AM users with the ability of AmBs to perform driving tasks without a driver, so for them, the experience with lower levels of automation might assure this ability. Our findings are in line with the results from earlier studies where the participants with technology experience used AmBs more frequentlyand indicated that they were comfortable with delivering driving tasks to the automated driving system and were willing to pay more for the trip in AmBs [8, 53].

6.3. Socioeconomic Variables. The travellers' segments have different socioeconomic characteristics that are significant or, if present in several segments, they show the opposite effect on the preference for AmBs. Therefore, only two similarities are detected, namely, having a high income when choosing flexible service (between PT and AM users) and an experience with driving assistance when opting for regular service (between car and AM users). As a consequence, we describe the influence of users' characteristics per traveller segment (car, PT, and AM) in the following order: parameters for both service types (generic), for regular service, for flexible service, and from positive to negative impact.

Employed car users do not feel enthusiastic about the new transport mode despite the service options offered. Having a PT card has a positive influence on choosing AmBs but a different impact, i.e., the marginal utility for regular service is the highest among parameters of socioeconomic variables (1.04) and roughly half of it for flexible service (0.478). Young car commuters with middle and high income have a negative perception of the regular service provided by the AmBs.

Medium and high level of education is a positive determinant for the regular service preference of PT users. Young- and middle-aged PT commuters with high income and living in the eastern region of the Netherlands tend to favour the flexible service. Having a scooter or a bicycle has a negative impact on the choice of the regular service. At the same time, PT commuters who possess a car or have had a traffic accident in the past have a negative perception of the flexible service.

For AM users, the possession of a driving licence has a positive impact on the preference for regular service and a high income for flexible service. Students or employed individuals with a medium and high level of education who have had a traffic accident in the past show a negative preference for the regular service. Holding a PT card has a negative influence when choosing a flexible service.

There are three more variables of particular interest, namely, knowledge about automated driving, experience with it, and preference for the type of supervision.

As is shown in Section 4.1, 65.2% of the participants stated that they have knowledge about automated driving, 46.5% have experience with driving assistance technology, and 14.4% have had experience travelling in an AmB or an automated vehicle (AV). However, only for PT users, the knowledge about automated driving has a significant negative influence on the preference for both service types. Similar results were obtained by Chee et al. [74] though without accounting for the current travel mode of the participants. As explained by Pernestål et al. [75], individuals that have knowledge about automated driving technology are likely to have less trust in safe driving. Contrary to this, Dong et al. [36] have found that participants with prior knowledge about automated driving are more willing to use automated buses.

Car and AM users who have had experience with driving assistance technology are not inclined to prefer regular service. For PT users, ride experience in an AmB or an AV is a positive factor when choosing the AmB, regardless of the provided service. However, based on this experience, car travellers see the flexibility of the service as a disadvantage. Experience with automated driving technology has a mixed influence on the willingness to use AmBs. The positive effect of taking a ride in an AmB is found in [16, 24, 25] and, in particular, on preference for on-demand operations [23]. However, just the opposite result is seen in [75]. As we see, there is a mixed influence on the preferences for AmBs of car and PT users with previous journey experience in an AmB or an AV. This incongruence might be derived from the differences in the expectations of automated driving technology. While for car users the experience might lead to disappointment with its current level, PT users may still give some credit for the early stages of deployment.

The absence of a human driver on board is considered to be the most noticeable change for passengers riding in AmBs. Therefore, the preferences for a driver's substitute (steward, operator, or both) that would help passengers to feel safe are frequently addressed in research. Although we may see in the results of some studies that respondents indicate that they would be comfortable with remote control by an operator or even without any supervision [11, 75], in other studies, the participants support the idea of having a steward on board to deal with any unexpected situations [8, 17, 18, 36]. In the present study, car users prefer remote control by an operator in both types of services. A similar result was found in [75]. As we have said above for the ride experience, car users might have higher expectations for the capabilities of automated driving technology; thus, they do not want to have a steward on board. While PT and AM users do not show a clear preference for the type of supervision.

6.4. Alternative-Specific Constants. Interpreting the mean of the unobserved part of utilities under the assumption of all other parameters remaining the same, we see the highest relative preference for the AmBs regardless of the service type in the AM users' segment. In contrast, car users show an indication of a negative preference for the AmB (flexible service). The slight negative generic ASC for the AmB is not significant in the PT users' segment. Statistically significant standard deviations for the ASCs indicate that taste heterogeneity is present in the unobserved part of utility. The recent study by Guo et al. [76] sheds light on possible sources of this heterogeneity when evaluating the influence of different context parameters through an SC experiment.

6.5. Study Limitations. First of all, the limitations of this study are related to the hypothetical nature of the SC experiment and the difficulties associated with imagining future commutes in the AmB alternatives. Another caveat comes from the design of the experiment itself, namely, the precautions we have taken. The respondent's current travel patterns are not reflected in full. Instead, the fixed reference trip attributes are imposed on the participants to represent either the first-mile parts of the trip or short (sub)urban commutes. At last, the survey was distributed online with the help of a panel company. Therefore, the distribution was limited to the participants of the panel, and those were groups of the population who have access to and use the Internet.

Despite the aforementioned limitations, the results of the present study give a starting point for developing integration strategies targeting different segments of travellers (car, PT, and AM). However, in time, this strategy should be checked and aligned with possible changes in the preferences of more experienced AmB users.

7. Conclusions

This paper explores the deployment potential of AmBs with respect to the service types, namely, "regular" (fixed route, fixed schedule) and "flexible" (door-to-door, on-demand) in first-mile trips or short (sub)urban commutes in the Netherlands. Additionally, it accounts for the preferences of travellers' segment according to their current travel mode (car, PT, and AM).

The results of the present study reveal some distinctive preferences for the AmBs and their service type by car, PT, and AM users. These findings give the initial indications for the development of integration strategies that consider the needs and interests of these three segments of travellers specifically.

Public transport users are the most likely segment of travellers that would appreciate the AmB offering flexible service. They show a higher preference for its on-demand and door-to-door features which they might lack in conventional-like regular service today. PT users have less sensitivity to the increase of in-vehicle travel time due to pick-ups and drop-offs of other passengers which is offset by the possibility to wait in the comfort of their homes with no need to walk to the bus stop. However, high sensitivity to the travel costs in both service types might indicate that the expectations of cheaper trips in AmBs are not met (in the SC experiment, the travel costs are set at the level of the conventional bus service). Regardless of the service type, a positive attitude towards riding in AmBs, having trust, and seeing an AmB as useful and enjoyable are important indicators of AmBs' preference by PT users. On the contrary, knowledge about automated driving technology in general negatively affects the choice for AmBs. However, having experience with driving assistance technologies and a ride experience in an AV or an AmB reassures their belief in the capabilities of the AmBs to drive safely. Meeting the expectations in travel costs reduction, building realistic knowledge about automated driving through information sessions and creating a positive ride experience might enhance the preferences of PT users for AmBs.

Car users show a higher appreciation for AmBs' regular service as indicated by the less negative perception of travel costs for this type of service. They might prefer to pay for a more predictable regular service rather than for flexible service due to the uncertainty associated with picking up and dropping off other passengers. Nevertheless, this may just indicate a certain level of lack of interest for PT since car users already enjoy flexibility with their current travel mode. Therefore, their perception of in-vehicle travel time and waiting time for AmBs regardless of the service type remains on the level of PT users' perception of AmBs' regular service. Nonetheless, similar to PT users, the preferences for AmBs regardless of the provided service are supported by a positive attitude towards riding in AmBs, trust in their safe operations, and recognition of AmBs' usefulness and pleasure of commutes. For car users, experience with driving assistance technology and ride experience in an AV or an AmB negatively influence their preferences for regular and flexible service, respectively, while they would prefer the remote control by an operator in both service types. To attract current car users to switch to multimodal PT commutes with AmBs' regular service on the first mile is not an easy task. The emphasis should be on a seamless connection to other transit modes, as transfers are known to have the most negative impact on PT service satisfaction [77], in addition to the positive difference in the travel costs between the use of a car and an AmB providing regular service. Reassurance with a positive ride experience is of the essence as well.

Active modes users do not show a specific preference for service type as explained by the attributes of the trip in an AmB (in-vehicle travel time, travel costs, and waiting time). However, they have lower sensitivity to the walking time to the bus stop when choosing a regular service than car and PT users which can be explained by using more physically demanding modes. For AM users, having a positive attitude towards riding in AmBs plays the strongest role in preferences for flexible service; the influence on the choices for regular service is more modest. Similar to car users', AM users' experience with driving assistance technology has a negative impact on their preferences for regular service. While the modal shift of AM users is the least desirable as they already prefer sustainable travel options for daily use, they might become occasional users of AmBs providing both service types, with a higher probability of choosing the flexible service. Similar to other segments of travellers (car and PT), a positive image of future trips in AmBs needs to be confirmed with a positive ride experience in AmBs.

The findings of the present study could be useful for city planners and transport operators when considering the introduction of AmBs for first-mile trips or short (sub)urban commutes. These results give insights into the decision-making process behind the preferences of the current car, PT, and AM users for the service type that might be provided by AmBs. We need to underline that up to today only a very small percentage of the population had a ride experience in AmBs. Therefore, irrespectively of the segment, prospective users' expectations should be monitored while gaining more experience with AmBs.

Policy-wise, this study underlines the importance of accounting for the current modality segment of the users when looking into application cases and contexts for the prospective integration of AmBs into PT systems. While the parsimonious generalization of the main instrumental variables may result in generic policy measures that fail to consider the specific needs of distinct target groups, the opposite is valid as well, developing different policy measures targeted at many groups can lead to an unnecessary increase in effort and cost. Hence, the sources of taste heterogeneity should be properly investigated.

In the end, we can suggest several follow-up research directions. The high resulting values of alternative-specific constants and their standard deviations (in the car and AM travellers' segments especially) signal that a substantial part of trade-off behaviour remains unexplained. More insights are needed about the reasons for choosing AmBs in different segments of travellers. When contemplating the future application cases and contexts for the AmBs, the prospective modal share of the AmBs among conventional transport modes would be of interest. Another aspect to consider is the temporary nature of stated choices. The introduction of AmBs is still at a very early stage, and time is needed for potential users to get accustomed to them. The opinion of the users might change over time as they gain more experience of and confidence in AmBs. Thus, longitudinal studies could give more insights.

Data Availability

The data used to support the findings of this study can be available upon request from the corresponding author.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

Acknowledgments

The distribution of the survey was financially supported by Goudappel BV. Study conceptualization and design were done together with partners from Goudappel BV. Data analysis, modelling, interpretation of results, and manuscript preparation were led by the Delft University of Technology.

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