An assessment of the willingness to choose a self-driving bus for an urban trip: A public transport user's perspective

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PREFACE

In front of you lies my thesis as the final part of the MSc Transport, Infrastructure and Logistics at the Delft University of Technology. This work resulted from a period of hard work in which I attempted to contribute to the transportation research in regard to stated user preferences. It was a challenging period with ups and downs, but in the end, I have enjoyed learning a lot about the application of discrete choice models and writing down the research in a scientific and comprehensible way.

I would like to thank several people that guided me in the process from a proposal to the conclusion of this thesis. First and foremost, I want to express my gratitude to my daily supervisor, Ir. Konstanze Winter, who supported me in every part of the research. Her extensive comments about the writing and the time she took to help me was invaluable. Next, I would like to thank Ir. Peter Morsink from Royal HaskoningDHV, he gave me the opportunity to contribute to the existing Interregional Automated Transport project. His feedback on my work and the laughs we had, either at the office or in the car, helped me in keeping motivated.

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At last, I want to thank my family and friends for their unconditional love in all phases I went through. I am very grateful for the encouragement and support of my parents in all my years of study. And for my friends, from Utrecht to Delft or wherever you live, thank you very much for the exciting student life you have given me.

Joost Wien
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SUMMARY PAPER

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A public transport user's perspective

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***Abstract*—The development of automated vehicles offers advantages for the transportation systems of the future. As a result, new and unknown challenges within the field of transportation arise. Moreover, there are uncertainties within the behavioural responses of travellers and amongst other things, the changes in the modal split within the transportation market. There is a lack of extensive knowledge of public transport user preferences regarding automated vehicles. In this study, the relative preferences for a trip with a self-driving bus were compared to a trip with a regular bus. To establish this, a stated preference experiment was conducted. Based on the responses of 282 respondents, a mixed logit model including latent variables was estimated. Based on the estimation results, it can be concluded that public transport users currently show a lower preference for the self-driving bus than for the regular bus. Moreover, travellers' preferences to travel on the autonomous bus improve when no surveillance is present. Travellers with an increased level of trust are found to perceive more utility of a self-driving bus. This effect is stronger for women, which could explain the outcome that women are less likely to travel by autonomous bus than men. Finally, the estimation results increase the understanding of stated preferences of public transport users for automated vehicles operated as public transport services.**

***Key Words*—Shared automated vehicles; Self-driving buses; Automated public transport; Public transport users; Mode choice.**

I. INTRODUCTION

Within the transport system, mobility is faced with various innovations to meet the needs of travellers. Integration of mobility services and the combination of technological innovations could lead to major changes in the transport system. One of these technological innovations is the automated vehicle.

The self-driving vehicle could provide benefits in the efficiency of time and use of resources, as well as reduced road congestion (Haboucha et al., 2017). Furthermore, technological advancements might change the way people look at mobility. Without the possession of a driver's license, the accessibility of, for example, the elderly, children and others less able to travel might increase. Moreover, traffic safety will increase since the number of traffic accidents could decrease (Fagnant & Kockelman, 2015; Haboucha et al., 2017). However, improved mobility of the society can result in detrimental effects of increased congestion and an increase of vehicle miles travelled (Fagnant & Kockelman, 2015).

A concept that could diminish these detrimental effects and lead to major changes in the transport system is the shared automated vehicle (SAV). SAVs are envisioned to provide demand-responsive transport services similar to taxis. SAVs could complement public transport in last-mile solutions or replace public transport trips (Krueger et al., 2016; Nordhoff et al., 2016), for example in the form of autonomous buses. In addition, the public transport service could increase its service area and optionally decrease waiting times due to on-demand services with wide availability of self-driving buses. SAVs might increase the accessibility and affordability of car sharing (Krueger et al., 2016) and, therefore, decrease car ownership (Fagnant et al., 2015). Integrating automated driving and public transport could be key to the development of automated vehicles (Nordhoff et al., 2016).

User demand for the self-driving vehicle is a prerequisite for its successful implementation (Nordhoff et al., 2016). Therefore, insight into peoples' attitudes towards automated vehicles is important. Travellers do not seem to embrace the use of automated vehicles yet (Yap et al., 2016; Haboucha et al., 2017). Especially, the perspectives of public transport users have received little attention in studies assessing the potential users of self-driving vehicles (Nordhoff et al., 2016). Therefore, little is known regarding the travellers' preferences of, and attitudes towards, automated vehicles within a public transport system (Krueger et al., 2016; Nordhoff et al., 2016; Yap et al., 2016; Dong et al., 2017).

Filling this research gap is the goal of this study. This study attempts to add knowledge to the field of choice behaviour regarding automated vehicles through the assessment of preferences of public transport users for a self-driving bus in an urban commute trip. The outcomes of this study may shed some light on users' attitudes towards a self-driving bus and how they trade off travel time and travel costs in order to decide on whether or not to use one.

In this study, the automated vehicle is regarded to be a self-driving bus with a seating capacity of 15 passengers that travels autonomously without the intervention of people.

The remainder of this paper is structured as follows: in section II a review on previous stated choice experiments regarding self-driving vehicles is given. The applied methodology for investigating users' preferences for a self-driving bus is presented in section III. In section IV, the survey and sample are discussed. Section V is devoted to the discussion of the results. Finally, the conclusions and recommendations for further research are presented in section VI.

II. Literature Review

Complimentary to current public transport modes, automated vehicles could be deployed as self-driving buses, which could benefit public transportation due to the efficiency of the operations, increased traffic safety and lower costs (Dong et al., 2017). These benefits are estimated in several studies on automated vehicle technology in general (e.g. Fagnant et al., 2015; Bansal & Kockelman, 2017). However, these studies do not consider individual behaviour effects of self-driving vehicles. As a result, the extent to which the use of automated vehicles in a public transport system will affect the modal split is not yet known (Correia et al., 2016).

Yap et al. (2016) were one of the first to discuss the position of the self-driving vehicle in the public transportation market. Based on literature, they assumed that travellers would be willing to pay less for reducing travel time than in conventional egress modes (Fagnant & Kockelman, 2015; Krueger et al., 2016), like the bus. Contrary to the assumption, the willingness to pay for travel time reduction in a self-driving vehicle seemed to be higher than for conventional buses and cars (Yap et al., 2016). A reason could be that people might not value the advantage of performing other activities while travelling (Yap et al., 2016). A more understandable reason could be that travellers might feel uncomfortable imagining a trip in a self-driving vehicle (Yap et al., 2016). Moreover, ignorance about the potential performance of automated vehicles might influence the stated use intention (Madigan et al., 2016).

De Looff et al. (2018) conducted a stated preference experiment in which they explored how people experience a trip with a self-driving vehicle compared to one with a regular car. Contrary to the results of Yap et al. (2016), De Looff et al. (2018) found that the value of travel time was lower for a self-driving vehicle with an office interior than the conventional car. This result corroborated the expectations of De Looff et al. (2018), which suggested that people are willing to work in a self-driving vehicle.

Yap et al. (2016) recommend advance research in mode choice preferences regarding the use of automated vehicles for the main part of a public transport trip; they argue that a main trip with a self-driving vehicle could enable more insight in its distinctive factors in comparison to other modes. Furthermore, Nordhoff et al. (2016) urge to take the public transport user perceptions into account in travel behaviour studies of self-driving vehicles, as the majority of studies focusing on user preferences and attitudes towards self-driving vehicles targeted the car drivers, e.g.: Payre et al. (2014); Haboucha et al. (2017); De Looff et al. (2018); Liljamo et al. (2018).

To be able to assess user preferences towards self-driving vehicles, the behaviour of users need to be inferred and analysed. Since automated vehicles are currently not a common mode to travel, primary means of obtaining user preferences stated preference experiments. In these experiments, observable factors are used that describe alternatives, such as travel time and travel costs.

Previous studies attempted to determine the potential usage of self-driving vehicles by estimating the relative preferences over other modes for specific trips. The findings of these first studies do not provide a uniform picture: people were found to prefer self-driving vehicles in controlled environments (Alessandrini et al., 2016), but choose their usual (non-automated) mode more often than the self-driving vehicle for their reference trip (Krueger et al., 2016) or prefer the conventional car, or the bus, over a self-driving vehicle as egress mode (Yap et al., 2016). However, some corroborations were found in these studies regarding socio-economic and underlying attitudinal factors. Young people, in particular men and people with a positive attitude towards environmental concerns, tend to be more favourable towards automated vehicles (Payre et al., 2014; Haboucha et al., 2016; Krueger et al., 2016; Piao et al., 2016). Besides, Kyriakidis et al. (2015) showed that men were less concerned about self-driving vehicles than women. In addition, a study by Liljamo et al. (2018) found, from a survey with 2.000 Finnish respondents, that public transport users and respondents without a car were significantly more positive towards automated vehicles than people not using public transport.

Additionally, the preference for self-driving vehicles is strongly influenced by the level of associated trust (Nordhoff et al., 2016; Yap et al., 2016). Low trust levels might play a role in the discomfort of using a driverless vehicle (Yap et al., 2016). People tend to trust self-driving vehicles in controlled environments more than in mixed traffic (Alessandrini et al., 2016).

Other attitudinal factors that appeared to affect the intention to use automated vehicles are the convenience of the self-driving bus and the participant's interest in technology. Individuals with a high technology interest are more likely to use automated vehicles (Haboucha et al., 2017). Additionally, De Looff et al. (2018) found that convenience was the only attitudinal factor that significantly influenced the decision making.

Considering trust in automated vehicles, the presence of a steward monitoring the bus movements showed a higher intentional usage, suggesting that trust is higher when a steward is present (Piao et al., 2014; Dong et al., 2017). Moreover, the ability to communicate with the bus operator might improve user preferences for self-driving buses, for example, with a communication system for information and remote supervision (Dong et al., 2017; Nordhoff et al., 2018). Dong et al. (2017) recommend testing strategies that address the issue of an absent employee.

III. Methodology

Since the self-driving bus is currently not a common alternative within the public transportation market, a stated choice experiment was conducted in order to quantify the relative preferences of travellers through a Mixed Logit discrete choice model. A survey has been designed with the intention to gather stated preferences of public transport users.

Alternatives and attributes

For this study, three alternatives were considered in the choice experiment. The first alternative is based on current bus services in the region of a future pilot, a service between Vaals (the Netherlands) and Aachen (Germany), to which this study contributes to. The second alternative is a self-driving bus that will be tested in the same future pilot, which will operate on a fixed route with either a scheduled or an on-demand service. The differences between the buses are the lack of a driver and fewer seats in the self-driving bus. The respondents were informed of the differences between the two buses. The third option is an opt-out alternative, which was added to increase the realism of the experiment. The opt-out represented any alternative a respondent can imagine to the available alternatives.

The attributes in the choice experiment differ between classical mode choice attributes travel time, travel costs and waiting time, for both the buses. The attribute levels are based on bus trips in Dutch (sub-)urban areas of approximately 3 kilometres. Two additional attributes for the self-driving bus were considered. 'Surveillance and information' comprises the presence of a steward, an interactive screen for communication with the bus operator and a visualisation of what the self-driving bus sees, or no extra surveillance. 'Service' comprises an on-demand or scheduled service. TABLE I gives an overview of the attributes and attribute levels considered in the stated choice experiment.

TABLE I. Overview of attributes and attribute levels used

Attribute	Attribute level			
Travel time	7 min	10 min	13 min	16 min
Travel costs	€1.00	€1.60	€2.20	€2.80
Waiting time	2 min	4 min	6 min	8 min
Surveillance & Information	Standard	Interactive screen	Steward	
Service	Scheduled	On-demand		

Choice sets

The design of the choice sets is based on a fractional factorial design, in this study, an orthogonal design is used. This design allows the selection of a subset of all possible choice situations. This method, however, is limited since no interaction effects between attributes can be estimated and statistical efficiency can decrease. An orthogonal design was considered sufficient since former research in the user preferences of self-driving vehicles did not provide similar and trustworthy parameter estimates, nor were two performed preliminary surveys considered to provide accurate priors to be applied in an efficient design.

With the use of the software package NGENE the orthogonal design was constructed (ChoiceMetrics, 2018). The design generated 24 choice sets, which were split into four blocks. Every respondent faced six choice sets and was informed that the choice concerned an urban bus trip from home to a work or study location. See Fig. 1. for an example of a choice set.

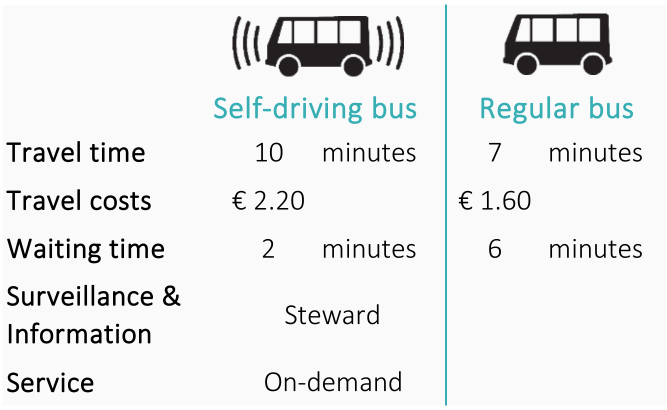

Fig. 1. Example of a choice set provided to respondents

Model specification

The final model specification that is used for the estimation of parameters is shown in Eq. 1. The first component includes β_x, which is the vector that estimates the taste parameters associated with the attributes of alternative i and x_i is a vector that contains the attribute levels of alternative i. In addition, β_τ is the vector that reflects the importance of the socio-economic variables τ_s of individual s. Through an exploratory factor analysis prior to the model estimation, underlying attitudinal factors were found. Mean sum scores represent the attitudinal factors for each individual s and are denoted by the vector φ_s in the model specification, where β_φ is the vector containing the parameters that estimate the marginal utility of the attitudinal factors. Finally, ε_i is the independent and identically distributed (i.i.d.) error term capturing the unobserved part of the utility U_i.

$$U_i = \beta_x x_i + \beta_\tau \tau_s + \beta_\varphi \varphi_s + \varepsilon_i \qquad (1)$$

Statements

To explore if attitudinal factors influence the choice process in this study, the attitudinal factors are quantified by presenting statements to respondents, see TABLE II. The respondents are asked to rate their level of agreement based on a five-point Likert scale (Likert, 1932). The statements represent variables that allow determining latent variables in the exploratory factor analysis. Most of the statements are based on variables in latent factors that were formed in previous research (Payre et al., 2014; Haboucha et al., 2016; Madigan et al., 2016).

IV. Survey and Sample

To generate respondents for the questionnaire the survey was distributed on several online social platforms. People that use public transport, at least on a yearly basis, were invited to fill out the survey. The aim was to collect a sample that represents commuters that travel within their city towards a work or study

TABLE II. STATEMENTS INCLUDED IN THE SURVEY

Variable	Trust in automated vehicles
TRUST_1	I believe a self-driving vehicle would drive better than the average human driver.
TRUST_2	I am afraid that the self-driving vehicle will not be fully aware of what is happening around it.
TRUST_3	I think that the self-driving system provides me with more safety compared to manually driving.
TRUST_4	I would entrust the safety of a close relative to a self-driving vehicle.
TRUST_5	I think that the self-driving bus only is safe when a steward is present.
Variable	**Technology interest**
TI_6	I try new products before others do.
TI_7	I am excited by the possibilities offered by new technologies.
TI_8	I have little to no interest in new technology.
TI_9	New technologies create more problems than they solve.
Variable	**Convenience**
CONV_10	Automated vehicles will make life easier.
CONV_11	The best part of the self-driving bus is that it can be requested on demand.
CONV_12	I think that using the self-driving bus is more convenient than using regular buses.
Variable	**Vehicle characteristics**
CHAR_13	I would feel more comfortable in a self-driving bus with several passengers than in one with few passengers.
CHAR_14	An interactive screen is a good replacement for a bus employee in the self-driving bus.
CHAR_15	I would feel more comfortable in a self-driving bus than in a regular bus.

location, either students or employees since this is an important target group of the self-driving bus service in the future pilot. The distributed survey was shared by other people to increase the number of responses. Since the choice experiment is based on a future pilot, also citizens in, and employees of, the municipality of Vaals and Aachen were asked to fill out the survey. They were approached via messages on the website of the municipality of Vaals and via contact with employees from the municipality of Aachen.

In total, 305 respondents started the survey, of which 292 completed all questions of the survey. Respondents were excluded from the analysis if they completed the survey in less than 5 minutes or if they did not fill in their gender or age. Ten respondents were left out of the analysis, which resulted in 282 useful responses with a total of 1692 choice observations.

For an indication of the sample characteristics, the sample is compared with the average public transport user on a daily basis in the Netherlands (CBS, 2018). See TABLE III for an overview of the sample characteristics. All respondents use public transport at least once a year, with a share of 71.6% using public transport every week. The share in gender is almost equal with a little higher share of men. Furthermore, the sample is relatively young with 70.2% of the respondents being below 30 years old. The sample is considered to be representative for a group of commuters that travel within their city towards a work or study location, for example, a campus.

TABLE III. SAMPLE CHARACTERISTICS

Socio-economic variable	Category	Sample
Gender	Female	48.9%
	Male	51.1%
Age	18 - 24 years	37.2%
	25 - 34 year	39.4%
	35 - 49 year	13.1%
	50 - 64 year	9.9%
	>64 year	0.4%
Education	Low	1.1%
	Middle	8.5%
	High	90.4%
Employment	Full time	45.0%
	Part time	16.7%
	Student	36.2%
	Other	0.0%
	Jobless	1.8%
	Retired	0.4%
Income	<€10,001	30.1%
	€10,001 - €20,000	7.8%
	€20,001 - €30,000	20.9%
	€30,001 - €40,000	13.8%
	€40,001 - €50,000	8.5%
	>€50,000	6.7%
	No information	12.1%
Public transport usage	(almost) Every day	15.6%
	5 days a week	16.0%
	4 days a week	13.1%
	3 days a week	11.0%
	2 days a week	11.0%
	1 day per week	5.0%
	A few times per month	11.7%
	One time per month	5.7%
	A few times per year	11.0%

V. RESULTS AND DISCUSSION

Factor analysis

In TABLE IV, the results of the factor analysis are shown, which is performed to determine the presence of underlying attitudinal factors in the sample. The attitudinal factors are incorporated as mean sum scores for each individual into the discrete choice model. This is a less refined method to determine attitudinal factors, but the interpretability of the factor scores is found to be sufficient to provide insight into the effects of attitudinal factors on the choice behaviour of the respondents.

Before the factor analysis was executed, the factorability of the variables was tested. The Kaiser-Mayer-Olkin (KMO) measure of sampling adequacy was 0.87, which is above the suitable value of 0.5. Additionally, the Bartlett's test of sphericity showed significant communalities between the variables, with $p < 0.05$ ($\chi 2$ (105) = 1,589.1). The tests showed that the variables were suitable to perform a factor analysis.

In the iterations, a total of five variables with a communality lower than 0.25 and factor loadings of less than 0.5 were removed from the analysis. This was the case for a total of five variables.

TABLE IV. ESTIMATION RESULTS ROTATED FACTOR MATRIX (FACTOR LOADINGS <0.3 ARE NOT SHOWN)

Variable	Factor 1	Factor 2	Communality
TRUST_3	0.791		0.663
TRUST_1	0.742		0.577
TRUST_4	0.716		0.562
TRUST_2	0.670		0.485
CHAR_15	0.578		0.416
TRUST_5	0.506		0.303
TI_7		0.916	0.898
TI_8		0.658	0.442
TI_6		0.498	0.329
TI_9		0.451	0.250

A simple structure could be reached when performing a varimax rotation. A similar outcome was found for the skewed rotation. Yet, the interpretability of the varimax rotation and the replicable results of the varimax rotation were preferable.

The factor analysis resulted in a 2-factor solution with 10 out of the 15 variables. The first factor includes variables that describe attitudes towards safety and performance of the self-driving bus, which was considered the 'trust in automated vehicles'. The other variables describe the interest in technology. The variables TI_6 and TI_9 have factor loadings below 0.5. However, these fit the interpreted factor and have no high double loadings. This attitudinal factor is named 'technology interest'.

Discrete choice model

A mixed logit model, including the attitudinal factors, was found to fit the data best. The mixed logit model corrects for panel effects, estimates a nesting effect for the two buses, and takes possible taste heterogeneity into account for the alternative specific constants and the travel time parameters. In the model, 1000 Halton draws from normal distributions were used, which gave stable parameter results.

TABLE V shows the estimation results of the discrete choice model that is considered in this study.

The alternative specific constants of the regular bus and self-driving bus show that the buses are preferred over the choice for another mode, which respondents could prefer over the two buses in case the alternatives were not attractive to them. The difference between the parameter values *Constant REB* (11.8 [p<0.01]) and *Constant SDB* (10.2 [p<0.01]) is not statistically significant, which indicates that there is no difference in the unobserved preferences within the population based on the data.

The standard deviations for the alternative specific constants show that there is significant individual specific taste heterogeneity in the perceived utility of the self-driving bus and regular bus. The standard deviation (σ *constant SDB* = 0.71) is significant for the self-driving bus with p-value < 0.01. The standard deviation of the regular bus (σ *constant REB* = 0.57) is considered significant with a p-value of 0.07. The degree of variation indicates that some individuals prefer the self-driving bus over the regular bus. The probability that the individual specific preference for the self-driving bus is equal to or greater than the mean alternative specific constant of the regular bus (11.8) is 1.2%. The probability that the individual specific preference of the regular bus is equal to or lesser than the constant of the self-driving bus (10.2) is 0.24%.

A significant nesting effect was found in the estimation (σ *nesting effect* = -4.88 [p<0.01]), which means that the self-driving bus and regular bus have common unobserved factors. An explanation could be that respondents felt forced to choose between one of the two buses, even if they had another preferred option in mind. Additionally, it might be that respondents like to travel by bus, whether it is humanly driven or not. However, adding mode alternatives would increase the realism of the

TABLE V. ESTIMATION RESULTS DISCRETE CHOICE MODEL

Parameter	Combined ML latent variable model with nesting effect and taste heterogeneity	p-value
σ nesting effect	-4.88 ***	0.00
α_i		
Constant REB	11.8 [10.7, 12.9] ***	0.00
Constant SDB	10.2 [8.8, 11.6] ***	0.00
σ constant REB	0.57 *	0.07
σ constant SDB	0.71 ***	0.00
β_x		
Travel costs REB	-1.8 ***	0.00
Travel costs SDB	-2.08 ***	0.00
Travel time REB	-0.15 [-0.27, -0.04] ***	0.00
Travel time SDB	-0.37 [-0.46, -0.27] ***	0.00
σ travel time REB	0.06 ***	0.00
σ travel time SDB	0.05 ***	0.00
Waiting time REB	-0.26 ***	0.00
Waiting time SDB	-0.19 ***	0.00
DRT service SDB	-0.37 **	0.02
Steward SDB	-0.30 **	0.01
Interactive SDB	0.04	0.68
β_τ		
Female REB	0.74 **	0.04
PT every month SDB	0.22	0.14
Pilot provinces SDB	0.07	0.51
β_φ		
Tech. interest (TI) SDB	0.35 **	0.04
Trust in AVs SDB	0.96 ***	0.00
Female TI SDB	-0.11	0.41
Female AV trust SDB	0.40 ***	0.01
No. parameters	23	
Initial log-likelihood	-1858.85	
Final log-likelihood	-964.39	
Adjusted ρ^2	0.47	

*** = significant at a 99% CI; ** = significant at a 95% CI;
* = significant at a 90% CI;
[..] interval estimate from standard deviation σ;
REB = Regular bus; SDB = Self-driving bus

choice experiment and is expected to lead to different outcomes regarding nesting effects.

Furthermore, the marginal utility of the travel costs for the self-driving bus is -2.08 [p = 0.0], which is less than for the regular bus, -1.8 [p = 0.0]. However, the small and statistically insignificant difference in a 95% confidence interval shows that travel cost does not differ significantly between the bus alternatives in the population. This is according to expectation when travel cost is assumed to be regarded as rational by decision makers.

The mean parameter travel time for a self-driving bus shows a marginal utility of -0.37 [p<0.01], which is significantly more than the marginal utility of travel time for the regular bus (-0.15 [p<0.01]). This means that travellers experience more disutility of the self-driving bus when the travel time increases. This could be explained by the difficulty that respondents may have when imagining a trip with a self-driving bus. Moreover, the lack of experience with automated vehicles could account for the stronger negative perception.

In the model was found that the standard deviations for travel time are significantly different from zero. This means that there exists individual-specific taste heterogeneity for travel time.

Based on the parameters for travel time and travel costs, the value of travel time (VOTT) is estimated, which shows the willingness to pay for travel time reduction. This allows to put the VOTTs of the self-driving bus and regular bus in perspective of representative VOTTs for bus trips in the Netherlands, which varies between 7.75 Euro per hour and 10.50 Euro per hour (Kouwenhoven et al., 2014). Since travel time is normally distributed, the VOTT is normally distributed as well. Hess et al. (2005) stress the concerns of unbounded distributions, which could lead to negative VOTTs. However, in this study no unexpected signs for travel time parameters were obtained.

TABLE VI shows the expected VOTTs from this study. The mean VOTTs show that it is expected that respondents are willing to pay less than half the costs for reducing travel time in a regular bus compared to an automated bus. This indicates that, compared to a regular bus, respondents associate travelling on a self-driving bus with more disutility. The results are in line with outcomes of previous studies that showed that people were hesitant towards using self-driving vehicles (Haboucha et al., 2017; Yap et al., 2016).

TABLE VI. VOTT ESTIMATES AND STANDARD DEVIATIONS [€/HOUR]

Alternative	Mean VOTT	Standard deviations VOTT	95% confidence interval
Self-driving bus	10.59	1.38	[7.87, 13.30]
Regular bus	5.13	1.94	[1.32, 8.94]

Waiting time was found to be less negative for the self-driving bus (-0.19 [p<0.01]) compared to the regular bus (-0.26 [p<0.01]). This is in line with the outcome of Khattak & Yim (2004), who showed that travellers were willing to wait longer for a taxi-like on-demand bus than their regular mode for commute trips. However, the waiting time for the on-demand self-driving bus could be different from the waiting time of a scheduled self-driving bus. Waiting time could be ignored by travellers, as they could leave their house just before the bus departure. The outcome of this study does not allow to draw an unambiguous conclusion on the influence of waiting time on the perceived utility of the buses.

The on-demand service decreases the perceived utility of the self-driving bus (-0.37 [p<0.05]), travellers prefer a scheduled self-driving bus. The on-demand service requires extra effort of the traveller, which does not give additional advantages in, for example, their flexibility. This could explain the perceived disutility of the on-demand service on a fixed route. The outcome does not allow to draw conclusions about the perceived utility of on-demand transport services in general.

Regarding the surveillance present in a self-driving bus, respondents prefer to have no extra surveillance in the self-driving bus. A present steward was found to negatively influence the perceived utility (-0.30 [p<0.05]), whereas the interactive system was not significantly different from zero (0.04 [p=0.68]). The outcomes indicate that extra surveillance is not perceived as am improvement to personal safety. Respondents might have not understood the attribute or perceived the presence of extra surveillance inconvenient because they are being watched. Additionally, the extra surveillance might be perceived as compensation for a possible unreliable self-driving bus. This outcome contradicts the findings of Piao et al. (2016) and Dong et al. (2017). The differences in outcome may be caused by the way data has been gathered. Piao et al. (2016) and Dong et al. (2017) directly asked respondents their willingness to use a self-driving bus with or without an employee. However, the choice experiment in this study might also demonstrate that in the trade-offs made surveillance is regarded as less important than other attributes.

Furthermore, the positive marginal utility of the parameter for monthly public transport users (0.22 [p=0.14]) shows, that the perceived utility of a self-driving bus is not significantly higher for users that travel by public transport at least every month compared to occasional public transport users. This could be explained by the difference between yearly and monthly public transport users, only 11.0% of the sample use public transport less than once a month. The effect of frequent public transport usage shows to be less strong than the significant difference that was found by Liljamo et al. (2018). They found that people who travel by public transport at least once a month had a more positive attitude towards self-driving vehicles than people that did not travel by public transport.

Based on different model estimations, age did not influence the perceived utility of a self-driving bus. A reason could be that young respondents are somewhat overrepresented in the sample, with 70.2% being below 30 years old. Yet, gender differences were significant. The indicator variable *Female REB* (0.74 [p<0.05]) shows that women prefer the regular bus more than men. The heterogeneity between gender is in line with previous studies that showed the less favourable attitude towards self-driving vehicles (Kyriakidis et al., 2015; Haboucha et al., 2016; Piao et al., 2016; Yap et al., 2016).

The differences between gender could moreover be explained by the level of trust in automated vehicles. Trust in automated vehicles is of more importance for the perceived utility of a self-driving bus for women than for men (*Female AV trust SDB* = 0.40 [$p<0.01$]). Moreover, the variables of the attitudinal factor trust in automated vehicles relate to the safety and performance perception of a self-driving bus. This suggests that experiencing personal safety and having trust in the auomation technology is more important for women than for men.

Additionally, the interest in technology affects the perceived utility of a self-driving bus positively (0.35 [$p<0.05$]), but less so than trust in automated vehicles (0.96 [$p<0.01$]). No significant difference between genders was found. High technology interest has a positive effect on the choice for a self-driving bus in general.

VI. Conclusion and Recommendations

The aim of this study was to compare the preference for a self-driving bus with that for a regular bus since there is a lack of extensive knowledge about public transport user preferences regarding self-driving vehicles. Therefore, a stated choice experiment was conducted since self-driving buses are no common alternatives on the transportation market. A discrete choice model is applied to assess the relative preferences.

From the observations and findings, it can be concluded, that public transport users currently show a lower preference for a trip in the self-driving bus than for the regular bus. They are willing to pay more for travel time reduction for a self-driving bus. However, for an urban commute trip, the perceived utility of a self-driving bus increases when it is operated as a scheduled service. An on-demand self-driving bus with a fixed route does not improve the utility of a self-driving bus.

Moreover, travellers' preferences to travel on the self-driving bus improve when no extra surveillance is present compared to when a steward or an interactive system is present. This is contrary to the expectation that surveillance would increase the perceived utility of a self-driving bus. Extra surveillance might not have increased the personal safety in the self-driving bus. Yet, experiencing safety while driving influenced the attitudinal factor of trust in automated vehicles, travellers with an increased level of trust are found to perceive more utility of a self-driving bus. This effect is stronger for women, an increased level of trust in automated vehicles enhances the perceived utility of the self-driving bus more for women than for men. The importance of trust in automated vehicles of women could explain the outcome that women are less likely to choose the self-driving bus than men. At last, the estimation and application outcomes of this study provide an increased understanding of the relative preferences of public transport users for self-driving vehicles operated as public transport services for urban trips.

Several topics remain for future research. To get a clearer picture of potential user groups and causal relationships with attitudinal factors, it would be worthwhile to extend the model estimation of the choices for self-driving buses with an integrated choice and latent variable model. Additionally, changes in attitudes towards self-driving buses could be assessed by performing a longitudinal study in future field studies with self-driving buses. Furthermore, this study provided insight into the relative preference of a self-driving bus compared to a regular bus and an opt-out alternative for an urban commuter trip. It would be beneficial to extend the data collection with more mode alternatives in the choice experiment in order to be able to improve the understanding of relative user preferences for self-driving buses in the (public) transportation market. It is expected that the strong nesting effect that is found will change when other modes are added. At last, to know more about waiting time a study could look into the different perceptions of waiting time for different services, either on-demand or scheduled self-driving buses, the different stages in the waiting period and factors that affect the perception of waiting time. In the case of an on-demand service, the view of waiting time and public transport could change since more flexibility is offered to the traveller.

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1 INTRODUCTION

Within the transport system, personal mobility is faced with various innovations to meet the needs of travellers. Integration of mobility services and the combination of technological innovations could lead to major changes in the transport system. One of these technological innovations is the self-driving vehicle. Although the development of self-driving vehicles shows substantial theoretical advantages (Fagnant, Kockelman & Bansal, 2015; Krueger et al., 2016; Haboucha et al., 2017), there are uncertainties among the preferences of end users, who do not currently seem to embrace the use of self-driving vehicles currently (Abraham et al., 2018). Especially the perspectives of public transport users have received little attention in studies assessing the potential users of self-driving vehicles (Nordhoff et al., 2016). Therefore, only little is known regarding the travellers' preferences of self-driving vehicles within a public transport system (Delle Site et al., 2011; Krueger et al., 2016; Nordhoff et al., 2016; Winter et al., 2016; Yap et al., 2016; Dong et al., 2017). By assessing the preferences of public transport users for a self-driving bus, relative to a regular bus, this study attempts to add knowledge to the field of choice behaviour regarding self-driving vehicles and will give recommendations to meet the needs of travellers to improve the development of the self-driving bus service.

1.1 AUTOMATED VEHICLES

The self-driving vehicle is a prominent topic in the current transport field. The self-driving vehicle could provide benefits in the efficiency of time and use of resources, as well as reduced road congestion (Haboucha et al., 2017). Furthermore, due to technological advancements, people might change the way they perceive mobility (Howard & Dai, 2014). Without the need of having a driver license, their accessibility may increase; for example, for elderly, children and others with less ability to travel, and moreover, their safety will increase since the number of traffic accidents could decrease (Fagnant & Kockelman, 2015; Haboucha et al., 2017). However, potential negative effects could result from the introduction of automated vehicles, based on the fact that improved mobility of the society can result in detrimental effects on congestion and an increase of vehicle miles travelled (Boesch & Ciari, 2015; Fagnant & Kockelman, 2015).

The combination of innovations in electrification, shared mobility and automation technology could lead to major changes in the transport system (Sprei, 2018). One concept that could lead the development in this field are shared automated vehicles (SAV), which are envisioned to provide demand-responsive transport services similar to taxis. SAVs could complement public transport in last-mile solutions or replace public transport trips (Krueger et al., 2016; Nordhoff et al., 2016), for example as self-driving buses. In addition, the public transport service could increase its service area and optionally decrease waiting times due to on-demand services with a wide availability of self-driving buses. Additionally, SAVs might increase the accessibility and affordability of car sharing (Krueger et al., 2016). For example, SAVs could pick up passengers at their origin or near a bus stop, instead of the need to walk a long distance, which is a key motivator in the usage of car sharing (Fagnant & Kockelman, 2014; Krueger et al., 2016). SAVs could transform ownership of vehicles to services, based on a subscription or pay-on-demand (Fagnant & Kockelman, 2014).

Furthermore, coordinating SAVs on a system-wide scale has the potential of providing flexible mobility. With demand-responsive transport, SAVs could offer a convenient alternative to a car or taxi, which might result in a substantial decrease in car ownership (Fagnant et al., 2015). Additionally, people would be able to pursue productive activities in the SAV, for example, work related ones (Krueger et al., 2016; König & Neumayr, 2017; De Looff et al., 2018).

De Looff et al. (2018) are one of the first to estimate the value of travel time (VOTT) for private automated vehicles. The authors found that travellers in an automated vehicle are willing to pay less money to reduce travel time compared to a conventional car. However, only when the automated vehicle had an office interior suitable for performing work-related activities travellers perceived a trip in an automated vehicle better than in a conventional car. Alessandrini et al. (2016), showed a relatively higher preference inside major facilities, like business parks, for the self-driving bus, but not for other routes with different purposes. Travellers continue to have hesitations towards the adoption of automated driving (Piao et al., 2016; Haboucha et al., 2017; Abraham et al., 2018). They might not see the theoretical advantage of performing other tasks while driving (Yap et al., 2016) and tend not to trust self-driving vehicles in mixed-traffic situations when no information about the vehicle is provided (Alessandrini et al., 2016).

Integrating automated driving and public transport could be key to the development of automated vehicles (Nordhoff et al., 2016). For major changes in the transport system, the self-driving vehicle should be used on a large scale. Therefore, insights into peoples' attitudes towards self-driving vehicles are of utmost importance, since they create mobility demand (Howard & Dai, 2014). Extensive knowledge of users' preferences and their attitudes towards the use of self-driving vehicles integrated into public transport is required to adjust this automated public transport system to their needs.

1.2 User preferences

User demand for the self-driving vehicle is a prerequisite for its successful implementation and governs the actual usage of the self-driving vehicle (Nordhoff et al., 2016). To assess the user preferences of automated vehicles, the future mode choice decisions of people need to be researched. Previous studies estimated the relative preferences for self-driving vehicles over other modes for specific trips to determine the potential usage of self-driving vehicles.

The findings of these first studies do not provide a uniform picture: people were found to prefer self-driving vehicles in controlled environments (Alessandrini et al., 2016), but choose their usual (non-automated) mode more often than the self-driving vehicle for their reference trip (Krueger et al., 2016) or prefer the conventional car, or the bus, over a self-driving vehicle as egress mode (Yap et al., 2016). Corroborations in these results are certain socio-economic and attitudinal factors. Young people, particularly men, and people with a positive attitude towards environmental concerns, showed interest in the self-driving vehicle. Additionally, the preference for self-driving vehicles is strongly influenced by the level of trust in self-driving vehicles (Choi & Ji, 2015; Nordhoff et al., 2016; Yap et al., 2016). Considering trust in self-driving vehicles, the presence of a steward monitoring the bus movements showed a higher intentional usage, suggesting that trust is higher when a steward is present (Piao et al., 2014; Dong et al., 2017). The ability to communicate with the bus operator might improve user preferences for self-driving buses and replace a steward, for example, with a communication system for remote supervision (Dong et al., 2017; Nordhoff et al., 2018).

To summarize, the results from previous studies suggest that the self-driving vehicle is most likely adopted first by young men and environmental positive travellers. Yet, strong hesitation towards automated vehicles still exists as many people tend to not trust the technology yet (Bazilinksyy, Kyriakidis & de Winter, 2015; Abraham et al., 2018). Improving the efficiency of the public transport system requires additional insight into travellers' preferences to cater to their needs. In order to do so, more knowledge of user preferences and attitudes towards self-driving vehicles in the public transport system is needed (Delle Site et al., 2011; Krueger et al., 2016; Nordhoff et al., 2016; Winter et al., 2016; Yap et al., 2016; Dong et al., 2017). Filling this research gap forms the crux of this study.

1.3 Relevance

From previous studies, it can be concluded that there is a need for more knowledge regarding the traveller preferences of self-driving vehicles within a public transport system. Yet, the perspectives of public transport users have received little attention in studies assessing the potential users of self-driving vehicles (Nordhoff et al., 2016). As Yap et al. (2016) state, the benefits of the self-driving vehicle as a public transport mode might be perceived differently along different parts of a trip. Exploring user preferences in another trip with a self-driving bus might increase insight in the shift of the modal split in public transport systems, which is largely unknown (Correia et al., 2016). Additionally, Bansal et al. (2016) recommend researching the stated behavioural responses regarding shared self-driving vehicles in different geographic regions and over time. The behavioural responses can be subject to change within a year (Abraham et al., 2018).

This study attempts to fill the knowledge gap in stated choice behaviour studies regarding self-driving vehicles from the perspective of the public transport user. In this study, the preferences for a self-driving bus relative to a regular bus, for an urban commute trip from home to a work or study location, are assessed. With the results, recommendations are given to cater to the preferences of public transport users in order to improve the development of a self-driving bus service.

Since the level of trust in self-driving vehicles positively influences the preference for a self-driving vehicle (Piao et al., 2014; Dong et al., 2017), the preference for the presence of surveillance is explored. It is expected that the perceived utility of a self-driving bus increases with the presence of surveillance, either in the form of a human steward or as an interactive system that can communicate with the bus operator.

Additionally, the outcomes of this study are also expected to contribute to the development of a self-driving bus service that will be tested at the border between the Netherlands and Germany. Furthermore, this study could serve as a basis for the development of a questionnaire amongst users of the self-driving bus in the pilot test.

Based on the distinctive nature of this study, it is expected that the results lead to a broader picture of the user preferences regarding self-driving vehicles in the public transport system. The relevance of this study is depicted in Table 1.1.

Table 1.1 Relevance of the study

Relevance of the study:
Scientific
Contribute to the understanding of travellers' choice behaviour regarding automated vehicles operated as public transport services for urban trips.
Assessment of the influence of an interactive system and a human steward in the self-driving bus on the perceived utility of a self-driving bus.
Contribution to a potential ex-post study of travellers using a self-driving bus.
Society
Behavioural research into application of a self-driving bus as a cross-border bus trip between the Netherlands and Germany.
Contribution to the development of a self-driving bus service between student apartments and a university campus.
Understanding the current preferences for self-driving buses complementing the public transport system.

1.4 SCOPE

This study focusses on the perspective of public transport users. Since the data collection would be performed via social media and a website, it was unsure whether a large number of respondents would be gathered that use public transport for their usual journeys. Therefore, a respondent in this study is considered a public transport user when said respondent uses public transport at least once a year.

This study contributes to the development of a self-driving bus service crossing the border from Vaals (The Netherlands) to Aachen (Germany). The details of the choice experiment are based on the pilot:

- The trip represents a (sub) urban trip from a traveller's home to a work or study location with a distance of approximately 3 kilometres.
- The self-driving bus can be operated as a scheduled service or as an on-demand service.
- The self-driving bus operates in mixed traffic and a stop-to-stop service is considered. When operating a self-driving bus in mixed traffic, travellers could be picked up at their origin by operating a door-to-door service. However, for this study, no door-to-door trips were considered since this service will not be offered in the future pilot.

The survey has been distributed in the Netherlands and Germany to assess the preferences of public transport users from the different countries. Differences in parameter estimates between nationalities could arise. This could be of interest for the cross-border pilot study in determining potential demand per country.

In the stated preference experiment the respondents were faced with a fully self-driving bus. The actual pilot will deploy an SAE level 4 vehicle (SAE International, 2016). For this study, it has been decided to consider a level 5 vehicle, which theoretically could replace a regular bus and is assumed to be the least difficult to understand for the respondents.

1.5 RESEARCH OBJECTIVE

In this study, the preferences of public transport users for a commuter trip by bus are analysed. The commuter trip comprises a bus journey in a (sub-)urban area with the distinction between a fully self-driving bus and a regular bus. The outcome of this study contributes to the knowledge regarding users' attitudes towards a self-driving bus implemented in the current public transport system.

The aim is to gain a better understanding on how traveller characteristics, their current attitudes towards self-driving vehicles, and mode attributes influence the choice for self-driving buses, and which roles the on-board steward and the interactive system play in this.

The main research question that is addressed in this study is:

To which extent do public transport users prefer a self-driving bus relative to a regular bus for sub-urban trips?

The following sub-questions were set up to answer the main research question:

1. Which traveller characteristics influence the preference for a self-driving bus and to which extent?
2. How do mode attributes influence the preference of travellers for a self-driving bus?
3. To which extent do attitudinal factors influence the perceived utility of a self-driving bus?
4. How does a frequent public transport usage influence the preference for a self-driving bus?
5. What are the differences between user preferences in the presence of a steward and an interactive system?
6. What is the relative preference for an on-demand self-driving bus compared to a scheduled self-driving bus?

1.6 Outline of this study

Chapter 2 reviews literature regarding self-driving vehicles within public transport and relating choice behaviour of travellers. The chapter ends with an overview of the considered factors for the assessment of relative preferences regarding self-driving buses. Chapter 3 introduces the pilot study of a self-driving bus, to which this study attempts to contribute. In chapter 4, the methodologies used in this study are explained. Then, in chapter 5, the design of the survey is discussed. The sample characteristics and the results from the applied exploratory factor analysis and discrete choice models are discussed in chapter 6. In chapter 7, a scenario analysis is discussed, based on the outcomes of the discrete choice model the model is applied. Chapter 8 follows with a discussion of the results, whereas chapter 9 gives recommendations for future research. At last, chapter 10 discusses the main conclusions from this study.

In this chapter, the objective of this study was discussed. The subject was introduced with a selection of performed studies in user travel behaviour regarding self-driving vehicles. It was found that there is a need for more knowledge regarding public transport user preferences of self-driving vehicles within a public transport system. Additionally, the scope of this study was determined in which a self-driving bus service of a future pilot is considered. This resulted in the main research question '*To which extent do public transport users prefer a self-driving bus relative to a regular bus for sub-urban trips?*'.

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2 LITERATURE REVIEW

In this chapter, a number of studies are reviewed that explored user preferences for self-driving vehicles and the attitudinal factors that might influence user preferences.

2.1 AUTOMATED PUBLIC TRANSPORT

Complimentary to current public transport modes, automated vehicles could be deployed as self-driving buses, which could benefit public transportation in its efficiency of the operations, traffic safety and lower costs (Dong et al., 2017). These benefits are estimated in several studies on automated vehicle technology in general (e.g. Fagnant & Kockelman, 2014; 2018; Bansal & Kockelman, 2017; Winter et al., 2017). However, these studies do not consider individual behaviour effects of self-driving vehicles. As a result, the extent to which the modal split will change in the case of the use of self-driving vehicles in a public transport system is rather unknown (Correia et al., 2016).

Yap et al. (2016) performed a stated preference survey where travellers had to choose between several egress modes for a train trip. The authors were one of the first to discuss the position of the self-driving vehicle in the public transportation market. Based on literature, they assumed that travellers would be willing to pay less for reducing travel time than in conventional egress modes (Fagnant & Kockelman, 2015; Krueger et al., 2016), like the bus. By estimating the value of travel time for self-driving vehicles the willingness to pay for the self-driving vehicle is determined. The value of travel time is determined by the estimated parameters travel time and travel costs in a discrete choice model.

Contrary to the assumption of Yap et al. (2016) that the willingness to pay for a self-driving vehicle would be less, they found that the willingness to pay for a self-driving vehicle was higher than for conventional buses, but also higher than for conventional cars. A reason could be that people might not value the advantage of performing other activities while travelling (Yap et al., 2016). However, this is not an advantage of a self-driving vehicle as a public transport mode, which suggests that the possibility of doing other things than controlling a vehicle should not be considered an advantage in a public transport environment. A more understandable reason could be that travellers might feel uncomfortable imagining a trip in a self-driving vehicle (Yap et al., 2016). Ignorance about the potential performance of a self-driving vehicle might influence the stated use intention (Madigan et al., 2016). Additionally, Yap et al. (2016) discuss the trust in automated vehicles relating to the perception of safety, which might play a role in the uncomfortable feeling of using a driverless vehicle. This corroborates other studies that analysed stated behavioural responses regarding self-driving buses (Delle Site et al., 2011; Alessandrini et al., 2016; Piao et al., 2016).

These studies attempted to increase knowledge of people's attitudes towards self-driving shuttle buses. They predominantly considered demonstration routes (Delle Site et al., 2011; Alessandrini et al., 2016; Piao et al., 2016) and new connections between specific public transport nodes and major facilities (Delle Site et al., 2011; Alessandrini et al., 2016) or residential areas (Alessandrini et al., 2016). Their results show that in a controlled environment, more people are willing to use the self-driving shuttle. This confirms the assumption of Lenz & Fraedrich (2016) that self-driving company buses could be imagined as individualized public transport.

As Alessandrini et al. (2016) suggest, users do not tend to trust the self-driving vehicle in mixed traffic. A lower speed might increase the attractiveness of the self-driving vehicle (Alessandrini et al., 2016). However, according to Delle Site et al. (2011), focussing on comfort when researching the user preferences of self-driving shuttles might be better than emphasizing the speed of the vehicle. The study of Piao et al. (2016) showed that a very low speed did not convince the users of the capabilities of self-driving shuttles. In addition, a higher speed of, for example, 50 km/h, might not be of influence on the overall performance of a self-driving bus. For example, average bus speeds in the metropole London do not exceed 30 kilometres an hour (e.g. TfL, 2018a), and the average speed of the buses in the city of London, for example, is 15 km/h (TfL, 2018b). Therefore, speed should maybe not be considered as a major capability of the vehicle in suburban or urban areas. Competing travel times and travel costs are more important for users of self-driving buses (Alessandrini et al., 2016; Madigan et al., 2016).

Moreover, Yap et al. (2016) recommend advance research in mode choice preferences regarding the use of self-driving vehicles for the main part of a trip; they argue that a main trip with a self-driving vehicle could enable more insight in distinctive factors compared to other modes. As a response, De Looff et al. (2018) remarked the conflicting results of Yap et al. (2016) with the literature discussing the expected lower disutility in case people use a self-driving vehicle (e.g. Fagnant & Kockelman, 2015; Krueger et al., 2016). Therefore, De Looff et al. (2018) conducted a stated preference experiment in which they explored how people experience a trip with a self-driving vehicle compared to one with a regular car. Contrary to Yap et al. (2016), they found that the value of travel time was lower for a self-driving vehicle with an office interior than the conventional car. This result corroborates the expectations of De Looff et al. (2018), which shows that people are willing to work in a self-driving vehicle. However, performing leisure activities in the self-driving vehicle was found to be valued higher than the value of travel time for the regular car.

Additionally, De Looff et al. (2018) question the reliability of stated choice behaviour, where respondents might not understand the context or might not be able to imagine having leisure time in the car. De Looff et al. (2018) considered a representative sample of the Dutch population, which represents a large number of people not using public transport, only 7.0% use public transport on a daily basis in 2017 (CBS, 2018a). The results show that 21.0% of the respondents always opted for the regular car. The ability of these travellers to imagine doing activities while travelling might be hard since they are not used to doing that while driving. In contrast, Liljamo et al. (2018) found, from a survey with 2.000 Finnish respondents, that public transport users and respondents without a car were significantly more positive towards self-driving vehicles than people not using public transport. For this study, it is assumed that public transport users are used to performing activities while travelling.

Furthermore, the results of De Looff et al. (2018) show that respondents prefer to travel alone over travelling rather than with others, which would be detrimental to the use of self-driving buses. In public transport, travellers are obliged to share a ride with others. Merat et al. (2017) suggest taking design requirements of the self-driving buses into account, which are often relatively small compared to regular buses. When these design requirements are not taken into account, personal space might be invaded for some travellers using the self-driving driving bus.

Finally, Nordhoff et al. (2016) points out that the majority of the studies, focusing on user attitudes towards automated vehicles, targeted the car drivers when exploring the preferences and attitudes towards self-driving vehicles, e.g.: Casley et al. (2013); Howard & Dai (2014); Payre et al. (2014); Schoettle & Sivak (2014); Choi & Ji (2015); Haboucha et al. (2017); De Looff et al. (2018); Liljamo et al. (2018). In account of the potential of public transport, Nordhoff et al. (2016) urge to consider the public transport user perceptions in travel behaviour studies of self-driving vehicles.

2.2 TRAVEL BEHAVIOUR RESEARCH

The assessment of the willingness to use self-driving vehicles is often determined by estimating the value of travel time (VOTT). The VOTT value can be deducted from a discrete choice model, which infers the perceived utility of alternatives out of individuals' choices in stated preference experiments. For such models, it is assumed that travellers aim at maximizing their perceived utility when choosing a certain alternative based on its different attributes like travel time and travel cost (Walker & Ben-Akiva, 2002).

In addition to the factors travel time and travel cost, this section goes one step further in discussing more factors that influence choice behaviour. It is assumed that the distinctive nature of this study could result in more specific differences between a self-driving bus and a regular bus. A distinction is made in observable factors, either instrumental and socio-economic and unobservable, attitudinal factors.

2.2.1 OBSERVABLE FACTORS

In stated preference behaviour experiments, observable factors are used that represent attributes describing alternatives, such as travel time, travel costs or the presence of a steward. Also, the demographics of people, e.g. gender, age, level of education or public transport usage, are observable.

Krueger et al. (2016) show that travel costs, travel time, but also waiting time, have significant effects on the adoption of shared automated vehicles, also called instrumental factors, which define the specific system details. First studies have shown for example that people are not willing to pay more for self-driving buses than regular buses (Alessandrini et al., 2016).

The heterogeneity in values of travel time is influenced by several factors, among other socio-economic factors. These factors are observable factors describing individuals, for example, for the assessment of specific user groups in a sample. Results show an increase in age typically decreases the intention to use a self-driving vehicle (Payre et al., 2014; Krueger et al., 2016; Piao et al., 2016). There are signs of heterogeneity, Delle Site et al. (2011) showed that an increase in age increases the willingness to use a self-driving shuttle. It is to be noted that Delle Site et al. (2011) considered a major facility to transport visitors to an exhibition centre where the self-driving vehicle was an alternative to walking or a conventional shuttle, which could have affected the outcomes. Additionally, Madigan et al. (2016) even suggest that age is not a factor when people have experienced a self-driving bus. Inconsistent age effects might be influenced by differences in subcultures between the samples (Nordhoff et al., 2018b). Initially, in this study, it is assumed that a lower age influences the willingness to use the self-driving bus positively.

Furthermore, men tend to be more favourable towards self-driving vehicles. Especially, young and well-educated men have a higher willingness to use self-driving vehicles than women do (Schoettle & Sivak, 2014; Haboucha et al., 2016; Krueger et al., 2016; Piao et al., 2016). Besides, Kyriakidis et al. (2015) showed that men were less concerned about self-driving vehicles. Additionally, women show less positive attitudes towards self-driving vehicles, a reason could be the absence of a human driver in a self-driving bus (Merat et al., 2017).

Since self-driving buses lack the presence of a driver the users should rely on the technology that controls the vehicle. Some studies denoted the concerns of personal safety when there is no form of customer service or operational monitoring by a public transport employee (Piao et al., 2016; Dong et al., 2017). These authors studied the willingness to use a self-driving bus with the presence or absence of an employee.

The pilot study of Piao et al. (2016) considered a self-driving shuttle bus in France. They concluded that people are cautious but willing to use the self-driving shuttle. Their willingness to use the self-driving shuttle bus could be higher if both human and self-driving buses are available, 60% of the respondents would use the self-driving shuttle with on-board public transport employee (Piao et al., 2016). Of the respondents, 40% would travel with the automated shuttle when no employee is present. Contrary, Dong et al. (2017) showed that only 13% would use the automated bus when no employee is present. In their study, they made a distinction in customer service and monitoring the operations of the vehicle, only customer service or no on-board employee. A reason why people are reluctant to use a self-driving bus without an employee might be because people feel less safe (Dong et al., 2017). However, when an employee was present offering customer service, 31% of the respondents would use the self-driving bus. This could imply that personal safety is increased when supervision is present. Piao et al. (2016) used a demonstration with self-driving shuttles as an example to infer the preferences for an on-board steward, while Dong et al. (2017) only asked people their willingness to ride a self-driving bus with or without an on-board steward.

It is to be noted that the presence of an on-board steward comes with a cost. In this situation, the cost savings that self-driving vehicles could provide would be eliminated (Dong et a., 2017). Additionally, an on-demand service of a self-driving bus might therefore not be possible to implement, although people tend to like an on-demand service (Piao et al., 2016). For example, with the on-demand minibus service Kutsuplus, it was shown that the costs of an on-demand service with human drivers were too high to be profitable, although the service was popular (HSL, 2016).

Merat et al. (2017) suggest that the ability to interact with the public transport operator could increase willingness to use. For example, the implementation of a communication system for remote supervision and interaction with the operator (Dong et al., 2017; Nordhoff et al., 2018). However, the extent to which a certain system would affect the willingness to use, and maybe the safety perception, of a self-driving bus is not known. Dong et al. (2017) recommend testing strategies that address the issue of an absent employee.

2.2.2 ATTITUDINAL FACTORS

In discrete choice modelling the utility of an alternative cannot be estimated precisely. A part of the utility ends up in the alternative specific constant which includes an error function. To increase the reliability of the estimation, attitudinal factors can be included to increase the explainable factors that influence the utility. This increases the validity of the demand estimation (Mokhtarian et al., 2015).

Attitudinal factors represent certain attitudes or tendencies an individual could have. Attitudes are used to explain behaviour. Pickens (2005) defines attitudes as: “a complex combination of things we tend to call personality, beliefs, values, behaviours, and motivations.”. Attitudes are different from perceptions, although the two are closely related (Pickens, 2005). A perception “is the process by which organisms interpret and organize sensation to produce a meaningful experience of the world” (Lindsay & Norman, 1977). An individual interprets information into something the individual can comprehend. The perception of information might be different from reality (Pickens, 2005). In this section, attitudinal factors are considered.

The results of Yap et al. (2016) suggest that the attitude towards sustainability of self-driving vehicles is of most importance on the intended use of self-driving vehicles. Secondly, the attitudinal factor trust in self-driving vehicles was of importance. This corroborates the findings of other research since user trust is one of the greatest contributors to the acceptance and adoption of self-driving vehicles (e.g. Choi & Ji, 2015). However, De Looff et al. (2018) performed a similar factor analysis as Yap et al. (2016) and tested whether the factors trust, safety and convenience of a self-driving vehicle would influence the choice behaviour. From their research trust influenced the choice for the self-driving vehicle the least. Convenience was the only significant attitudinal variable that influenced the choice predominantly.

Other attitudinal factors considered by Yap et al. (2016) were work productivity in the self-driving vehicle, the enjoyment of driving a car and service reliability of a self-driving vehicle. When travellers enjoy driving a car, the total utility of using a self-driving vehicle decreases (Kyriakidis et al., 2015; Yap et al., 2016). The other factors were of slight positive influence. Measures regarding the sustainability aspect of the self-driving vehicle and the trust in self-driving vehicles could have more potential to improve the perceptions and attitudes of travellers (Yap et al., 2016).

In addition to this, a thorough literature review by Merat et al. (2017) shows that trust in automation is a major contributor to the adoption of self-driving vehicles and is affected by other factors. Among other, the attitude towards the usability of the self-driving vehicle, if the self-driving vehicle performs as a traveller expects, could increase trust (Hoff & Bashir, 2015; Nordhoff et al., 2017). Also, the presence of an interactive system could increase the willingness to use a self-driving bus, because it could positively affect user trust in the self-driving vehicle (Merat et al., 2017). People tend to prefer any form of control in a self-driving vehicle (Nordhoff et al., 2018).

Another attitude that showed an effect on the intention to use self-driving vehicles is technology interest. Individuals with increased interest in technology, the ones that are considered early adopters of technology (Winter et al., 2017; Zmud & Sener, 2017); technology-savvy individuals (Bansal et al., 2016) and people with a high interest in technology (Haboucha et al., 2017) are likely to use self-driving vehicles.

Dong et al. (2017) show the concerns regarding the safety of automated buses from the perspective of public transport users. Both operational and personal safety affect the attitude towards automated buses, equipping features like communication systems in the automated bus should be considered (Dong et al., 2017). Albeit, according to the results of the exploratory study of Dekker (2017) the need of surveillance is affected by the level of trust a traveller has, increased trust in the self-driving vehicle decreases the importance of any surveillance present.

Furthermore, Nordhoff et al. (2017) investigated user acceptance of automated shuttles in public transport. The authors found that ease of use and social influence are of influence on the use of automated shuttles as well as usability. These factors respectively describe the ease at which a user can use the automated shuttle and the effect others have on the individual attitude towards automated shuttles.

This chapter reviewed literature regarding self-driving vehicles and relating user preferences. It became clear that self-driving vehicles offer potential benefits to the public transport system. The findings of these first studies on user preferences regarding self-driving vehicles do not provide a uniform picture, there are uncertainties among the preferences of end users. However, the studies suggest that the self-driving vehicle will most likely be chosen first by young, well-educated men and environmental positive travellers. The assessment of the user preferences in transportation studies is commonly performed with the use of discrete choice modelling. The variables that influence choice behaviour were discussed. A distinction was made in observable variables, like travel time, and unobservable variables, like attitudes. These variables allow the assessment of the user preferences in transportation studies. The discussed studies are used as a reference for the discussion of the results.

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3 TESTING A SELF-DRIVING BUS

This study contributes to the development of a self-driving bus service in the interregional area of Vaals and Aachen. Therefore, the design of the choice experiment is based on the pilot area. This chapter discusses the pilot details.

The German public transport company ASEAG is planning to deploy a self-driving bus in addition to their current bus service between Vaals and the University of Aachen, Rheinisch-Westfälische Technische Hochschule (RWTH). With this service, ASEAG wants to serve students, employees and visitors of the university campus.

3.1 INTERREGIONAL AUTOMATED TRANSPORT

This study attempts to add insight to the public transport user perspective for a pilot that will be held in 2019 with a self-driving bus. The pilot is part of an international collaboration between several private and public parties, called Interregional Automated Transport (I-AT), that focuses on sharing knowledge and improving product innovations. The collaboration is initiated to improve knowledge in automated alternatives for public transport, since automated driving offers benefits for the mobility of travellers and for low-density passenger flows, for example, the last mile. The parties have a joint interest in the potential advantages of automated vehicles in the transportation system. A contribution to their goal is the planned test of a pilot with a self-driving bus in the region of Aachen (Germany) and Vaals (The Netherlands).

3.2 AACHEN-VAALS PILOT

The Aachen-Vaals pilot will operate a self-driving bus, the Mission, between two main traffic nodes. The pilot does not consider first and last mile transport. However, the experience from this pilot is of value for last mile projects (Intrafic, 2018), since knowledge and experience will increase regarding the technical and operational aspects and user perceptions of self-driving buses. For this study, the user perspective regarding self-driving buses prior to the pilot is of interest.

The case study area comprises the cities Vaals (The Netherlands) and Aachen (Germany). This region is an interesting study area because of the first cross-border pilot with an automated vehicle, between the Netherlands and Germany. The cross-border collaboration could contribute to the future deployment of self-driving vehicles in different countries. Since policy standards for the operation of self-driving vehicles within and across countries are not clear yet, the collaboration could speed up the policy design and implementation of self-driving vehicles in different countries in the European Union.

The pilot consists of a public transport service, provided by the German public transport company ASEAG, with a regular bus, a scheduled self-driving bus and an on-demand self-driving bus. Additionally, a shared car and a shared bike service are available in the city of Aachen. These two services are not in the scope of this study, since they are not available in Vaals and because this study aims to compare a trip with a regular and a self-driving bus.

The self-driving bus will operate on a fixed route and serves customers based on a schedule, also an on-demand service will be part of the pilot. When the on-demand service is available, user requests are served at the fixed stops. In the first stage, a fixed route of 3,8 kilometres between the student apartment and the bus stop of the University Hospital is considered (Figure 3.1), an alternative route is proposed as an option. During the project, an additional route to the north of the campus will be explored.

Because the service is proposed to be a public transport service with a fixed route, only predetermined stops are served, no door-to-door service is considered. However, an extra bus stop will be added near a student apartment which results in a minimum walking time for these residents. The shuttle will operate in mixed traffic where it will have to take other road users into account. With the use of traffic lights, the self-driving bus will be guided when crossing roads. Furthermore, the route crosses the border, therefore, the self-driving bus is designed to comply with Dutch and German legislation. The self-driving bus is designed to travel at a maximum speed of 50 kilometres per hour. Contrary to former pilots, and to the author's knowledge, this is the first time a self-driving bus is designed to reach that speed.

To this date, the presence of a human controller in a road vehicle is mandatory by law, for safety reasons. Therefore, a steward will be present in the self-driving bus during the pilot. The steward controls the vehicle in circumstances where the self-driving bus is not able to drive and in case of emergency situations. Since the self-driving bus is an SAE level 4, high automation, vehicle, not all circumstances can be controlled autonomously and thus a controller is necessary. Besides a steward on-board of the automated vehicle, an operator in a remote-control room communicates with the steward and is able to stop the autonomous operation by a stop command. The latency in communication between the remote-control room and the self-driving bus is another reason to have a steward in the self-driving bus.

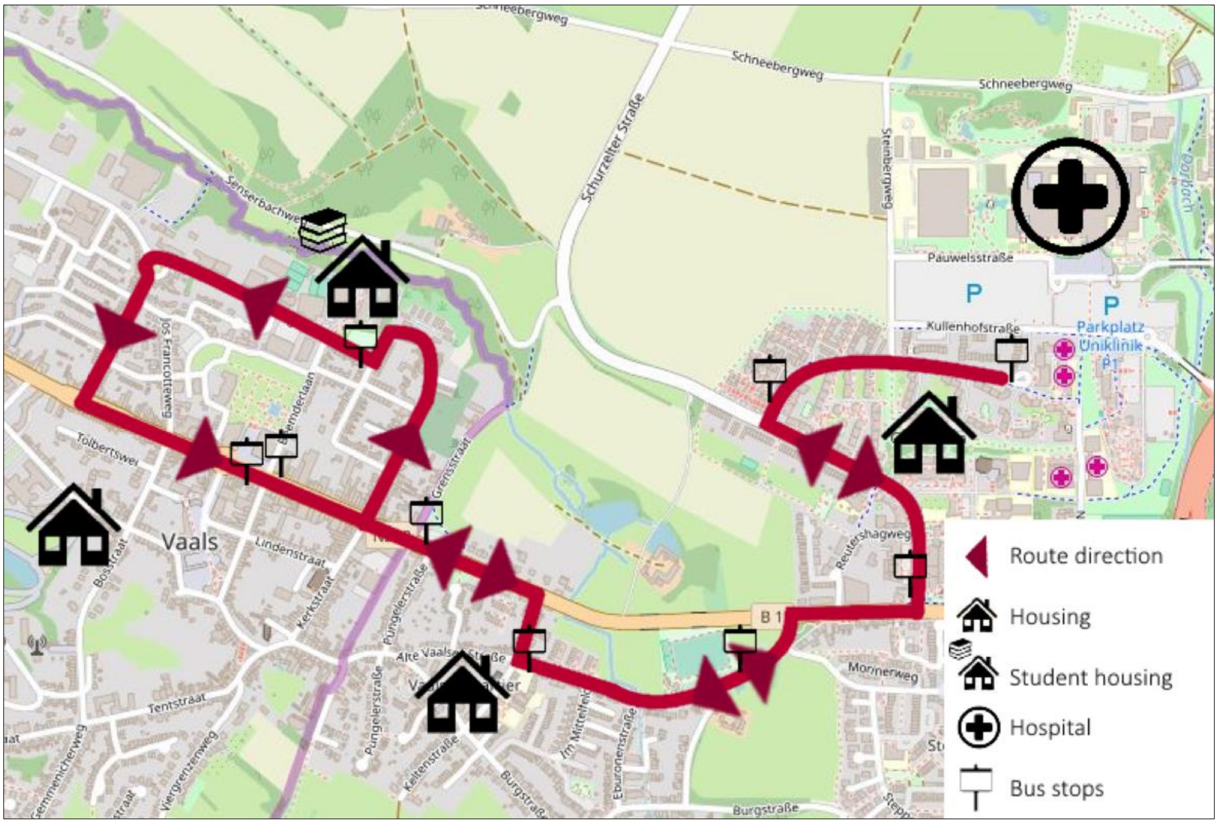

Figure 3.1 Current proposed route for I-AT pilot with the Mission

3.2.1 Customer journey

For travellers, the public transport modes and privately shared modes are accessible via a single digital platform. This platform is called the Mobility Broker web application and allows its users to plan, book and pay their trips for all available modes. Based on their chosen trip option, the traveller receives a confirmation with the ticket. In case the self-driving bus is chosen, their seat reservation is sent along. Figure 3.2 shows screenshots of the mobility broker with the planning and trip information part.

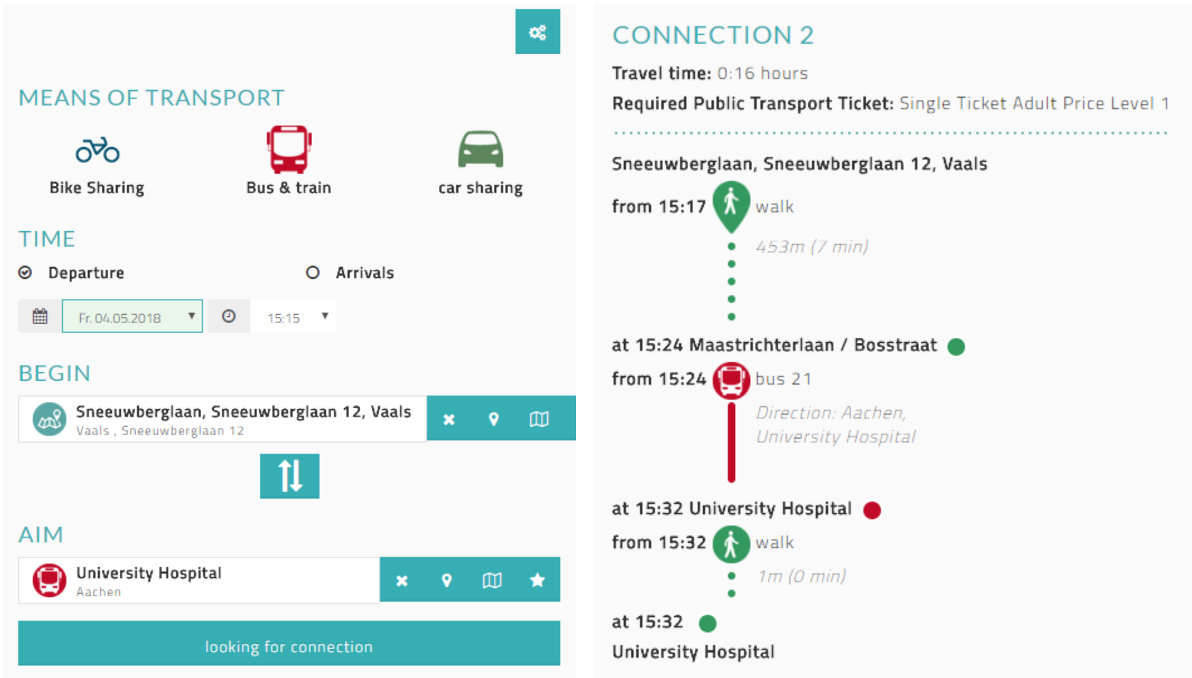

Figure 3.2 Planning of a trip and the resulting travel option on the right – © Mobility Broker

3.2.2 Case study area

Vaals is a suburb of Aachen and has 9,874 inhabitants (CBS, 2018b). Of these inhabitants the last two years more students of the University of Aachen, Rheinisch-Westfälische Technische Hochschule (RWTH), moved to Vaals. Because of the growth in the number of students at the RWTH, and the lack of student housing, the municipality of Vaals decided to build student houses. Since the end of 2016 a total of 250 student apartments were built. According to plan, an additional number of 210 apartments were built in 2018 to accommodate a total of 460 students (Gemeente Vaals, 2018). The RWTH campus is close to the location, which is in favour of students looking for housing. All the apartments are rented, and a large number of students are on the waiting list for an apartment in the Katzensprung building (Gemeente Vaals, 2018; De Limburger, 2018).

Inhabitants of Vaals planning a trip to Aachen are able to go by bike and car or take public transport, specifically the bus services of the public transport companies ASEAG (Germany) and Arriva (The Netherlands). For trips to the university campus and the university hospital, two bus lines are available.

- The second bus line 21 is operated by the Dutch public transport company Arriva, see Figure 3.3. Bus line 21 provides a direct connection from the bus station Maastrichterlaan/Bosstraat, next to the Vaals Busstation, to the university hospital bus stop every half hour, the travel time of this trip is 7 minutes and costs €1.46 (ASEAG, May 2018).
- The German public transport company ASEAG of the city and region of Aachen operates bus line 33 between Vaals and Aachen University Hospital directly, see Figure 3.4 for the route. Bus line 33 has a frequency of 2 buses per hour between the University Hospital and Vaals Busstation. A trip from the Vaals Busstation to the University Hospital takes 14 minutes and costs €2.70 (ASEAG, May 2018).

Current bus passenger counts between Vaals and the University Campus were not available during the writing of this study. An internal source from 2016 (Royal HaskoningDHV) showed the traffic flows of passenger vehicles and trucks. On average, 6,900 vehicles cross the border from Vaals to Aachen and 6,600 vehicles the other way around on a two-lane road. Modal split data were not available.

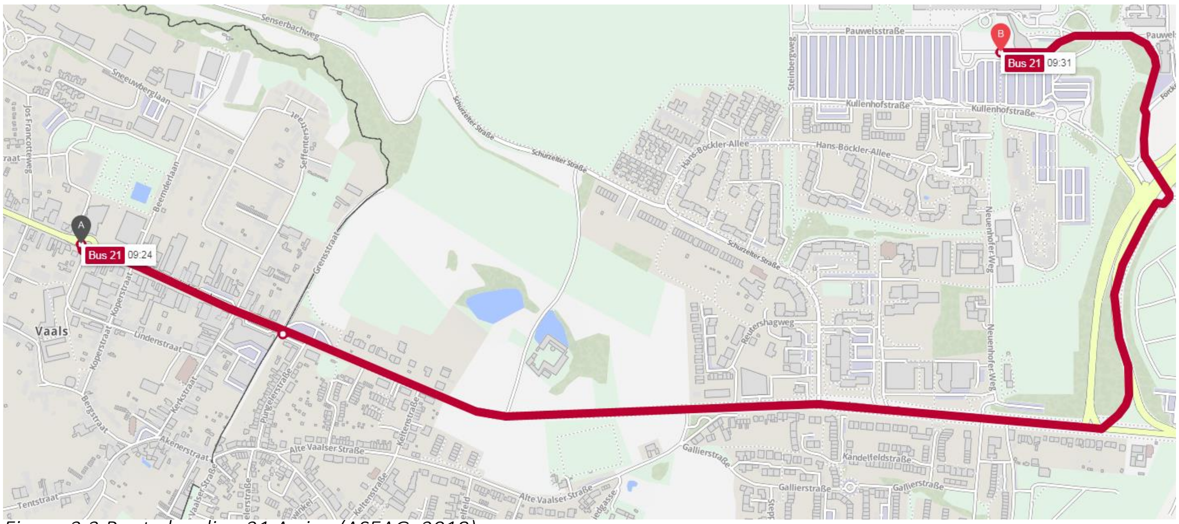

Figure 3.3 Route bus line 21 Arriva (ASEAG, 2018)

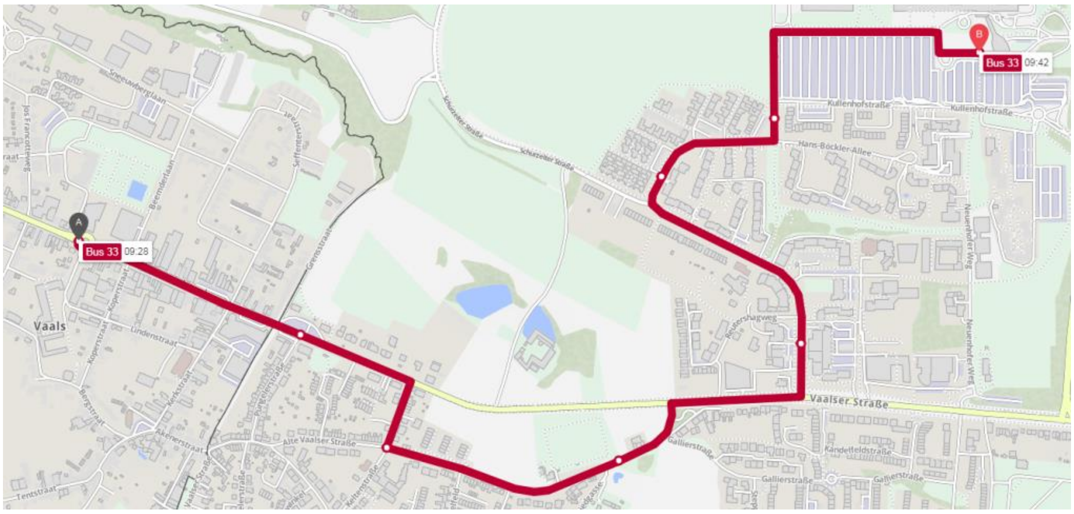

Figure 3.4 Route bus line 33 ASEAG (ASEAG, 2018)

3.2.3 POTENTIAL USERS

With the pilot of I-AT, an additional public transport service is considered. Since the walking distance to the bus stop near the student apartments is reduced from 7 minutes to less than a minute, the parties of the I-AT project assume students have an attractive public transport alternative. Additional to the students, potential users of the self-driving bus are employees of the University of Aachen including the University Hospital, as well as visitors of the hospital. The University Hospital has approximately 7,000 employees and every year around 40,000 patients visit the hospital (Uniklinik RWTH, 2016), there is no documentation on how many of the employees of the University of Aachen live in Vaals. Around 45,000 students, of which at least 460 live in Vaals, were registered to the University of Aachen in the winter semester of 2017/2018 and almost 10,000 people were employed (RWTH, 2018).

In this chapter, a future pilot study with a self-driving bus between Vaals and Aachen is introduced. The pilot is part of an international collaboration between several private and public parties, called Interregional Automated Transport (I-AT), that focuses on sharing knowledge and improving product innovations. The cross-border route that will be driven in the pilot study is discussed. In addition, details of the case study area are given regarding the current bus services and potential users for the self-driving bus in the area. The design of the choice experiment in this study is based on the pilot context.

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4 METHODOLOGY

The methodology is discussed, which is used to conduct the analysis of the preferences of users. First, the choice for a stated preference experiment is discussed. Second, the factor analysis is introduced, which is performed to explore underlying attitudinal factors. Third, the discrete choice model is introduced, with which the preferences of users are estimated.

4.1 STATED PREFERENCE EXPERIMENT

To explore the preferences of users, some quantitative methodologies can be applied. As is discussed in the introduction and the literature review, many factors that influence user preferences are found from discrete choice models which model data from revealed preference (RP) experiments or stated preference (SP) experiments. These two types of experiments enable to determine the preferences of people by eliciting choices from, or ratings of, alternatives.

With RP experiments the choices made are based on real-market alternatives with their corresponding characteristics. Since the choices are based on reality the results create a high validity. However, limitations of RP experiments are that demand for hypothetical conditions cannot be evaluated, adequate variation in data is hard to obtain, strong correlation between the explanatory variables decreases the ability to analyse the actual trade-offs made and explanatory variables have to represent objective measures describing service variables like time and cost for the trip (Kroes & Sheldon, 1988).

Contrary, SP experiments can include non-existing alternatives into the set alternatives to determine individuals' preferences for the hypothetical transport alternatives. The resulting data enable the estimation of user preferences (Kroes & Sheldon, 1988). Advantages of SP experiments are the ease of control since the researcher can determine the evaluated conditions, and the application of the method is less costly (Kroes & Sheldon, 1988). With SP experiments the researchers are flexible since they can construct hypothetical choice alternatives and include sufficient variation in the choice set with mixes of attributes to estimate the proposed utility function (Hensher, 1994). Because of the control in constructing the choice sets, data could result in more statistical efficiency (Adamowicz et al., 1998), which suggests that fewer data are needed than with an RP experiment. However, a disadvantage is the stated response which might not be similar to actual behaviour (Kroes & Sheldon, 1998).

For this study, SP experiments are chosen, since self-driving buses are only deployed in small numbers for testing and are not available for most travellers. An SP experiment allows to analyse the user preferences prior to the actual use of a self-driving bus by the respondents.

Stated preference is divided into two categories for analysing travel behaviour. Conjoint analyses focus on the response of specific alternatives with a rating scale or by ranking several alternatives. Conjoint analysis does not allow to predict choices, it only allows to infer the consumer preferences (Adamowicz et al., 1998). For the prediction of choices, discrete choice analysis can be performed. With discrete choice analysis, respondents are asked to choose the alternative from the presented alternatives. Accordingly, a discrete choice model enables the determination of utility of attributes, such as travel cost and travel time, that represent the perception of respondents on the attributes of the alternatives (Hensher, 1994). For this study discrete choice analysis is used, since choosing an alternative is easier than rating the alternatives and the choices can be expressed in predictions directly through the discrete choice models (Hensher, 1994). The discrete choice analysis allows to determine the relative preference of the self-driving bus to the regular bus and infer the trade-offs made between the attributes.

4.2 Exploratory factor analysis

Attitudinal factors could play a role in the decision making of individuals and improve the travel demand estimation (Mokhtarian et al., 2015). However, attitudes towards automation, in general, are latent (Merritt, Heimbaugh, Lachapell, & Lee, 2013). Additionally, the attitudes cannot be measured directly (Yap et al., 2016). To explore the underlying latent factors, that might influence the decision making, an exploratory factor analysis (EFA) is performed. With the use of measurement instruments, like rating scales of agreement, the EFA is able to explore the underlying latent factors (Suhr, 2006).

Besides an exploratory factor analysis, a confirmatory factor analysis can be applied as well. For this study, this approach was not preferred. Since it is a method to determine if the underlying latent factors relate to the observed variables based on hypothesized factors (Suhr, 2006). In contrary, EFA extracts factors without consideration of the hypotheses regarding factors of the researcher (Thompson & Daniel, 1996). Therefore, this study used an exploratory factor analysis, the presence of underlying factors is more of interest than specific hypothesised factors.

Henson & Roberts (2006) provide a list of the considerations that need to be made to conduct an exploratory factor analysis. First, a matrix of associations needs to be determined. This matrix shows the relationships between the variables. The respondents will assign their level of agreement to the variables with the use of statements. The types of matrices that can be considered are correlation matrices or variance/covariance matrices. Most statistical analysis software use correlation matrices, which is the case for the software used in this study.

Secondly, there are two common ways used to extract factors from the data. Either, principal components analysis (PCA) and principal factor analysis (PAF). With factor extraction, one tries to place as much common variance in the first factor as possible (Suhr, 2006). Subsequently, every following factor attempts to account for the maximum common variance for the remaining common variance, which is determined by iterations until there is, as good as, no common variance for the variables.
The difference between PCA and PAF is the analysis of the entries on the diagonal of the matrix of associations. PCA considers the ones on the diagonal, whereas PAF uses the estimates of reliability (Thompson & Daniel, 1996). There is debate if PCA can be considered a factor analysis. Since PCA intends to summarize the variables into a smaller number of components and does not consider the specific latent factors, which PAF explicitly focusses on, by maximizing the common variance among the variables (Henson & Roberts, 2006). Therefore, this study used the principal factor analysis.

With EFA a minimum number of factors are extracted that try to explain the maximum amount of common variance. The total number of factors that will be extracted should be interpretable and contribute to the factor solution to be retained in the analysis (Hanson & Roberts, 2006). There are several methods to determine the correct number of factors. Hanson & Roberts (2006) concluded that the most used methods are the Kaiser rule and the scree-test, which are used in this study. According to the Kaiser rule, a factor should have at least an Eigenvalue of 1 to be retained as a factor (Kaiser, 1960). Additionally, the scree-test depicts the Eigenvalues in a plot, from the point the line levels off all factors should be excluded from the analysis (Cattell, 1966).

Before the exploratory factor analysis can be executed, the final decision that needs to be made is the factor rotation and coefficient interpretation. Factor rotation is used to improve the interpretability of the factors since the high factor loadings are maximized and the low loadings are minimized (Henson & Roberts, 2006; Williams, Onsman & Brown, 2010). The two main types of factor rotation used are orthogonal and oblique rotation (Abdi, 2003; Suhr, 2006). In orthogonal rotation, the factors are orthogonal, which represent axes in the factor space that remain at an angle of 90 degrees (Abdi, 2003).

The most common method used is the orthogonal rotation VARIMAX. VARIMAX attempts to load each variable at one factor and allows for small loadings on a limited number of other factors. Besides, every factor represents a small number of variables (Abdi, 2003). Other orthogonal rotations are QUARTIMAX and EQUIMAX. QUARTIMAX minimizes the number of factors that are able to explain the variables by simplifying the rows of the factor matrix (variables), compared to simplifying the columns by the VARIMAX method (Kaiser, 1958). This could result in a more general factor where most variables load on (Kaiser, 1958). The EQUIMAX can be considered as an in-between method that compromises between both VARIMAX and QUARTIMAX (Abdi, 2003).

With oblique rotation, the axes in the factor space can have varying angles. However, with small correlations, since two strongly correlated factors could be interpreted as one factor (Abdi, 2003). An advantage of this method is that a variable has less high loadings on two factors, which prevents the elimination of variables too early in the iteration process. Additionally, this method iterates earlier towards a simple structure of the factor patterns than with orthogonal rotation, which increases the simplicity of the factor interpretation. However, it can be argued that orthogonal rotation is preferable over the oblique rotation since orthogonal rotations estimate fewer parameter matrices, which produces more replicable results (Henson & Roberts, 2006). Additionally, all alternative rotations are hardly used compared to VARIMAX (Abdi, 2003). Therefore, VARIMAX is chosen in this study.

4.3 Discrete choice modelling

Discrete choice modelling is used as the methodology to predict the decision making of travellers (Ben-Akiva & Bierlaire, 1999). Discrete choice modelling uses econometric modelling techniques to estimate choice behaviour (Adamowicz et al., 1998). With the accumulation of the choices made in the stated preference experiment relative preferences can be estimated. The decision maker, or individual, makes a choice out of a discrete choice set which includes several alternatives with varying attributes per choice set. With discrete choice modelling, it can be assumed that the decision maker chooses the alternative that provides the maximum utility (U_i) (Train, 2003), see Equation 4.1. In this study, random utility maximization is used, since it is a well-known method for discrete choice models in travel behaviour studies and allows the comparison of the outcomes with former studies that applied discrete choice modelling.

$$U_i > U_j \;\; \forall \;\; j \neq i \tag{4.1}$$

From the researcher's point of view, the perceived utility is not observed, but the attributes that describe the chosen alternative are observed. Because the decision of the respondent is influenced by unobservable factors of the utility, U_i is decomposed in

$$U_i = \; V_i + \varepsilon_i \tag{4.2}$$

This way the modelling of choices becomes probabilistic, since the ε_i is an error term, which represents the unobserved utility next to the systematic (observed) utility V_i like travel time (Adamowicz et al., 1998).

The total utility is expressed as a linear additive function, together with the error term, this results in the following utility function for an alternative.

$$U_i = V_i + \varepsilon_i = \sum_m \beta_m x_{im} + \varepsilon_i \tag{4.3}$$

β_m is the coefficient of attribute m and x_{im} is the value of attribute m, for example, a specific travel time.

In this study, the utility function is extended to estimate the marginal utilities for the observable and attitudinal factors that could influence the relative preference for a self-driving bus compared to a regular bus. The utility functions are shown in the final model estimation, section 6.3.

The models that are estimated in this study for the estimation of the preferences of public transport users are introduced in the next sections.

4.3.1 Multinomial Logit

The multinomial logit (MNL) model is the most used discrete choice model (Train, 2003). The probability (P_i) of choosing alternative i for a MNL model is:

$$P_i = \frac{e^{V_i}}{\sum_j e^{V_j}} \qquad 4.4$$

The probability of a choice is affected by the assumption of the error term, in an MNL model the error term (ε_i) is independently and identically distributed (i.i.d.). This means that the unobserved factors in the utility are uncorrelated over the alternatives and, because of this independence, all have the same variance (Train, 2003). Therefore, the choice probability of alternatives with i.i.d., unobserved utility is only determined by the differences between the alternatives.

The assumption of independent alternatives is considered as one of the limitation of MNL models (Train, 2003). Unobserved factors of an alternative could be similar for other alternatives. However, in the MNL model a change of the attribute values for an alternative will affect the probability of other alternatives equally. This property is called the independence from irrelevant alternatives (IIA-property). An MNL model would avoid the correlated preference when estimating the choice of the individual. Secondly, MNL does not represent taste heterogeneity for attributes of alternatives. For example, a longer travel time could have stronger effect on the perceived utility of an alternative for an individual compared to another individual. The third limitation concerns the sequence of choices of an individual, which are likely to correlate, the MNL model is not able to accommodate these panel effects.

4.3.2 Mixed Logit

The assumptions in the MNL model provide convenience for researchers (Train, 2003). However, the assumptions might not be realistic. A Mixed Logit (ML) model overcomes the limitations of the MNL model. ML models allow for random taste variation, unrestricted substitution patterns and can capture panel effects to account for the correlation within unobserved factors over time (Train, 2003).

Taste heterogeneity

Individuals can differ in their preferences for specific attributes and alternatives: the random taste variation. This can be captured by estimating a standard deviation of the attribute parameters or the alternative specific constants. With the estimation of a standard deviation, a parameter becomes individual-specific.

Nesting effect

Alternatives can have common factors that might not be observed by the researcher. To represent the common unobserved factors an error component can be added to multiple alternatives (Train, 2003). A significant error component means that there is correlation between the specific alternatives, which is the nesting effect. With a significant error component, the IIA property does not hold and the change in utility of an alternative will affect the probability of the other nested alternative more than other alternatives in the model estimation.

Panel effects

The choices of an individual are generally correlated in stated preference experiments. To account for the correlation across the choices of an individual, the model can estimate all sequence of choices made by the same individual (Train, 2003). This improves the explanation power of the ML models. Parameter estimates can be found that have more realistic substitution, or correlation, patterns for alternatives, improved realism of the taste heterogeneity and capture correlation in choices of an individual (Train, 2003). Not correcting for the panel effects could make the identification of heterogeneity in the preferences and tastes difficult.

4.3.3 Discrete choice model with attitudinal variables

To estimate if attitudinal factors have an influence on the relative utility of the self-driving bus, latent factors can be integrated into discrete choice models. The latent factors resulting from the factor analysis are incorporated as averaged sum scores without measurement error. This method gives an intuitive interpretation of the attitudinal factors (DiStefano et al., 2009).

With this method, the varying loadings of the variables on the extracted factors are ignored (DiStefano et al., 2009). Variables with low loadings have the same influence on the sum score as variables with higher loadings. This approach does not capture relations with socio-economic characteristics, attitudinal factors and the attributes from the choice experiment (Walker & Ben-Akiva, 2002). This could be overcome by estimating an integrated choice and latent variable model (ICLV) (Temme et al., 2008; Daly et al., 2012).

The complexity of the ICLV model and the exponential increase in computation time for increasing numbers of factors (Temme et al., 2008), have led to the decision to incorporate mean sum scores, or factor scores, in the discrete choice model. It is assumed that the interpretability of this approach is sufficient for the assessment of the effects of attitudinal factors on the perceived utility of a self-driving bus.

4.4 Factors considered in this study

In this study, a few factors are included in the assessment of the relative preferences for a self-driving bus. The decisions that are made concerning the included factors are partially explained by the pilot test, which captures specific parts of the service for a self-driving bus. The discussions of the factors are followed by the respective expectations in this study.

Observable factors

Time and cost

Travel time, travel cost and waiting time are classical attributes in mode choice experiments to design realistic alternatives and ultimately determine the willingness to pay for mode alternatives. In discrete choice models, the outcomes of the estimated marginal utilities for these attributes are negative (Krueger et al., 2016; Yap et al., 2016; De Looff et al., 2018).

Surveillance

This study considers the future self-driving bus service of the pilot discussed in chapter 3. In the self-driving bus, a steward will be present. In the literature review was found that travellers prefer to have any form of control. An interactive system for communication and supervision of an operator could affect the willingness to use a self-driving bus and, maybe, the safety perception of travellers. Therefore, it is decided to include surveillance, either the presence of steward or an interactive system, in the choice behaviour analysis. It is expected that the perceived utilities of both the on-board steward and interactive system are positive, which would contribute to an increased utility of the self-driving bus by travellers.

Service

A self-driving bus could be operated on-demand or based on a schedule, which is similar to the pilot test considered. In this study, the different service types are included in the estimation of the choices of public transport users. This allows to assess the perceived utility of the service types and to compare if an on-demand self-driving bus on a fixed route is preferred over a scheduled self-driving bus.

Socio-economic characteristics

Differences in age and gender effects were found in previous studies regarding the attitudes towards self-driving vehicles. These characteristics are included in the discrete choice model to estimate if similar effects can be found. It is expected that men and younger respondents perceive more utility of a self-driving bus.

Liljamo et al. (2018) found that monthly public transport users have a more favourable attitude towards self-driving vehicles. Since public transport users are the target group in this study, the effect of public transport usage is assessed. It is expected that a more frequent public transport usage increases the perceived utility of a self-driving bus.

Attitudinal factors

Previous studies show that attitudinal factors influenced the choice behaviour of people (Kyriakidis et al., 2015; Yap et al., 2016; De Looff et a., 2018). Therefore, this study included several statements capturing indicators of attitudinal factors to analyse if underlying attitudinal factors are present in the resulting sample. The variables that are considered in this study relate to *trust in automated vehicles, technology interest, convenience of self-driving buses and the attitude towards vehicle characteristics of the self-driving bus.* It is explored if underlying attitudinal factors are of influence for the choice of a self-driving bus, which attitudinal factors are underlying in the sample is discussed in section 6.2. The other attitudinal factors were considered to be less relevant for a public transport trip and are, therefore, not represented by statements in this study.

The considered factors are shown in the conceptual model in Figure 4.1. Through the factor analysis it is determined if underlying attitudinal factors are present in the obtained data, before the possible influence of the underlying factors on the choice for a self-driving bus is estimated.

The methodologies that are used in this study are discussed. Since the self-driving bus is not a common vehicle, it has been decided to apply a stated preference experiment to gather information of user preferences. To explore if underlying attitudinal factors affect the decision making within the choice experiment, it was concluded to conduct an exploratory factor analysis (EFA). With the accumulation of the choices made in the stated preference experiment, relative preferences can be estimated. Therefore, discrete choice modelling is applied in this study. In the last section, this chapter discusses the factors that are included in this study for the assessment of public transport user preferences.

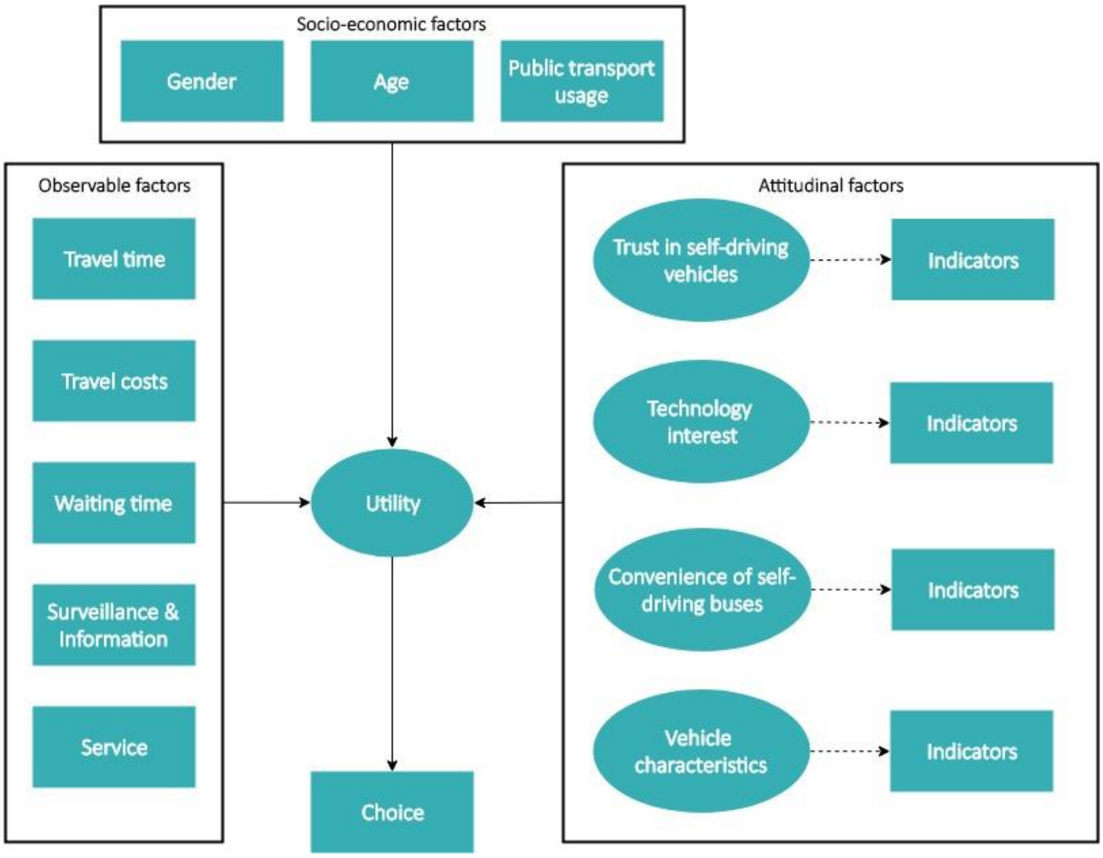

Figure 4.1 Conceptual model including considered factors in this study

5 SURVEY DESIGN

In this chapter, the design of the survey is discussed. The design of the survey was assisted by the test with two preliminary surveys. The preliminary surveys were distributed to assess the level of understanding by respondents and to improve the survey for the final distribution. With the use of these surveys, the pilot from the case study and literature, the final survey has been designed. Some adaptations that were made, that resulted from these surveys, are mentioned in the discussion of the survey design. More details about the preliminary surveys can be found in Appendix I and J.

All surveys were designed with the software tool SurveyMonkey, which allowed to create a sharable weblink and the random distribution of the different blocks containing six choice sets.

The final survey can be found in Appendix K. The survey contained the following parts:
- Introduction of the research
- Part 1: Introduction of the choice experiment
  Six choice sets
- Part 2: Attitudinal statements
- Part 3: Questions with socio-economic variables
- Possibility to sign up for the raffle
- The closing of the survey

5.1 STATEMENTS

To explore if attitudinal factors influence the choice process in this study the attitudinal factors were quantified by presenting statements, see Table 5.1. The respondents were asked to rate their level of agreement based on a five-point Likert scale (Likert, 1932). The statements represented variables that allow determining latent variables in the exploratory factor analysis. Most of the statements are based on latent factors that are formed in previous research. This could increase the possibility of forming attitudinal factors and allows to compare these factors with former studies. Additional statements were added concerning the attitude towards vehicle characteristics, which could be of influence on the preference for the self-driving bus (Merat et al., 2017). Some statements were adjusted after performing the preliminary surveys to increase the understanding for respondents and to fit the specific objective of the variable.

5.2 DESIGN OF STATED PREFERENCE EXPERIMENT

For the stated preference experiment the respondents need to choose out of at least two alternatives. The respective alternatives have varying attributes, consisting of at least two attribute levels. Respondents have to choose out of a selection of alternatives shown in multiple choice sets. These choice sets are generated using an experimental design.

5.2.1 ALTERNATIVES

For this study, three alternatives were considered in the choice sets. Two alternatives are based on the pilot in Vaals and Aken and the third alternative is an opt-out for another mode. The first alternative is the regular bus and the second alternative is the self-driving bus, see Figure 5.1. The differences are the lack of a driver and a lower seat capacity for 16 travellers for the self-driving bus. The respondents were informed of the differences between the regular and self-driving bus. Other differences are the type of service and surveillance & information, which were chosen as attributes for the self-driving bus, these are shortly discussed in the next section.

Table 5.1 Statements included in the final survey

Variable	Trust in automated vehicles	
TRUST_1	I believe a self-driving vehicle would drive better than the average human driver.	Adapted from Casley et al. (2013)
TRUST_2	I am afraid that the self-driving vehicle will not be fully aware of what is happening around him.	Adapted from Yap et al. (2016)
TRUST_3	I think that the self-driving system provides me more safety compared to manually driving.	Adapted from Payre et al. (2014)
TRUST_4	I would entrust the safety of a close relative to a self-driving vehicle.	Adapted from Casley et al. (2013)
TRUST_5	I think that the self-driving bus only is safe when a steward is present.	
	Technology interest	
TI_6	I try new products before others do.	Adapted from Roehrich (2004)
TI_7	I am excited by the possibilities offered by new technologies.	Ewing and Sarigollu (2000)
TI_8	I have little to no interest in new technology.	Adapted from Roehrich (2004)
TI_9	New technologies create more problems than they solve.	Adapted from Jensen et al., 2014)
	Convenience	
CONV_10	Automated vehicles will make life easier.	Adapted from Haboucha et al. (2016)
CONV_11	The best part of the self-driving bus is that it can be requested on demand.	Created for the present study
CONV_12	I think that using the self-driving bus is more convenient than using regular buses.	Adapted from Madigan et al. (2016)
	Vehicle characteristics	
CHAR_13	I would feel more comfortable in a self-driving bus with several passengers than with a few passengers.	Created for the present study
CHAR_14	An interactive screen is a good replacement for a bus employee in the self-driving bus.	Created for the present study
CHAR_15	I would feel more comfortable in a self-driving bus than in a regular bus.	Created for the present study

In the first pilot, three alternatives were considered. However, the preliminary estimation of the data showed that the two alternative specific constants of the self-driving bus, either demand responsive and based on schedule, were insignificant. If the two alternatives were kept, the alternative specific constants of the self-driving buses would be influenced by the services considered. This could result in unexplainable differences in the estimation results since the constants would explain the differences between the services and all aspects that are not considered in the model estimation. The choice for two alternatives allows estimating the main effect of the alternative specific constant based on the error term without assumptions regarding the service type.

For the final experimental design, two adaptations were made. The stated preference experiment should represent a realistic scenario. Since a traveller has the option to not travel by bus, an opt-out alternative was added to the choice options. The opt-out alternatives can represent any alternative a respondent can imagine as an alternative to the presented buses. Adding an opt-out increases the realism of the choice context and could enhance the theoretical validity of the relative position of the alternatives (Adamowicz & Boxall, 2001). Additionally, the efficiency of the parameter estimates could improve significantly (Louviere, Hensher & Swait, 2000). However, the choice for an opt-out decreases the information about the relative preference for the available alternatives from the same number of observations (Brazell et al., 2006).

	 Self-driving bus	 Regular bus
Travel time	10 minutes	7 minutes
Travel costs	€ 2.20	€ 1.60
Waiting time	2 minutes	6 minutes
Surveillance & Information	Steward	
Service	On-demand	

Figure 5.1 Example of a choice set (translated for presentation purposes)

5.2.2 ATTRIBUTES AND ATTRIBUTE LEVELS

The choice sets that were designed differentiate by several attributes. The attributes included in this study are *travel time*, *travel cost*, *waiting time*, *surveillance & information* and *service*. The attributes travel time, travel costs and waiting time were considered equal for the regular bus and the self-driving bus. The choice for the equal attribute levels simplifies the choice sets for the respondents. Table 5.3 gives an overview of the attributes and the considered attribute levels.

For *travel time* four attribute levels were established. The travel times are pivoted around the current travel times of the pilot region and similar bus trips between around 3 kilometres in other Dutch (sub) urban areas. In the first preliminary survey the value of travel times (VoTT) were unrealistic, therefore the attribute levels of travel time were increased in range for a representative value of travel time. The travel times chosen for the stated preference experiment are *7*, *10*, *13,* and *16* minutes.

Travel costs for the bus trip are based on current travel costs for bus trips between Vaals Busstation and Aachen Uniklinik, and similar trip lengths in other Dutch (sub) urban areas. Regarding the VoTT in the preliminary survey, the attribute levels of travel costs were reduced for realistic choice sets. The considered travel costs are *€1.00, €1.60*, *€2.20, €2.80*. The values of travel time that result out of the chosen attribute levels are shown in Table 5.2. The values vary around the known representative values of travel time for buses (€7.75 to €10.50) for different trip types (Kouwenhoven et al., 2014).

Table 5.2 Value of Travel Times based on attribute levels in the final survey

VOTT	VoTT (/hour)
Max. VoTT	€ 36.00
	€ 24.00
	€ 12.00
	€ 8.00
	€ 6.00
Min. VoTT	€ 4.00

Waiting time is the time a traveller has to wait at the bus stop until a bus arrives there. It is assumed that people arrive randomly at the bus stop regardless their origin. In the preliminary surveys, respondents mentioned the high waiting times for a bus trip starting from home. The respondents mentioned that they would wait in their house in case of a high waiting time (e.g. 14 minutes in the preliminary survey). Therefore, the waiting times considered were slightly less than the average waiting times in the pilot region. The waiting times were limited to *2*, *4*, *6* and *8* minutes. The maximum waiting time of 8 minutes was included to enable the effects of a wide range on the choice probabilities.

For the self-driving bus, two additional attributes were considered. The attribute *Surveillance & information* represents the measures that could be taken to increase the level of customer service level and surveillance of the vehicle. The presence of an on-board *steward* from the public transport company is one of the attribute levels, which was named the 'bus employee' in the survey. The second attribute level is the interactive system, which was called an *interactive screen* in the choice experiment. The interactive screen allows the traveller to communicate with the public transport operator. The third attribute level was named *standard*, which only consists of the standard travel information screen and camera's, similar to what is present in a regular bus.

The preliminary surveys had different parameter estimates for the surveillance attribute. The first survey showed a positive marginal utility of the interactive system, but an insignificant parameter for the steward. The second survey resulted in opposite outcomes, the interactive system was not significant and the presence of a steward was significant. The preliminary samples had a high share of young respondents (below 30 years old), who showed indifference regarding the automation of the self-driving vehicle. This could explain the different parameter results. Therefore, it was decided to keep both attribute levels steward and interactive screen to determine the marginal utility with a larger sample.

Service was included as the final attribute. The service for the self-driving bus differed in a scheduled service and an on-demand service, based on the pilot in the case study area. The preliminary surveys showed insignificant results for the service, which could be a result of more importance of other attributes or misunderstanding of the service description. Since the service is of importance for the pilot study, *service* was kept as an attribute in the final survey. The study of Piao et al. (2016) showed positive attitudes towards an on-demand service. A larger sample might result in significant results.

Table 5.3 Overview of attributes and attribute levels for the alternatives

Attribute	Level 1	Level 2	Level 3	Level 4
Travel time	7 minutes	10 minutes	13 minutes	16 minutes
Travel costs	€1.00	€1.60	€2.20	€2.80
Waiting time	2 minutes	4 minutes	6 minutes	8 minutes
Surveillance & Information	Standard	Interactive screen	Steward	
Service	Scheduled	On-demand		

5.2.3 Experimental Design

The respondents had to choose out of the alternatives discussed in section 5.2.1. These alternatives are presented in the experimental design, which combines the attributes and the attribute levels for the alternatives into an experiment (Hensher, 1994). There are a number of requirements for the design of stated preference experiments. For a successful stated preference experiment, the requirements discussed in ChoiceMetrics (2018) are used in this section.

Labelled or unlabelled design

The alternatives include alternative-specific parameters for the self-driving bus. Because of this model specification, the design had labelled alternatives.

Attribute level balance

With attribute level balance, the levels occur an equal number of times during an experiment. Because every level is presented with an equal number of times, the parameters can be estimated with less bias (Hess & Rose, 2009). In addition, attribute level balance is a desirable property for orthogonal design and ensures that every attribute level is estimated well (ChoiceMetrics, 2018). Therefore, attribute level balance has been applied in the experimental design.

Attribute levels

An increasing number of attribute levels improves the richness of the data up to a certain point (Chintakayala, Hess, Rose, & Wardman, 2009). To determine if there are non-linear effects in the data at least three attribute levels should be considered, since the more levels are used the better the non-linear effects could be found (Hess & Rose, 2009). However, an increased amount of attribute levels has a negative effect on the statistical efficiency. For the attributes *travel time*, *travel costs* and *waiting time* four attribute levels were chosen. Furthermore, the attribute levels for *surveillance & information* and *service* were predetermined, respectively three and two levels.

Attribute level ranges

Attribute levels with wide ranges are statistically preferable for the estimation of parameters with smaller standard errors. However, it is important to control for dominant alternatives, which do not give much information about the trade-offs made by respondents (Rose & Bliemer, 2013). A high attribute level range could give significant effects, but these might be minor (Chintakayala et al., 2009). Contrary, the ranges should not be too small for respondents, since very small ranges cannot be distinguished (Rose & Bliemer, 2013). For this study, the attribute level ranges were based on the real values from the pilot area to represent realistic scenarios.

Experimental design

For the construction of the experimental design, a type of design needs to be chosen. The design starts with the decision about the amount of choice sets the researcher wants to present to the respondents. For a choice experiment, a full factorial design and a fractional factorial design can be considered. With the full factorial design, all possible choice situations are generated. This results in a large number of choice situations, which is quite impracticable to evaluate (Hensher, 1994). Therefore, fractional factorial designs are developed. These designs allow selecting a subset of all choice situations. However, statistical efficiency can decrease and interaction effects between attributes cannot be estimated. Mostly the main effects explain the variance in the behavioural responses (Louviere, 1988 as cited in Hensher, 1994). Two types of fractional factorial designs are orthogonal design and efficient design.

The orthogonal design is used in most experimental designs (Bliemer & Rose, 2011). In this design, all correlations between attributes are zero. Additionally, interaction effects are assumed to be zero, which enables the decrease of choice situations needed. Research argues the efficiency of orthogonal designs and performed studies to provide empirical evidence for the use of other designs, moreover efficient design (Hess et al., 2008; Bliemer & Rose, 2011). Arguments are the possibility of dominant alternatives in the choice sets, the fact that econometric models do not require orthogonal data (Hess & Rose, 2009), and that the outcomes of orthogonal design often are not orthogonal. The latter is among other because of the use of blocking (Rose & Bliemer, 2013), and irrational behaviour, which leads researchers to delete responses (Lancsar & Louviere, 2006).

The efficient design does not aim to minimise the correlation between attributes, but it aims to estimate parameter estimates with as small possible standard errors as possible in order to find more reliable parameter estimates (Hess et al., 2008). The advantage of the efficient design is the ability to avoid dominance and that on average fewer respondents are needed for the estimation of reliable parameter estimates due to lower standard errors (Bliemer & Rose, 2011). However, for an efficient design, there is a need of priors for the parameters which require a literature study for parameter values or a pilot study for preliminary parameter estimates.

This study applied an orthogonal design for the stated preference experiment. The disadvantages of orthogonal design are known. However, the design was considered to be sufficient for the expected sample size. Additionally, in the efficient design, the parameter priors need to be accurate for prediction quality, which increases the importance of pilot surveys (Bliemer & Rose, 2011). Furthermore, according to Rose & Bliemer (2013) orthogonal designs should be used when there exists no information about likely parameter estimates.

In this study, it is concluded that former research in the user preferences of self-driving vehicles did not provide similar and trustworthy parameter estimates to apply an efficient design. The results from the preliminary surveys were not considered potential and accurate priors, because of the different estimation outcomes for the attributes surveillance and the service, and alternative specific constants.

This might lead to wrong priors and lower prediction quality as a result. Additionally, conclusions about clear dominance were not made, unless a respondent only considers travel costs and travel time in their choices, and no other variables such as surveillance.

Number of choice sets
Several choices have an influence on the number of choice sets in the experimental design. The uneven distribution of attribute levels considered in this study resulted in 24 choice sets. The attribute *surveillance & information* contains three attribute levels, which influences the design negatively. To assess the relative preferences for the *steward* and *interactive screen* over no extra measures, the third attribute level of *standard* measures was kept.

To not exhaust respondents, it is preferred to face them with fewer choice sets in the survey. Therefore, blocking is used, which adds a column to the experimental design which could increase the number of choice sets if three blocks were considered. However, four blocks are considered for the final survey, which results in six choice sets per respondent. This was preferred over two blocks with 12 choice sets per respondent, which might result in early drop-out of the survey.

5.3 Socio-economic characteristics

Information about the respondents was gathered with the use of socio-economic variables. With these variables, the characteristics of the respondents from the sample are compared to those of the population of public transport users. Besides, relationships with their responses can be analysed, which can explain the heterogeneity of preferences between the respondents (Ben-Akiva & Bierlaire, 1999). Additionally, the variables are used in the data analysis, as explainable variables. On the next page, Table 5.4 shows the socio-economic variables that were included in the survey and the related answer categories.

The *Personal variables* enable the statistical analysis of the characteristics of the respondents. The *Behaviour related* variables provide information about the travel behaviour in the sample and allow to estimate if and to which extent these variables affect the choices of respondents.

In chapter 5, the design of the survey is discussed. The survey consisted of three parts. First, to explore if attitudinal factors influence the decision making in this study, it was decided to quantify the attitudinal factors by presenting statements to the respondents. Second, the design of the stated preference experiment is discussed, which contained the alternatives self-driving bus, regular bus and an opt-out alternative to choose another mode than the buses. For the construction of the choice experiment it was chosen to apply an orthogonal design. Third, characteristics of respondents were gathered with the use of a number of socio-economic variables.

Table 5.4 Socio-economic variables collected in the survey

Personal	Categories of answers
Gender	Female Male
Year of birth	Open (year)
Type of employment	Working full-time Working part-time Student I do not have a job Volunteer Retired
Education level	Low Medium High Other
Postcode	Open (numbers)
Net individual annual income	<€10,000 €10,001 – €20,000 €20,001 – €30,000 €30,001 – €40,000 €40,001 – €50,000 €50,001 – €60,000 €60,001 – €70,000 €70,001 – €80,000 €80,001 – €90,000 €90,001 – €100,000 >€100,000 No answer

(Travel) Behaviour related	Categories of answers
Smartphone usage	Every few minutes A few times an hour About once an hour A few times a day About once a day Less than once a day I do not have a phone
Use of public transport / Use of the bus	(almost) Daily 5 / 4 / 3 / 2 days a week 1 day a week A couple times per month Rarely Never
Trip stage of bus usage	From and to train station (or other station) To destinations in my hometown To destinations outside my hometown I do not make use of the bus Other
Modes used to travel in order of usage	Bus, Tram, Metro, Train, Bike, Car, Walking
Considering more bus use	Yes, both with fixed schedule and on-demand. Yes, but only with a fixed schedule Yes, but only with an on-demand service Maybe No
Subscription for bus trips	Yes, I can travel unlimited by bus. Yes, I can travel with discount by bus. No
Experience with ride sharing	No, I am not familiar with those services No, I have never used those services Rarely Yes, every month Yes, every week Yes, every day

6 RESULTS

The results of this study are discussed in the following chapter. First, the statistical analysis of the sample is discussed. Additionally, the factor analysis is presented with the underlying factors that are present in the sample. Accordingly, the approach to the final model is discussed, which leads to the discussion of the model estimation outcomes.

To generate respondents for the questionnaire, the survey was distributed on several online social platforms and via e-mail. People that use public transport, at least on a yearly basis, were invited to fill out the survey. The aim was to collect a sample that represents commuters that travel within their city towards a work or study location, either students or employees since this is an important target group of the self-driving bus service in the future pilot. By sharing a web link on LinkedIn and Facebook, which was additionally shared by others, 150 respondents were reached within one week. Since the choice experiment is based on a future pilot, citizens in, and employees of, the municipality of Vaals and Aachen, and the network of employees of the cooperating parties in the Interregional Automated Transport project were asked to fill out the survey. They were approached via messages on Facebook, LinkedIn, e-mail and the website of the municipality of Vaals and via contact with employees from the municipality of Aachen. With the help of others distributing the survey a total of 305 people filled out the survey.

6.1 SAMPLE CHARACTERISTICS

In total, 305 respondents started the survey, of which 292 completed all questions of the survey. Ten respondents were excluded from the analysis based on the fact that they completed the survey in less than 5 minutes or because they did not fill in their details about gender and age. This resulted in 282 useful responses with in total 1,692 choice observations. The sample consists of 45 German and 237 Dutch respondents. It is assumed that the differences in nationalities are too small for a separate analysis. Besides, nationality was not found to be of statistical significant influence during the model estimations.

For an indication of the sample characteristics, the sample is compared with the average public transport user on a daily basis in the Netherlands (CBS, 2018a), in this section referred to as the population. Table 6.1 shows the detailed information of the sample. All respondents use public transport at least once a year. The share in gender is almost equal with a little higher share of men, the difference of 1.1 percent with the population is very small. Also, the age categories between 35 and 64 years old are quite similar to the population. However, the age category 25 to 34 years old is oversampled. Furthermore, the number of respondents in the youngest group of respondents is a little underrepresented. Additionally, the number of respondents above 64 years old is low. It might be that these people were not reached via the online distribution amongst working people.

The sample represents high educated people, based on Dutch education levels (CBS, 2018c). This result shows again the effects of distributing a survey via a limited network on social media. Respondents with lower levels of education could therefore not be reached. Accordingly, the number of unemployed and retired people are underrepresented. Furthermore, there are no respondents in the category ‘Other’, this category includes people with alimony among others. These people could be unemployed and might not be reached easily with the survey distribution, still, they represent 9.4% of the population of public transport users.

The sample shows some representativeness regarding the population of daily public transport users, see the discussion below. The sample does not represent some large groups in the population, e.g. the jobless and low educated people. Moreover, the working people and students are represented in this sample with a strong overrepresentation of full-time employees. However, for this study, the sample is considered to be representative for commuters, either students or employees, that travel within their city towards a work or study location, like a campus. This is an important target group of the self-driving bus service in the case study area.

Table 6.1 Statistical overview sample (N = 282)

Socioeconomic variable	Category	Sample	Public transport users	Difference of sample with daily PT users
Gender	Female	48.9%	47.9%	1.1%
	Male	51.1%	52.1%	-1.1%
Age	18 - 24 years	37.2%	44.6%	-7.3%
	25 - 34 year	39.4%	23.0%	16.4%
	35 - 49 year	13.1%	11.7%	1.4%
	50 - 64 year	9.9%	9.5%	0.4%
	>64 year	0.4%	11.3%	-10.9%
Education	Low	1.1%	22.4%	-21.3%
	Middle	8.5%	35.8%	-27.3%
	High	90.4%	41.8%	48.6%
Employment	Full time	45.0%	16.7%	28.3%
	Part time	16.7%	13.7%	2.9%
	Student	36.2%	27.0%	9.1%
	Other	0.0%	9.4%	-9.4%
	Jobless	1.8%	26.8%	-25.1%
	Retired	0.4%	6.2%	-5.9%
Income	<€10.001	30.1%	36.7%	-6.6%
	€10.001 - €20.000	7.8%	13.7%	-5.9%
	€20.001 - €30.000	20.9%	11.1%	9.8%
	€30.001 - €40.000	13.8%	11.5%	2.3%
	€40.001 - €50.000	8.5%	13.4%	-4.8%
	>€50.000	6.7%	13.5%	-6.8%
	No information	12.1%		12.1%
Public transport usage	(almost) Every day	15.6%		
	5 days a week	16.0%		
	4 days a week	13.1%		
	3 days a week	11.0%		
	2 days a week	11.0%		
	1 day per week	5.0%		
	A few times per month	11.7%		
	One time per month	5.7%		
	A few times per year	11.0%		
Bus usage			Bus users (KiM, 2018)	
	4 days or more per week	23.8%	10.0%	13.8%
	1 to 3 days per week	23.0%	13.3%	9.7%
	1 to 3 days per month	32.6%	26.7%	6.0%
	Twice or less per quarter	20.6%	50.0%	-29.4%

6.2 Exploratory factor analysis

To determine the influence of attitudinal factors on the preferences of respondents, a factor analysis has been performed which resulted in underlying attitudinal factors that are present in the sample. These attitudinal factors are incorporated in the model estimation as mean sum scores of the different factors.

Suitability for factor analysis

A priori, the factorability of the variables is examined with the use of well-recognized methods. The Kaiser-Mayer-Olkin (KMO) gives an indication of the strength of the underlying factors between 0 and 1. The KMO measure of sampling adequacy is 0.87, which is above the commonly considered value of suitability of 0.5 (Williams et al., 2010). Additionally, Bartlett's test of sphericity must be significant ($p < 0.05$). This test shows that there is significant correlation between variables, with $p < 0.05$ ($\chi2$ (105) = 1,589.1), see Table 6.2. It can be concluded that the sample data are adequate for a factor analysis.

Table 6.2 Factor analysis adequacy test of data

Kaiser-Meyer-Olkin Measure of Sampling Adequacy		0.87
Bartlett's Test of Sphericity	Approx. Chi-Square (χ^2)	1,589.1
	Degrees of freedom (df)	105
	Significance (p-value)	0.00

Applied rotations

In a first step, the factor analysis has been performed with an oblique rotation, oblimin, which is recommended by Henson & Roberts (2006). Subsequently, the factor analysis has been performed with the chosen orthogonal rotation, namely the VARIMAX rotation. With this approach it was assessed if variables would not be eliminated too early in the VARIMAX rotation and if a similar simple structure, compared with the oblique rotation, could be obtained.

The Oblimin and VARIMAX solutions showed similar results along the iterations. The oblique solution showed that there is some correlation between the factors, see Table D.5 in Appendix D. The orthogonal solution obtained the same simple factor pattern. Moreover, the attitudinal factors are well interpretable and the use of the replicable orthogonal solutions is of interest for subsequent research in user preferences of self-driving vehicles. For these reasons, this study continued with the results of the VARIMAX rotation.

Latent factors

shows the results of the factor analysis. The factor loadings below 0.3 are suppressed in the table to enhance the interpretability of the factor structure. The low factor loadings do not give problems in the model estimation.

During the iterations, a total of five variables with communalities lower than 0.25 and factor loadings of less than 0.5 were removed. After six iterations with both rotation techniques, a two-factor solution has been found. See Appendix D for the full iteration towards the final solution.

The first attitudinal factor includes variables that concern the trust in automated vehicles, see Table 6.3. The variable CHAR_15 ("I would feel more comfortable in a self-driving bus than in a regular bus.") shows a strong correlation with the factor and is considered a relevant indicator regarding trust in automated vehicles. Therefore, the first attitudinal factor is interpreted as *trust in automated vehicles (AVs)*. The second attitudinal factor contains the variables regarding technological interest. The variables TI_6 and

TI_9 have factor loadings below 0.5, however, they fit the interpreted factor and have no high double loadings. This attitudinal factor is named *technology interest*.

Table 6.3 Rotated Factor Matrix with factor loadings per variable (statement) and its corresponding communality (N = 282)

Variable	Statements	Factor 1	Factor 2	Communality
TRUST_3	I think that the self-driving system provides me more safety compared to manually driving.	0.79		0.66
TRUST_1	I believe a self-driving vehicle would drive better than the average human driver.	0.74		0.58
TRUST_4	I would entrust the safety of a close relative to a self-driving vehicle.	0.72		0.56
TRUST_2	I am afraid that the self-driving vehicle will not be fully aware of what is happening around him.	0.67		0.49
CHAR_15	I would feel more comfortable in a self-driving bus than in a regular bus.	0.58		0.42
TRUST_5	I think that the self-driving bus only is safe when a steward is present.	0.51		0.30
TI_7	I am excited by the possibilities offered by new technologies.		0.92	0.90
TI_8	I have little to no interest in new technology.		0.66	0.44
TI_6	I try new products before others do.		0.498	0.33
TI_9	New technologies create more problems than they solve.		0.45	0.25

Factor loadings <0.3 are suppressed

The reliability of the extracted factors is assessed, by determining the internal consistency of the set of variables representing the factors with the use of Cronbach's alpha (Santos, 1999). The alphas show that the factors have satisfactory high levels of internal consistency, as determined by a Cronbach's alpha of 0.84 for *trust in AVs* and 0.75 for *technology interest*, see Appendix D.2. Cronbach's alpha. The correlations between the variables are sufficient, the elimination of more variables for any of the factors would not considerably increase the reliability of the extracted factors.

Factor scores

The factor analysis is the first step in the sequential model estimation. The two latent factors are incorporated in the discrete choice models as mean sum scores of the primary scores for the variables. A higher value indicates that the individual has greater trust in automated vehicles or has greater technology interest. The advantage of this approach is that the latent factors are easy to interpret, as the use of mean sum scores enhances this ease of interpretation (DiStefano et al., 2009).

6.3 Model estimation

Discrete choice modelling is applied to assess the influence of varying factors on the relative preferences for a self-driving bus. A number of models are estimated, of which the most important are discussed in this section. First, a series of variables are discussed to understand the parameter values in the results. Secondly, the approach towards the final model with the highest fit of the data is discussed. The results of this study are based on this final model.

6.3.1 Variable coding

In the model estimation, dummy coding has been applied for the nominal and socio-economic variables. The attribute levels were recoded as indicator variables. This means that for these variables, which have K attribute levels, K-1 indicator variables were estimated. The results from the model estimation give the marginal utility that the indicator variable (IV) contributes to the total utility of an alternative. The attribute *Service* is dummy coded to zeros and ones, where the scheduled service is coded as the base value (zero). The other variables are effect coded by replacing the attribute levels with 1, 0 or -1, where the base value is the unweighted average of all levels across the full sample (Daly et al., 2016). The variables that were not included in the final model due to insignificance are shown in Appendix E, the significant variables are shown in Table 6.4.

Table 6.4 Effect coding of nominal variables

Variable	Indicator variable 1	Indicator variable 2
Service		
Scheduled	0	
On-demand	1	
Surveillance		
No surveillance	-1	-1
Steward	0	1
Interactive system	1	0
Gender		
Male	-1	
Female	1	
Pilot provinces		
Others	-1	
Limburg and Nordhrein-Westfalen	1	
Monthly public transport usage		
Less than once a month	-1	
At least once a month	1	

6.3.2 Final model specification

In order to find the model with the highest explanatory power, various models were estimated. The final model that was chosen for the discussion of the results, is a mixed logit model that corrects for panel effects and assumes a normal distribution (unbounded) of the alternative specific constants and the travel time parameters. The model was estimated with 1,000 Halton draws, which showed stable parameter results compared to the models estimated with fewer draws.

In total three models are presented in this section. First, a multinomial logit (MNL) model and an extended MNL model including the significant socio-economic and attitudinal factors variables have been estimated. Then the MNL models were extended with error components to assess the heterogeneity for the unobserved preferences and to assess the correlation between choices of individuals.

The final model was chosen based on the model that fits the data best. This was done with the use of the adjusted rho-square (ρ^2) statistic as proposed by Horowitz (1983), which accounts for the differences in the number of estimated parameters of the compared models. A higher adjusted ρ^2 indicates that the considered model fits the data better than the model to which it is compared with. Additionally, the likelihood ratio test (LRS) is used to assess if a model fits the data significantly better than the base MNL model, see Table F.1 with the threshold LRS value in Appendix F.

Table 6.5 shows that every model is a significant improvement of the base MNL model and the final combined ML model fits the data best with an adjusted ρ^2 of 0.47.

Table 6.5 Model fit of estimated models

Estimated models	# of parameters	Final log likelihood	LRS with base model	Adjusted ρ^2
Null	0	-1858.85	-	-
Base MNL	11	-1278.64	-	0.31
MNL socio-economic and LVs	18	-1197.70	161.88	0.35
Combined ML nesting effect, ASC and TT taste heterogeneity	23	-964.39	628.50	0.47

Model specification

The final model specification that was used for the estimation of parameters was adapted from the utility function from Yap et al. (2016) and also used by De Looff et al. (2018), see Equation 6.1. The first component includes β_x, which is the vector that estimates the taste parameters associated with the attributes of alternative i and x_i is a vector that contains the attribute levels of alternative i. In addition, β_τ is the vector that reflects the importance of the socio-economic variables τ_s of individual s. The mean sum scores that represent the attitudinal factors for each individual s are represented by the vector φ_s, where β_φ is the vector containing the parameters that estimate the marginal utility of the attitudinal factors. Finally, ε_i is the independent and identically distributed (i.i.d.) error term capturing the unobserved part of the utility U_i.

$$U_i = \beta_x x_i + \beta_\tau \tau_s + \beta_\varphi \varphi_s + \varepsilon_i \qquad (6.1)$$

The utility functions with which these results have been estimated are shown in formula 6.2, 6.3 and 6.4. The equations are based on the final model specification of Equation 6.1, respectively the self-driving bus (SDB), the regular bus (REB) and the opt-out alternative of no bus (NOB). The constant α_{NOB} of the opt-out alternative is normalised to zero. The constants of the self-driving bus and regular bus are interpreted to be relative to the normalized constant of the opt-out. Since the alternative specific constants are included, the unobserved utility of the error term has a zero mean by construction (Train, 2003). The extension of the utility functions for the Mixed Logit model is discussed in section 6.3.3.2.

$$\begin{aligned} U_{SDB} = \alpha_{SDB} + \beta_{TT\_SDB} \cdot TT_{SDB} + \beta_{TC\_SDB} \cdot TC_{SDB} + \beta_{WT\_SDB} \cdot WT_{SDB} + \beta_{Steward} \cdot SURV_{steward} \\ + \beta_{Interactive} \cdot SURV_{interactive\ screen} + \beta_{DRT} \cdot Service_{DRT} + \beta_{\mathrm{PT\ every\ month}} \\ \cdot PT_{every\ month} + \beta_{Pilot\ provinces} \cdot Provs_{pilot} + \beta_{Trust} \cdot Sum_{trust} + \beta_{Tech} \cdot Sum_{tech} \\ + \beta_{femaletech\ SDB} \cdot Tech_{Female} + \beta_{femaletrust\ SDB} \cdot Trust_{female} \end{aligned} \qquad (6.2)$$

$$U_{REB} = \alpha_{REB} + \beta_{TT\_REB} \cdot TT_{REB} + \beta_{TC\_REB} \cdot TC_{REB} + \beta_{WT\_REB} \cdot WT_{REB} + \beta_{Female\_REB} \cdot Female \qquad (6.3)$$

$$U_{NOB} = \alpha_{NOB} \qquad (6.4)$$

Table 6.6 shows the model estimation outcomes. The significance level of the parameters is highlighted for confidence intervals of either 99%, 95% or 90%, which represent the probabilities that the confidence interval contains the true value of the population parameter. This is different from the 95% confidence interval estimate given in the brackets (mean parameter (β) ± 1.96 * standard deviation (σ)), which is the range in which the specific parameter with estimated standard deviation can vary. In Appendix F all details of the models are presented in which two additional models are included that show the iteration towards the final model.

Table 6.6 Estimation outcomes of the base & reference MNL models and the final combined ML latent variable model

Parameter	MNL base	MNL socio-economic and latent variables	Combined ML latent variable model with nesting effect and taste heterogeneity	p-value
σ nesting effect	-	-	-4.88 ***	0.00
α_i				
Constant REB	5.8 ***	6.14 ***	11.8 [10.7, 12.9] ***	0.00
Constant SDB	7.67 ***	5.14 ***	10.2 [8.8, 11.6] ***	0.00
σ Constant REB	-	-	0.57 *	0.07
σ Constant SDB	-	-	0.71 ***	0.00
β_x				
Travel costs REB	-1.21 ***	-1.3 ***	-1.8 ***	0.00
Travel costs SDB	-1.46 ***	-1.56 ***	-2.08 ***	0.00
Travel time REB	-0.10 ***	-0.11 ***	-0.15 [-0.27, -0.04] ***	0.00
Travel time SDB	-0.26 ***	-0.29 ***	-0.37 [-0.46, -0.27] ***	0.00
σ Travel time REB	-	-	0.06 ***	0.00
σ Travel time SDB	-	-	0.05 ***	0.00
Waiting time REB	-0.17 ***	-0.18 ***	-0.26 ***	0.00
Waiting time SDB	-0.12 ***	-0.14 ***	-0.19 ***	0.00
DRT service SDB	-0.26 **	-0.27 **	-0.37 **	0.02
Steward SDB	-0.17 *	-0.18 *	-0.30 **	0.01
Interactive SDB	-0.04	-0.04	0.04	0.68
β_τ				
Female REB	-	0.33 ***	0.74 **	0.04
PT every month SDB	-	0.23 **	0.22	0.14
Pilot provinces SDB	-	0.14 *	0.07	0.51
β_φ				
Tech. interest (TI) SDB	-	0.25 **	0.35 **	0.04
Trust in AVs SDB	-	0.78 ***	0.96 ***	0.00
Female tech SDB	-	-0.17 **	-0.11	0.41
Female trust SDB	-	0.36 ***	0.40 ***	0.01
Adjusted ρ^2	0.31	0.35	0.47	

*** = significant at a 99% CI, ** = significant at a 95% CI, * = significant at a 90% CI, *[..] confidence interval from random parameter, REB = Regular bus, SDB = Self-driving bus*

6.3.3 Towards the final model

Parameters representing characteristics of the data sample are discussed in this section. An analysis of different models with varying parameters was performed, which resulted in a number of parameters that improve the explanatory power of the model.

6.3.3.1 Multinomial Logit

The first model that was estimated is a base multinomial logit (MNL) model. This model only includes the attributes from the choice experiment. Secondly, the socio-economic variables and afterwards the attitudinal factors were incorporated into the model. The socio-economic variables were included one-by-one. Accordingly, the significant parameters for the socio-economic variables were estimated simultaneously. The significance of the socio-economic variables was checked by including all socio-economic variables and eliminate the insignificant parameters.

Attitudinal factors

The two attitudinal factors 'trust in AVs' and 'technology interest' were included in the base MNL model one-by-one. Since it was expected that the attitudinal factors are correlated with socio-economic characteristics, like gender and age, interaction effects were estimated. From these interaction effects, the only significant effects were found in the interactions between gender and the two attitudinal factors ($\beta_{female\ tech\ SDB}$ and $\beta_{female\ trust\ SDB}$), this was similar for the mixed logit models. An MNL model with the socio-economic variables and the attitudinal factors showed the highest loglikelihood for the parameter estimates. This model is used as the reference model for the advanced model that is discussed in the next section.

6.3.3.2 *MIXED LOGIT*

As discussed in section 4.3.1, the MNL model has some limitations. To overcome the property of independence from irrelevant alternatives and capture correlation across choices of individuals, a mixed logit (ML) model was estimated. Different ML models were estimated to determine if there exist random effects for the parameter estimates, based on a normal distribution. The significant random effects are introduced.

Panel effects

The choices of an individual are generally correlated in stated preference experiments. To account for the correlation across the choices of an individual, the model was extended to make the preferences individual-specific, meaning that it estimates the correlation across the sequence of choices from an individual. All ML models presented in this study correct for these panel effects.

Nesting effect

The presence of correlation between unobserved factors for the self-driving bus and regular bus was assessed. Therefore, an error component $\vartheta_{nesting}$ was estimated which accounts for the nesting effect between the self-driving bus and regular bus. This nesting effect reflects the correlations between the utilities of the two bus alternatives. The utility functions for the bus alternatives were extended with the following specification, with $\sigma_{nesting}$ being the degree of variation for the unobserved correlated factors.

$$\vartheta_{nesting} \sim N(0, \sigma_{nesting}) \tag{6.5}$$

Taste heterogeneity

The potential heterogeneity across individuals in the sample was captured by estimating standard deviations for the individual-specific random parts of the alternative specific constants (α_i) and travel time (β_{TT_i}) parameters. The utility functions were altered with the following specifications.

$$\alpha_{SDB} \sim N(\alpha_{SDB},\ \sigma_{SDB}) \tag{6.6}$$

$$\alpha_{REB} \sim N(\alpha_{REB},\ \sigma_{REB}) \tag{6.7}$$

$$\beta_{TT\_SDB} \sim N(\beta_{TT\_SDB}, \sigma_{TT\_SDB}) \tag{6.8}$$

$$\beta_{TT\_REB} \sim N(\beta_{TT_{REB}}, \sigma_{TT\_REB}) \tag{6.9}$$

The parameters α_i and β_{TT_i} represent the mean parameter values that have an unobserved degree of variation of σ_β, the standard deviation. An insignificant sigma means that there is no individual-specific heterogeneity for the alternative specific constant or travel time parameter. In case all sigmas are insignificant, the ML model becomes an MNL model without correlation between unobserved utilities for individuals.

6.3.4 Discussion of the parameter estimates

The final parameter estimates allow examining the effects of the attributes from the choice experiment and additional variables. With the estimation of both the mean and standard deviation of a few parameters, the influence of heterogeneity across individuals is captured. The standard deviations are referred to as the sigma parameter. The last two columns of Table 6.6 shows the outcomes of the model estimation to which the following discussion is referring to.

Observable variables

Travel time

The mean travel times show values with the expected sign, the marginal utilities of travel time for the regular bus and self-driving bus are, respectively, -0.15 [p < 0.01] and -0.37 [p < 0.01]. The travel time for a self-driving bus is more negative than for the regular bus. The difference between the marginal utilities of travel time for the self-driving bus and regular bus is statistically significant (95% confidence level). This means that travellers are more sensitive to increased travel time for the self-driving bus, which indicates that travel time in a self-driving bus is experienced as worse when the travel time increases. An increase in travel time for a regular bus has less than half the effect compared to the self-driving bus.

Travel cost

A similar relative difference is present in the parameter values for the travel costs. The marginal utility of the travel cost for the self-driving bus is -2.08 [p < 0.01]. An increase in travel costs is valued less negatively for the regular bus, -1.8 [p < 0.01]. However, the small and statistical insignificant difference in a 95% confidence interval shows that the parameter travel costs does not differ significantly between the bus alternatives in the population. This is according to expectation when travel costs are assumed to be regarded rational for decision makers.

Waiting time

For the waiting time parameters, the differences are opposite to travel time and travel cost. Individuals show less marginal disutility of waiting for the self-driving bus (-0.19 [p < 0.01]) than for the regular bus (-0.26 [p = 0.0]). This means that individuals are willing to wait longer for the self-driving bus than for the regular bus. However, the differences are just statistically insignificant, which suggests that the difference is not present in the population. This outcome is discussed further in the discussion (chapter 8).

Service

The estimated parameters of the combined ML model suggest that an on-demand service decreases the utility of the self-driving bus in this experiment. The negative parameter for the on-demand service (*DRT service SDB*) gives the relative marginal utility of -0.37 [p = 0.02] to the scheduled service, which means that a scheduled service of a self-driving bus is preferred over an on-demand service. This is discussed further in the discussion of the results (chapter 8).

Surveillance

Another observable variable that was presented in the choice experiment was the type of surveillance and information in the self-driving bus. All models show a negative sign for the presence of a steward, which was not expected. The outcome for *Steward SDB* (-0.30 [p = 0.01]) means that a steward is perceived as more negative than an interactive system. Furthermore, the presence of an interactive system was not significant [p = 0.68]. This suggests that an interactive system does not influence the preference for the self-driving bus. These parameters indicate that the respondents prefer no extra surveillance and/or information in the self-driving bus, since a self-driving bus without additional surveillance has more perceived utility for the respondents.

Socioeconomic variables

Gender

For the socio-economic variables the effects of gender, public transport usage and respondents living in the pilot provinces were estimated. The effect coding of these variables shows that only the indicator variable *Female REB* is significant. This estimated value of 0.74 [p = 0.04] for indicator variable *Female REB* shows that women are more likely to choose the regular bus than men. This outcome indicates that a man has a negative marginal utility of the regular bus, relative to a woman. This means that the attractiveness of the regular bus is lower for a man than a woman.

Relative to the other alternatives in the choice set, parameter *Female REB* shows that a woman has a higher preference for the regular bus over the self-driving bus and the opt-out for other mode alternatives. This means that the female respondents prefer the regular bus over the self-driving bus, and relatively more than man.

Pilot region inhabitants and public transport users

The survey has been distributed within the region of the planned pilot study. Therefore, it is assessed if the perceived utility of respondents living in the pilot region is affected by the planned pilot, by determining if their perceived utility is different than for the other respondents. The parameter *Pilot provinces SDB* that corresponds with the respondents living in the pilot provinces, shows a highly insignificant outcome in the mixed logit model (0.07 [p = 0.51]). This means that there is no difference in preference for the self-driving bus of respondents living in the pilot region.

The parameter for respondents that use public transport at least once a month (*PT every month SDB*), suggests a small positive effect for the self-driving bus. However, this parameter is also statistically insignificant [p = 0.14]. Other parameter estimates for frequent public transport users, see the indicator variables of 'Public transport usage' in Appendix E, also show insignificant outcomes. This means that the frequent public transport users have no higher relative preferences for the self-driving bus than less frequent public transport users in the sample.

Attitudinal factors

Trust in automated vehicles

Other factors regarding the individual's characteristics are the attitudinal factors. Similar to previous studies, the outcomes show that underlying factors affect the choice behaviour significantly. The attitudinal factor trust in AVs has the highest positive value (0.96 [p < 0.01]), which means that respondents who trust automated vehicles have a higher preference for the self-driving bus. *Female AV trust SDB* shows that this effect is even stronger for women (0.40 [p = 0.04]). The interaction variable of trust in AVs and gender shows a positive value, indicating that trust in the automated vehicle for a woman has a stronger effect on the preference for the self-driving bus than man. This suggests that a woman with no trust in AVs is less likely to choose the self-driving bus than a man with a similar level of trust.

Technology interest

Individuals with a strong interest in technology are more willing to choose the self-driving bus over others. Herein the effect of gender shows no significance, which suggests that technology interest, in general, will have a positive effect on the preference for the self-driving bus.

STANDARD DEVIATIONS OF PARAMETERS

Nesting effect

A nesting effect for the self-driving bus and regular bus has been estimated relative to the opt-out alternative 'another mode'. The sigma *nesting effect* shows that there is a correlation between the unobserved factors for the self-driving bus and regular bus. This means that the self-driving bus and regular bus have common unobserved factors. If a respondent prefers to travel by bus instead of another alternative, the attractiveness of both the self-driving and regular bus will simultaneously be higher with a marginal utility of -4.88 [$p < 0.01$] as the standard deviation. Additionally, when for example the self-driving bus becomes more attractive due to the decrease of its travel costs, the probability that the regular bus is chosen will diminish stronger than for another alternative, which in this experiment would be the opt-out choice.

It can be concluded that the model does not exhibit the property of independence from irrelevant alternatives and thus the independent and identically distributed assumption of the errors between self-driving bus and regular bus does not hold.

Taste heterogeneity

The mean alternative specific constants (*constant REB* and *constant SDB*) suggest that the buses are preferred over an opt-out alternative. Herein, the respondents tend to prefer the regular bus over the self-driving bus, since the alternative specific constant of the self-driving bus is lower. However, the differences between the alternative specific constants are not statistically significant, which means that it cannot be concluded that the difference is present in the population. The parameter estimates for the alternative specific constants and the travel times are made individual specific, by estimating standard deviations of the parameters. The standard deviations show that there is individual specific taste heterogeneity for the self-driving bus and regular bus. The standard deviation (*σ constant SDB*) of the constant of the self-driving bus is significant with $p < 0.01$. The standard deviation of the constant of the regular bus is considered significant with $p = 0.07$.

The degree of variation for the self-driving bus (0.71 [$p < 0.01$]) is greater than for the regular bus (0.57 [$p = 0.07$]). This means that the alternative specific constant for the self-driving bus deviates more across individuals than for the regular bus. The degree of the individual specific taste heterogeneity for the alternative specific constants indicates that some individuals prefer the self-driving bus over the regular bus. This probability is calculated by estimating the probability that the individual specific preference for the self-driving bus is equal to the mean alternative specific constant of the regular bus or higher, which is 1.2%. The probability that the individual specific preference of the regular bus is equal to or below the constant of the self-driving bus is 0.24%.

The mean travel time for the self-driving bus (*Travel time SDB*) shows a strong negative utility of the self-driving bus compared to the regular bus. Standard deviations (*σ travel time SDB* and *σ travel time REB*) were estimated to assess the taste heterogeneity for travel time. The sigmas for travel time are significant [$p < 0.01$], which means that there is heterogeneity in the individual-specific travel time parameters.

For the service and surveillance types, a model was estimated to assess if there is taste heterogeneity in the sample. However, no significant effects were found in any model, which are therefore not presented in the results.

6.3.5 ESTIMATION OF THE EXPECTED VALUE OF TRAVEL TIME

The values for the parameters of travel time and travel costs can be compared with estimates of the value of travel times for existing modes. The VOTT is the ratio between the linear parameters travel time and travel cost (Equation 6.10). It represents the value which a person is willing to pay for travel time reduction. By comparing the expected VOTTs of this study with the known VOTTs of the Netherlands, the willingness to pay for the regular bus and self-driving bus can be put in perspective of existing estimates. The VOTT is a common way to indicate the willingness-to-pay for certain attributes (Hess, Bierlaire, & Polak, 2005).

$$VoTT\ (euro/hour) = \frac{\beta_{travel\ time}}{\beta_{travel\ cost}} * 60\ minutes \qquad 6.10$$

Kouwenhoven et al. (2014) estimated a broad number of values of travel time for certain modes in the Netherlands. They showed that, for commuters, the willingness to pay for travel time reduction of an hour by bus varies between €7.75 and €10.50 euros per hour. This is considered a representative range for the VOTT for the regular bus.

Since the travel time parameters are estimated with a standard deviation that is normally distributed, a different approach is needed to calculate the VOTT. Hess et al. (2005) stress the concerns of unbounded distributions for random taste heterogeneity for travel time coefficients in mixed logit models since the normal distribution of VOTTs could lead to negative outcomes, which would be counterintuitive. This might be an artefact of the model specification or because of the poor explanatory power of a model (Hess et al., 2005). The model presented in this study was estimated based on a normal distribution, but no unexpected signs for the travel time parameters were obtained.

The expected VOTTs for the self-driving bus and regular bus are presented in Table 6.7. Accordingly, the 95% confidence intervals are determined with Equation 6.11, adapted from Sillano & de Dios Ortuzar (2005). The parameter travel cost is fixed and the parameter travel time can vary (Sillano & de Dios Ortuzar, 2005).

$$VoTT\ interval\ \left(\frac{euro}{hour}\right) = \left(\frac{\beta_{travel\ time}}{\beta_{travel\ cost}} \pm \left(1.96 * \frac{\sigma_{travel\ time}}{\beta_{travel\ cost}}\right)\right) * 60\ minutes \qquad 6.11$$

Table 6.7 Expected Value of Travel Time for the self-driving bus and regular bus in [€/hour], and their 95% confidence intervals

Alternative	Mean VOTT / hour	Standard deviation VOTT / hour	95% confidence interval
Self-driving bus	€ 10.59	€ 1.38	[€ 7.87, € 13.30]
Regular bus	€ 5.13	€ 1.94	[€ 1.32, € 8.94]

The mean VOTT estimations show that the expected VOTT of the self-driving bus is similar to the value of time for commuter trips of business employees in the bus (€10.50 per hour), whereas the expected VOTT of the regular bus (€5.13 per hour) is lower than 'other' trip purposes by bus of €6.00 per hour (Kouwenhoven et al., 2014).

The expected VOTTs for the regular bus are much lower than the ones for the self-driving bus. Respondents are willing to pay less than half the price for reducing travel time in the regular bus compared to the self-driving bus. This suggests that respondents associate more disutility of travelling by a self-driving bus for an equal trip duration, compared to the regular bus.

Chapter 6 discussed the results that were obtained from the survey. The sample characteristics were discussed which showed that the sample is considered to be representative for commuters that travel within their city towards their university or work. Additionally, the results from the factor analysis were given. The factor analysis showed that the attitudinal factors trust in automated vehicles and technology interest are present in the sample. The incorporation of the resulting attitudinal factors in the discrete choice model as mean sum scores showed that the attitudinal factors are of influence on the decision making for a self-driving bus. Moreover, the outcomes of the model estimation showed that the marginal utility of travel time for a self-driving bus is lower than for the regular bus. Extra surveillance or an on-demand service do not increase the perceived utility of a self-driving. Travellers are willing to pay half the price for reducing travel time in a regular bus, suggesting they prefer to travel with a regular bus than with a self-driving bus.

7 MODEL APPLICATION

On the basis of the estimation outcomes, a scenario analysis is performed by applying the model to different designed scenarios. This chapter explores the sensitivity of the choice model towards operational characteristics such as travel time, travel costs and the presence of a steward on-board the self-driving bus. Illustrating the trends in the choice probabilities puts the results in a broader perspective, without being interpreted as a forecast for a potential modal split. In order to analyse choice probabilities, several scenarios are designed and the expected modal shares are assessed. Amongst other things, this chapter first looks at sensitivity for the travel time and travel costs and secondly it looks at the same sensitivity with an additional characteristic of the presence of an on-board steward on the self-driving bus. Finally, it looks at the competition between the self-driving bus and a regular bus for different desired operational characteristics. Based on the understanding of the effects of the policy measures and sensitivity towards the operational characteristics on the choice probabilities for the self-driving bus, policy recommendations are discussed in section 9.3.

7.1 SIMULATION OF CHOICE PROBABILITIES

The choice probabilities of alternatives within the scenarios are computed with the use of the mixed logit probability function of Equation 7.1 (adapted from Train (2003) and Hess et al. (2005)). The probabilities are integrated over the densities of parameters $f(\beta)$, which represent the normal distributed parameters with specific mean β and standard deviation σ_β. The probability is based on the weighted average for the different values of β given by the density $f(\beta)$ (Train, 2003).

$$P_i = \int P_i\,(\beta) f(\beta) d\beta \tag{7.1}$$

With mixed logit, the integral of the choice probabilities does not have a closed form since it assumes an unobserved part of utility that is distributed (Train, 2003). Therefore, the integral of choice probabilities is approximated with the use of simulation, which determines averages by drawing from a density (Train, 2003). A number of R draws are made from the distribution of the random parameters (υ_n^r), with mean parameter β and standard deviation σ_β. In this study, these parameters have a normal distribution representing the parameters for the travel times, alternative specific constants and nesting effect, which are drawn R times. For each draw of the random parameters, conditional choice probabilities of the alternatives are estimated. The resulting average choice probabilities for R draws are computed with equation 7.2, derived from Train (2003).

$$P_i = \frac{1}{R} \cdot \sum_{r=1}^{R} P_i\,(\beta)|\upsilon_n^r \tag{7.2}$$

For the convenience of the reader, the utility functions, including the parameter values of the discrete choice model are depicted, see equations 7.3, 7.4 and 7.5. These utility functions are used to compute the choice probabilities for the alternatives, respectively the self-driving bus, regular bus and opt-out alternative for another mode of transport. The total utility of an alternative is derived from the fixed parameters β and the random parameters σ_β.

$$\begin{aligned} U_{SDB} = 10.2 &- 0.37 \cdot TT_{SDB} - 2.08 \cdot TC_{SDB} - 0.19 \cdot WT_{SDB} - 0.3 \cdot SURV_{steward} - 0.04 \\ &\cdot SURV_{interactive\ screen} - 0.37 \cdot Service_{DRT} + 0.22 \cdot PT_{every\ month} + 0.07 \cdot Provs_{pilot} \\ &+ 0.96 \cdot Sum_{trust} + 0.35 \cdot Sum_{tech} - 0.11 \cdot Tech_{Female} + 0.4 \cdot Trust_{female} \\ &+ \vartheta_{nesting} \end{aligned} \tag{7.3}$$

$$U_{REB} = 11.8 - 0.15 \cdot TT_{REB} - 1.8 \cdot TC_{REB} - 0.26 \cdot WT_{REB} + 0.74 \cdot Female + \vartheta_{nesting} \tag{7.4}$$

$$U_{NOB} = 0 \tag{7.5}$$

The random parameters are drawn 1,000 times, which obtained stable outcomes in the model estimation as well as in the model application. The random parameters are specified below.

$$\alpha_{SDB} \sim \mathcal{N}(10.2, 0.71) \tag{7.6}$$

$$\alpha_{REB} \sim \mathcal{N}(11.8, 0.57) \tag{7.7}$$

$$\beta_{TT\_SDB} \sim \mathcal{N}(-0.37, 0.05) \tag{7.8}$$

$$\beta_{TT\_REB} \sim \mathcal{N}(-0.15,\ 0.06) \tag{7.9}$$

$$\vartheta_{nesting} \sim \mathcal{N}(0, 4.88) \tag{7.10}$$

7.2 Scenarios

This subchapter discusses the designed scenarios to explore changes in the choice probabilities for the self-driving bus, regular bus and the choice for another mode. The discussed scenarios represent changes in operational characteristics and policy measures that could, for example, induce shorter travel times and increased travel costs or remove the obligation for a steward on-board a self-driving bus. A number of scenarios are investigated to explore trends in the modal shares for the collected sample under various circumstances.

In the model application, threshold values for travel time and travel costs of the self-driving bus are assessed and several illustrations are given of choice probabilities for equal values of travel time and travel costs of the two bus alternatives. By determining the maximum costs or time for a trip with the self-driving bus, it is assessed for which travel time and travel costs the choice for a self-driving bus results in an equal or higher choice probability compared to the regular bus. The model estimation shows that the respondents prefer to travel by a regular bus. In view of this outcome, the threshold values allow the illustration of the travel time and travel costs ranges in which the self-driving bus is likely to be chosen. These illustrations could increase the understanding of competitive service levels for the self-driving bus in the discussed choice scenarios. Moreover, the discussion of the break-even points is used to give an illustration of the sensitivity of the operational characteristics. A competitive modal share of the self-driving bus might not be the goal of policy makers.

In addition to finding these threshold values, the variation in measures, either policy or technical, shed light on the changes in the expected modal shares of the two bus alternatives and give an indication of what different travel times, travel costs and no on-board steward would do, rather than finding the threshold values for the travel costs or travel time for an equal modal share for the self-driving bus. For example, when policy makers intend to reduce travel costs for a self-driving bus to increase the modal share of the self-driving bus relative to a regular bus, they could decide to introduce a subsidy for every trip by self-driving bus to encourage travellers to travel by self-driving bus. For this example, the designed scenarios could make the policy measure for a subsidised trip tangible, by illustrating the range of choice probabilities in low travel costs circumstances. However, the outcomes of the computed scenarios could also give reasons for policy makers to not consider a self-driving bus as a new bus service. For example, if a policy maker is sceptical regarding the employment of bus drives, the scenario analysis may be a basis to clarify their position that bus drivers are still needed and that resignation of the bus drivers does not provide better bus services. Overall, the discussed scenarios are an indication of the changes and effects of policy measures for the choice probabilities of a self-driving bus, a regular bus and the choice to travel with another mode.

The attributes waiting time and service are fixed in the designed scenarios. As is discussed in chapter 8, the waiting time can be different for a scheduled service or an on-demand service. Nygaard & Tørset (2016) found that travellers arrived at the bus stop between 2 to 5 minutes before the departure of the bus. Since the waiting time perception of travellers is not unambiguous for the services in this experiment, the waiting time has been set to 2 minutes in the model application. Additionally, the on-demand service showed to decrease the attractiveness of the self-driving bus. Since the on-demand service with a fixed route does not add advantageous besides the extra effort of ordering the bus, the service was set to a scheduled service for all designed scenarios.

7.2.1 Sensitivity of operational characteristics in the pilot region

In this section, it is assumed that policy makers intend to explore the operational characteristics of the self-driving bus in terms of travel time and travel costs by looking at their impact on the modal share. For the self-driving bus that is considered in the pilot study from chapter 3, a pre-determined route is selected. However, there could be an assessment for a change in the route that is operated, which reduces or increases the travel time for the self-driving bus. Similarly, policy measures that represent a new pricing policy for the self-driving bus could be a topic of interest for policy makers.

The sensitivity of both travel time and travel costs on the modal shares are discussed. In these scenarios there is no steward on-board the self-driving bus, see section 7.2.2 for the effect of the presence of a steward on the choice probabilities. It is assumed that the self-driving bus competes with one of the current bus services between Vaals Busstation to the University Hospital in Aachen, which either takes 14 minutes and costs €2.70 or takes 7 minutes and costs €1.50, as described in chapter 3.2. The operational characteristics of the regular bus are fixed, which represents the current bus services. For the self-driving bus, the travel time or the travel costs vary per scenario to explore the sensitivity of these operational characteristics on the modal shares. See Table 7.1 for an overview of the scenarios that are explained in more detail in the following paragraphs.

Table 7.1 Scenarios designed to assess the choice probabilities of the self-driving bus competing with the buses in the pilot region

	Alternative	Travel time	Travel costs
Scenario 1: Travel time sensitivity for a low-cost bus trip	Self-driving bus	**[7 - 16 minutes]**	€ 1.50
	Regular bus	7 minutes	€ 1.50
Scenario 2: Travel costs sensitivity for a short bus strip	Self-driving bus	7 minutes	**[€1.00 - €2.80]**
	Regular bus	7 minutes	€ 1.50
Scenario 3: Travel time sensitivity for an expensive bus trip	Self-driving bus	**[7 - 16 minutes]**	€ 2.70
	Regular bus	14 minutes	€ 2.70
Scenario 4: Travel costs sensitivity for a long bus trip	Self-driving bus	14 minutes	**[€1.00 - €2.80]**
	Regular bus	14 minutes	€ 2.70

[..] changes in operational characteristics

Competing with a short and low-cost urban bus service

The first two scenarios are based on the short and low-cost bus trip by the regular bus in the pilot study region. For the first two scenarios, the probability distributions are visualised in Figure 7.2 and Figure 7.1. The choice probability that the self-driving bus is chosen with the same travel costs and travel time is 62%, for the regular bus the share is 34% and a remaining 4% chooses to travel with another mode.

Scenario 1: Travel time sensitivity for a low-cost bus trip

Under the first scenario, the travel costs have been set to €1.50 for both buses and a short route is considered with a travel time of 7 minutes for the regular bus, see Table 7.2 for the probability distributions. In this scenario, the travel time of the self-driving bus can have longer travel times than the regular bus and still stay competitive to the regular bus. For example, the route of the self-driving bus could be adapted to detour on dedicated lanes to decrease the presence of obstacles on its route, which would increase the comfort for its passengers. To illustrate, the outcome of the model application in Figure 7.2 shows, that the travel time of the self-driving bus can increase as much as 2.2 minutes relative to that of the regular bus before its modal share becomes lower than that of the regular bus.

Table 7.2 Scenario 1: Fast and cheap; probabilities of alternatives with changes in travel time for the self-driving bus without a steward

SDB travel times	7 min.	10 min.	13 min.	16 min.
Self-driving bus	62.2%	42.1%	24.1%	12.0%
Regular bus	33.7%	52.7%	69.8%	81.3%
Opt-out	4.0%	5.2%	6.1%	6.7%

Scenario 2: Travel costs sensitivity for a short bus strip

In scenario 2 the travel time was set to 7 minutes for both buses and the travel costs of €1.50 for the regular bus, see Table 7.3. The travel costs varied for the self-driving bus. The sensitivity of the travel costs for the self-driving bus indicates that a trip with the self-driving bus can be more expensive than it can be for the regular bus. A pricing policy to decrease the travel costs for a self-driving bus would have less effect when it operates on a short urban trip. However, if the operation costs force policy makers to increase the fares for travelling by a self-driving bus, a subsidy could reduce the fares for the self-driving bus. Figure 7.1 shows that this subsidy would need to reduce the fares to an approximated maximum difference of €0.40 relative to the regular bus to give similar modal shares for the two buses. Decreasing the subsidy for the fares by increasing the difference in travel costs to €0.70 gives an approximate of 36% modal share for the self-driving bus.

Table 7.3 Scenario 2: Fast and cheap; probabilities of alternatives with changes in travel costs for the self-driving bus without a steward

SDB travel costs	€1.00	€1.60	€2.20	€2.80
Self-driving bus	78.1%	58.6%	35.8%	17.2%
Regular bus	19.0%	37.2%	58.6%	76.3%
Opt-out	2.9%	4.3%	5.6%	6.5%

Competing with a long and expensive urban bus service

The following two scenarios consider the bus service in the pilot region with a substantially longer travel time of 14 minutes and travel costs of €2.70 for the regular bus. In the third scenario, the travel time sensitivity for the self-driving bus is discussed, in the fourth scenario, the travel costs for the self-driving bus varied.

Figure 7.4 and Figure 7.3 depict the choice probabilities for the two scenarios. Under equal trip conditions for both buses of 14 minutes travel time and travel costs of €2.70, the self-driving bus is chosen in 27% of the times, which is less than half the time the regular bus is chosen with a choice probability of 57%.

Scenario 3: Travel time sensitivity for an expensive bus trip

In this situation, a trip with the self-driving bus costs €2.70, similar to that of the regular bus that travels from Vaals Busstation to the University Hospital in Aachen in 14 minutes. In this scenario, travellers are less willing to choose the self-driving bus compared to the regular bus, see Table 7.4. For example, operating the self-driving bus on a shorter route than the regular bus, which could reduce the travel time, would be needed to increase the modal share of the self-driving bus. Figure 7.4 indicates that the travel time of the self-driving bus needs to be reduced with 3 minutes for a break-even point.

Table 7.4 Scenario 3: Slow and expensive; probabilities of alternatives with changes in travel time for the self-driving bus without a steward

SDB travel time	7 min.	10 min.	13 min.	16 min.
Self-driving bus	67.6%	50.3%	32.2%	17.9%
Regular bus	21.6%	36.3%	52.2%	65.2%
Opt-out	10.8%	13.5%	15.6%	16.9%

Figure 7.2 Probability distribution with travel time increase of the self-driving bus, travel time regular bus fixed at 7 minutes

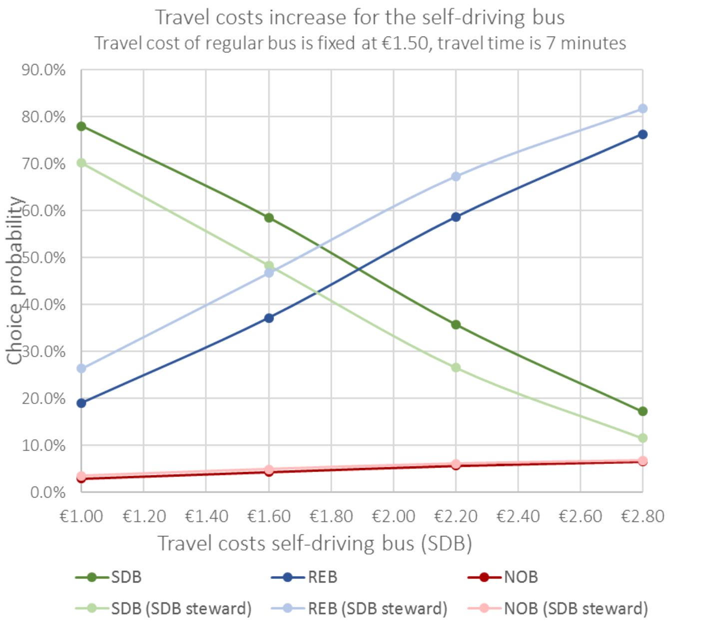

Figure 7.1 Probability distribution with travel cost increase of the self-driving bus, travel costs regular bus fixed at €1.50

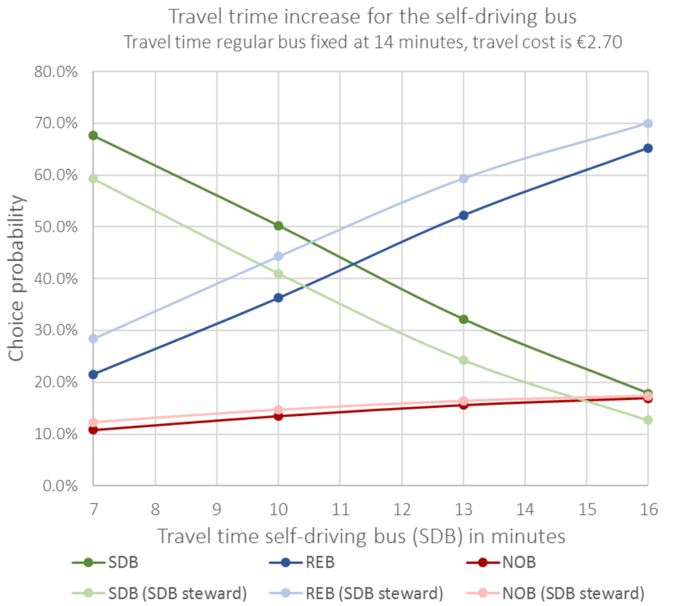

Figure 7.4 Probability distribution with travel time increase of the self-driving bus, fixed time regular bus at 14 minutes

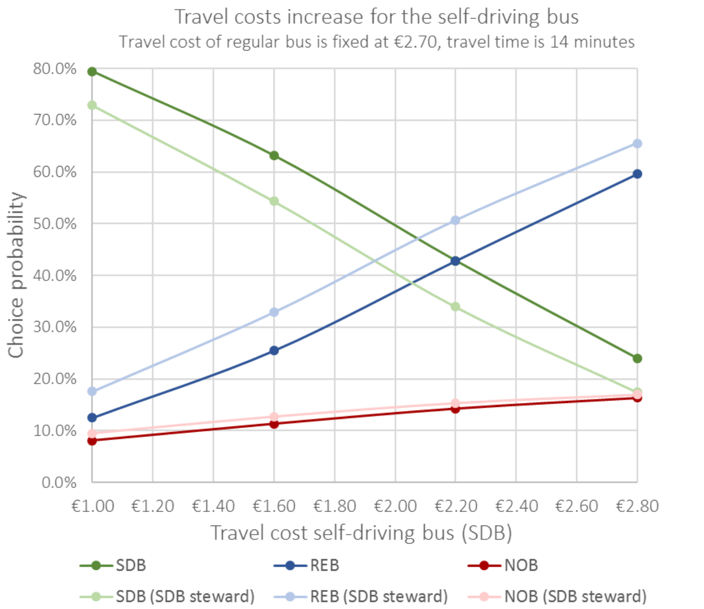

Figure 7.3 Probability distribution with travel cost increase of the self-driving bus, fixed travel cost regular bus at €2.70

Scenario 4: Travel costs sensitivity for a long bus trip

This scenario (Table 7.5) illustrates that in case policy makers intend to explore the modal share of a self-driving bus for a long trip, that the fares of the self-driving bus need to be decreased relative to the regular bus for a competitive modal share. However, this depends on the desired modal share from policy makers. For similar modal shares for the two buses, a long trip by self-driving bus would be helped with a subsidy reducing the travel costs for the self-driving bus. Subsidizing a trip of a self-driving bus by €0.50 compared to that of the regular bus shows an equal modal share in this scenario, see Figure 7.3.

Table 7.5 Scenario 4: Slow and expensive; probabilities of alternatives with changes in travel costs for the self-driving bus without a steward

SDB travel costs	€1.00	€1.60	€2.20	€2.80
Self-driving bus	79.4%	63.1%	42.9%	24.0%
Regular bus	12.5%	25.5%	42.8%	59.6%
Opt-out	8.1%	11.3%	14.3%	16.4%

Based on the choice probabilities, it can be observed that in scenarios 3 and 4 the choice to travel with another mode has increased shares compared to the first two scenarios. For example, choosing another mode, when a trip of 14 minutes is considered, has a minimum probability of 8% when the travel costs of the self-driving bus are €1.00 and a maximum probability of 16% for travel costs of €2.80. For a trip of 7 minutes, this is 3% and 7%, respectively. The outcomes confirm that the high travel costs and long travel time decrease the perceived utility of both buses. This shows to be stronger for the overall modal share of the regular bus compared to the self-driving bus in scenario 3 and 4. To illustrate, relative to the first two scenarios, the choice probability for another mode eats the share away from the regular bus in both scenarios 3 and 4.

7.2.2 Impacts of an on-board steward

This section is devoted to the exploration of the impacts on the modal share of an on-board steward in addition to the sensitivity analysis to travel costs and time. According to the results of the model estimation, it is seen that there is a negative effect on the presence of a steward. The scenarios in this section look at the impacts of the negative influence that the presence of a steward has on the modal share, by simultaneously looking at sensitivity towards travel time and travel costs of the self-driving bus. Therefore, the same scenarios are used with an additional dimension of an on-board steward on the self-driving bus. Figure 7.2 to Figure 7.3 show lines with a lighter shade that represent the choice probabilities for the self-driving bus with an on-board steward. See Appendix H.1. Probabilities of alternatives in competition in pilot region with steward for self-driving bus for the listed choice probabilities with a steward on-board the self-driving bus.

Competing with a short and low-cost urban bus service

For the first two scenarios with a short travel time of the regular bus, the model application indicates that a steward present on the self-driving bus reduces the share of the self-driving bus relative to the regular bus. To illustrate, the modal share decreases by 10 percentage point for the self-driving bus, the share of the regular bus increases by 9 percentage point. The modal shares indicate that the range in increased travel time or travel costs for the self-driving bus relative to the values for the regular bus become lower with an on-board steward. A threshold value for similar modal shares is found for a maximum travel time difference of 0.7 minutes relative to the regular bus or increasing the fare of the self-driving bus by no more than €0.10.

Competing with a long and expensive urban bus service

If the law continued to obligate the presence of an on-board steward, the modal share of the self-driving bus would reduce by 7 percentage point, under equal trip conditions of 14 minutes travel time and

€2.70 travel costs. With a steward on-board the self-driving bus, it is found that that the maximum travel time is 4.3 minutes lower than for the regular bus with equal choice probabilities, see Figure 7.4. In case a pricing policy would reduce the fares of the self-driving bus a minimum of €0.80 should be considered for equal modal shares of the two buses.

On average, the modal share of the self-driving bus reduces by 8% in case it is required to have stewards on-board self-driving vehicles. This makes it difficult to increase the travel costs of the self-driving bus relative to the regular bus for short trips, or to allow for a detour of the self-driving bus for a low-cost trip. For a longer trip with the regular bus, the relative modal share of the self-driving bus requires stronger pricing policies or shorter routes to improve its modal share.

7.2.3 CHANGES IN ATTRIBUTE VALUES FOR BOTH BUSES

This section explores the competitiveness of the self-driving bus relative to the regular bus by looking at impacts of the same operational changes to both buses. This is explored in order for the policy makers to get an idea of what happens if they choose different routes with different travel times and travel costs. In addition, the required travel costs are explored in a situation where the policy maker desires at least an equal modal share for the self-driving bus compared to the regular bus. However, travel costs would be different for different modal shares, which is not explored in this model application. The scenarios only consider a self-driving bus without an on-board steward.

The different routes represent the scenarios that are discussed in this section, see Table 7.6. These routes have travel times of 7 minutes, 10 minutes and 14 minutes, which are the same for the two buses in each scenario. In the scenarios, the travel costs vary for both the self-driving bus and regular bus. Table 7.7 to Table 7.12 give an overview of the modal shares for the alternatives, differences in choice probabilities between the self-driving bus and regular bus and the break-even values for the travel costs for the self-driving bus to have a similar choice probability as the regular bus. In Appendices H.2. Travel costs variation for buses with travel time of 7 minutes H.3. Travel costs variation for buses with travel time of 10 minutes and H.4. Travel costs variation for buses with travel time of 14 minutes figures are shown that visualise the choice probabilities in line charts.

Table 7.6 Scenarios designed to assess the choice probabilities of alternatives with changes in travel costs values

	Alternative	Travel time	Travel costs
Scenario 5: Route A	Self-driving bus	7 minutes	[€1.00 - €2.80]
	Regular bus	7 minutes	[€1.00 - €2.80]
Scenario 6: Route B	Self-driving bus	10 minutes	[€1.00 - €2.80]
	Regular bus	10 minutes	[€1.00 - €2.80]
Scenario 7: Route C	Self-driving bus	14 minutes	[€1.00 - €2.80]
	Regular bus	14 minutes	[€1.00 - €2.80]

[..] changes in travel costs

ROUTE A

The scenario considers a short trip that serves fewer bus stops and therefore travels from the Vaals Busstation to the University Hospital in Aachen in 7 minutes. The equal travel costs for the two buses show that the self-driving bus has a higher modal share for all considered travel costs between €1.00 and €2.80, see Table 7.7. Therefore, if policy makers consider a short urban bus trip, pricing policies to encourage travelling by self-driving bus might be of low impact. It is shown that for short urban bus trips relative higher travel costs for the self-driving bus to the regular bus can be asked. Table 7.8 gives an indication of threshold values for the travel costs of a self-driving bus, which shows that higher travel costs between €0.20 and €0.45 can be asked for an equal travel time of 10 minutes.

Table 7.7 Share in choice probabilities with equal travel costs for a trip of 7 minutes in Route A

	€1.00	*Difference with REB*	€1.60	*Difference with REB*	€2.20	*Difference with REB*	€2.80	*Difference with REB*
SDB	65.5%	33.6%	61.5%	27.4%	57.0%	21.0%	52.0%	14.6%
REB	31.8%		34.1%		36.0%		37.4%	
NOB	2.7%		4.4%		7.0%		10.5%	

Table 7.8 Maximum travel costs for the self-driving bus for equal choice probabilities for a trip of 7 minutes in Route A

	REB €1.00	*Difference with REB*	REB €1.60	*Difference with REB*	REB €2.20	*Difference with REB*	REB €2.80	*Difference with REB*
Max. travel costs SDB	€1.45	€0.45	€1.97	€0.37	€2.50	€0.30	€3.00	€0.20
Choice probability	48%		47%		46%		44%	

ROUTE B

In route B the trip makes a small detour, this time to serve more bus stops, which results in an increased travel time of 10 minutes for both buses. The varying travel costs for both the regular bus and self-driving bus show that the modal shares stay relatively stable, see Table 7.9. As a result, the break-even point in modal shares are reached by relatively small changes in travel costs for the self-driving bus, see Table 7.10. In this perspective, a policy maker could consider this scenario where the modal shares do not vary that much. However, depending on their policies for bus services, more differentiated services for specific routes could be of more interest.

Table 7.9 Share in choice probabilities with equal travel costs for a trip of 10 minutes in Route B

	€1.00	*Difference with REB*	€1.60	*Difference with REB*	€2.20	*Difference with REB*	€2.80	*Difference with REB*
SDB	53.6%	10.9%	49.3%	4.6%	44.8%	-1.4%	40.0%	-6.7%
REB	42.7%		44.7%		46.1%		46.7%	
NOB	3.8%		6.0%		9.1%		13.3%	

Table 7.10 Maximum travel costs for the self-driving bus for equal choice probabilities for a trip of 10 minutes in Route B

	REB €1.00	*Difference with REB*	REB €1.60	*Difference with REB*	REB €2.20	*Difference with REB*	REB €2.80	*Difference with REB*
Max. travel costs SDB	€1.15	€0.15	€1.67	€0.07	€2.18	-€0.02	€2.70	-€0.10
Choice probability	48%		47%		45%		44%	

ROUTE C

The last scenario that is discussed illustrates the modal shares of the alternatives in the choice situation of this study for a bus trip of 14 minutes. Compared to a short trip of 7 minutes, the model application gives relative higher shares for the regular bus compared to the self-driving bus for all travel costs, see Table 7.11. The travel costs of the self-driving bus require a reduction between €0.36 and €0.50 for an equal modal share compared to the regular bus, see Table 7.12. A policy measure could be introduced to reduce the travel costs by subsidizing trips with the self-driving bus for long trips. The extent to which the fares are reduced depends on the policy that policy makers intend follow.

Table 7.11 Share in choice probabilities with equal travel costs for a trip of 14 minutes in Route C

	€1.00	*Difference with REB*	€1.60	*Difference with REB*	€2.20	*Difference with REB*	€2.80	*Difference with REB*
SDB	37.7%	-19.2%	33.8%	-24.1%	30.0%	-28.0%	26.2%	-30.6%
REB	56.9%		57.9%		58.0%		56.8%	
NOB	5.5%		8.3%		12.0%		17.0%	

Table 7.12 Maximum travel costs for the self-driving bus for equal choice probabilities for a trip of 14 minutes in Route C

	REB €1.00	*Difference with REB*	REB €1.60	*Difference with REB*	REB €2.20	*Difference with REB*	REB €2.80	*Difference with REB*
Max. travel costs SDB	-	-	€1.24	-€0.36	€1.76	-€0.44	€2.30	-€0.50
Choice probability	-		46%		45%		42.5%	

7.2.4 Insights from the model application

The scenario analysis carried out in this study provides a broader perspective of the results of this study. From the discussed scenarios the sensitivity of some operational characteristics on the modal shares for the self-driving bus and a regular bus are approximated.

It is found that the self-driving bus can be a competitive alternative for short urban trips. The sensitivity of the travel costs for the self-driving bus indicate that higher fares can be asked while maintaining relative high modal shares compared to the regular bus. There is some freedom for policy makers to adapt the operational characteristics for a self-driving bus service. Increasing the travel time by, for example, making a detour to serve more bus stops or to use a dedicated lane for an increased comfort level, does not radically decrease the relative modal share of the self-driving bus in case the regular bus has a travel time of 7 minutes.

For a long trip by one of the buses, the scenarios showed a low modal share of the self-driving bus compared to the regular bus, which is as expected considering the results of the model estimation. Stimulating trips by self-driving bus, with a subsidy that reduces the fares, could be considered by policy makers when an increased modal share for a self-driving bus is desired. However, a longer trip might be better served by a regular bus, since the regular bus has a higher probability of being chosen with different pricing policies.

These scenarios were designed without the presence of an on-board steward. It was shown that in competition with the current bus services between Vaals and Aachen, the self-driving bus with an on-board steward would have, on average, an 8% lower modal share compared to the regular bus. This reduces the freedom of policy makers to adapt the operational characteristics for short or low-cost bus trips. In addition, assuming that equal modal shares for the buses are desired, stronger pricing policies to reduce the fares become needed.

For indicative purposes, the required travel costs of the self-driving bus were assessed for equal modal shares of the two buses. However, policy makers could desire other routes or modal shares for the self-driving bus. For example, because they have limited subsidies to reduce the fares of the self-driving bus. In those cases, other modal shares will be found. Still, the model application gives an increased understanding of the sensitivity of a number of operational characteristics for modal shares of the self-driving bus and regular bus.

An application of the choice model is discussed in this chapter. The chapter explored the sensitivity of the choice model towards operational characteristics such as travel time, travel costs and the presence of a steward on-board the self-driving bus. The scenarios illustrated that a self-driving bus is a competitive alternative for short urban trips. For long trips the modal share of the regular bus was higher. Some break-even points to reach an equal modal share were discussed to illustrate the sensitivity of operational characteristics. The indicative purpose of the sensitivity of the choice model was of interest, without being interpreted as a forecast for potential modal split.

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8 Discussion

The corroborations and contrasts of the results with previous work and expectations of this study are discussed.

Travelling in the self-driving bus

The higher disutility that respondents associate with the travel time in the self-driving bus, affects the willingness-to-pay for reduction of travel time (VOTT) considerably. The results of this study suggest that travellers do not perceive advantages of travelling in a self-driving vehicle compared to the regular bus. This is in line with the findings of Yap et al. (2016) and similarly contrasting their hypothesis and suggestion that the advantages might be perceived in the main trip of a shared self-driving vehicle. It needs to be noted that Yap et al. (2016) considered egress trips of a multimodal train trip considering a different type of shared self-driving vehicle than the self-driving bus of this study. In addition, the results are in line with other studies that showed hesitation towards using self-driving vehicles (Bazilinksyy et al., 2015; Haboucha et al., 2017; Abraham et al., 2018). However, the study of De Looff et al. (2018) indicates that people prefer the automated vehicle with office interior over the conventional car, which could mean that car users are more willing to use a self-driving vehicle than public transport users.
An explanation of the perceived disutility of travelling on the self-driving bus could be that travellers find it difficult to imagine a trip with a self-driving bus. Moreover, the lack of experience in using a self-driving bus could decrease the preference for the regular bus. The pilot with a self-driving bus offers the possibility to assess if peoples' attitudes change when they experience the self-driving bus.

Attitudinal factors

This study shows corroborating evidence that trust is a major attitudinal factor that influences travellers' preferences for using a self-driving vehicle, as has been shown in various previous studies on the subject (Choi & Ji, 2015; Bansal et al., 2016; Haboucha et al., 2017; Yap et al., 2017). Especially, the trust that women have in self-driving vehicles is of importance for their intention to use a self-driving vehicle. Previous studies showed that men perceive self-driving vehicles to be safer and trust their performance more than women (Casley et al., 2013; Kyriakidis et al., 2015). Similarly, this study shows that the variables with the highest loading on the factor of *trust in AVs* relate to the safety perception and performance perception among others. The results show that experiencing safety while driving and having trust in the execution of the self-driving task is more important for women than for men. Another explanation could be the feeling of personal safety in the self-driving bus without a steward on the self-driving bus, which women might perceive as less positive than men. However, this study shows that a steward does not influence the preference for a self-driving bus positively, for both men and women. Surveillance by human staff is therefore not perceived to improve personal safety.

Additionally, the influence of technology interest shows a positive contribution to the perceived utility of a self-driving bus. This corresponds to previous studies, people with a high interest in technology are more likely to use the self-driving vehicle (Bansal et al., 2016; Haboucha et al., 2017; Winter et al., 2017; Zmud & Sener, 2017). A high technology interest has a relatively lower effect on the utility of the self-driving bus than an individual with high trust in automated vehicles.

Surveillance

The results show that the presence of surveillance in the self-driving bus does not influence the willingness to use the self-driving bus positively. This means that respondents do not perceive extra surveillance in the self-driving bus to be advantageous, neither in the form of a human steward nor as an interactive system. This outcome was not according to expectation since people could be more willing to use a self-driving bus with surveillance present. The outcome could be explained by the fact that respondents did not understand the surveillance attributes, or they did not read the context description of the choice experiment thoroughly. Furthermore, respondents might have perceived the presence of surveillance inconvenient, for example, because they do not want to be watched. Additionally, the presence of a steward or an interactive system might be perceived as a compensation for the lack of reliability of the self-driving bus, which could strengthen the distrust. This could suggest that respondents trust the self-driving bus more than the surveillance features, which would contradict the claim of Dong et al. (2017) that an abrupt shift to self-driving buses without a steward would alienate public transport users.

The outcome of this study regarding the importance of surveillance is different to findings from previous studies, which show a dominant influence of the presence of an employee on the willingness to use a self-driving bus (Piao et al., 2016; Dong et al., 2017). The differences in outcome may be caused by the way data has been gathered. Piao et al. (2016) and Dong et al. (2017) directly asked respondents their willingness to use a self-driving bus with or without an employee. Their approaches might have affected the attitudes of the respondents. In this study, surveillance was presented only as an attribute in the choice experiment. The approach of a choice experiment with multiple attributes could give a skewed view of the influence of surveillance features in the self-driving bus. The outcome of the conducted choice experiment might also demonstrate that in the trade-off process surveillance features are regarded as less important compared to the other attributes presented in the experiment.

Socio-economic variables

Age

The estimated models did not show significant outcomes for age and were therefore not included in the model estimations shown in this study. For all models estimated in the process of defining the final model, age has been shown to be insignificant. This shows that age might not explain heterogeneity in preferences for the willingness to use a self-driving bus. The insignificance of age could be explained by the relatively young sample. 70.2% of the sample is below 30 years old, no significant differences were found between this group and the elder respondents. The results could thus be biased towards the opinion of younger people.

Gender

In addition to women´s stronger distrust in self-driving vehicles, this group prefers the regular bus over the self-driving bus. The influence of gender found in this study is in line with previous studies, which showed that men tend to have a more favourable attitude towards self-driving vehicles than women (Schoettle & Sivak, 2014; Kyriakidis et al., 2015; Haboucha et al., 2016; Piao et al., 2016). The higher preference for the regular bus among women can be explained by their lower levels of trust in automated vehicles than men, as was shown in previous studies (Schoettle & Sivak, 2014; Kyriakidis et al., 2015). Additionally, lower levels of trust in automated vehicles could explain that women's trust in automated vehicles is of more importance to increase their willingness to choose a self-driving bus than a similar level of trust of men.

Public transport usage effect

In this study, it was expected that heavy public transport users have relatively higher preferences for the self-driving bus than occasional users. However, the model estimations showed no significant differences among the daily or weekly users and the occasional public transport users. Therefore, an additional parameter was estimated that separated the respondents that use public transport at least once a month with the yearly users, which was significant for the MNL model. However, the parameter is only significant at an 80% confidence interval in the final model. This outcome gives a conflicting result with the research of Liljamo et al. (2018). Their results show that respondents that travel at least once a month with public transport, have a more positive attitude towards the use of self-driving vehicles.

However, Liljamo et al. (2018) considered a more balanced distribution of the sample between public transport users and non-users. In this study, the yearly public transport users only represented 11.0% of the sample. This might explain the insignificant outcome for the monthly public transport user, which is a rather large share of respondents, relative to yearly users.

Effects of unobserved parameters

The results show that there is heterogeneity across the alternatives and the travel time and that a substantial amount of information is not captured with the estimated parameters. The difference between respondents who perceive more disutility when imagining a trip with the self-driving bus, and the respondents who perceive relatively less disutility, can be partially explained by the heterogeneity. Additionally, the nesting effect shows that there are common unobserved factors for the self-driving bus and regular bus. An explanation of the correlated unobserved factors could be that the respondents felt forced to choose out of the two buses since the opt-out only represented another alternative. Another explanation of the correlated factors for the two buses could be that some respondents like to travel by bus, either the self-driving bus or the regular bus. However, the presence of an additional alternative in the choice set could result in different outcomes. This would increase the realism of available alternatives for urban trips, which allows the assessment of nesting effects for multiple alternatives. If other alternatives would be added, it is expected that the nesting effect found in this study will be less strong since a sub-group in the sample could prefer the new alternative over the other alternatives.

Choosing another mode in the model application

Since no full disclosure over the opt-out choices was available it is rather unsure what the motivation of choosing an opt-out alternative was. The choice experiment might have forced respondents to choose out of the two buses without considering alternative modes to travel to work or study. This is a point of attention since that could bias the outcomes of the model estimation and thus the application of the model in this study. The choice probabilities give a hypothetical modal share of the self-driving bus competing with the regular bus, correcting for a number of travellers that would choose for another mode. The share of travellers that would choose another mode could be much higher, concerning the fact that more citizens in cities in the Netherlands travel by bike within their city than they use bus, tram or metro (KiM, 2017).

Model fit and the power to explain the data

A short reflection of the models is discussed. Several models were estimated before the final model for the data analysis was chosen. It was expected that more socio-economic variables would influence the decision making in the choice experiment. The outcomes of the multinomial logit and mixed logit models showed that the data was not able to explain the marginal utility of the indicator variables of a large number of socio-economic variables, see the list in Appendix E. Gender effects showed consistency in the model estimations. During the analysis, a number of assessments were made to determine any influence of socio-economic factors. However, when looking at the sample, the overrepresented high educated people and the young age distribution of 77.6% below 35 years old might have a rather similar preference for the alternatives considered in the choice experiment. The standard deviations showed that there is heterogeneity in the sample, however, this was not explained by the socio-economic variables.

The model with the highest model fit was determined based on the likelihood ratio test (LRS), which gave the final model for this study with the highest explanatory power from an adjusted rho-square of 0.47. With a sample size of 282 respondents and 1692 choice observations, the models showed good explanatory power based on the adjusted rho-square, which is deemed acceptable above a value of 0.1.

8.1 LIMITATIONS IN THIS STUDY

FACTOR SCORES

The attitudinal factors are represented by individual factors scores as mean sum scores. These scores allow an intuitive interpretation of the outcomes. For example, an increase in trust in AVs, the individual factor score, will increase the utility of the self-driving vehicle. With this method, no relations with socioeconomic characteristics and the attributes from the choice experiment can be explored (Walker & Ben-Akiva, 2002). Additionally, with the used factor scores the variables have the same influence, regardless of the specific factor loading (DiStefano et al., 2009). However, for this study, the interpretability of the factors scores was sufficient to provide insight into the effects of attitudinal factors and allows transferability of the factors in future studies.

ON-DEMAND VERSUS SCHEDULED SERVICES

The outcomes based on the choice experiment suggest that an on-demand service decreases the utility of the self-driving bus. The self-driving bus was presented to the participant as a transport service operated on a fixed route, which can be scheduled based or demand driven. The self-driving bus did not have the full advantage of an on-demand service, since it did not operate from door-to-door, which would improve the flexibility of an on-demand self-driving bus. The extra effort that is required for an on-demand service, without any additional advantageous, could explain why respondents did not prefer an on-demand self-driving bus over the scheduled alternative. While the outcome of the experiment, therefore, does not allow to draw conclusions on the perceived utility of on-demand transport services in general, it does give valuable information about the perceived value of the specific on-demand service operated in the future pilot.

WAITING FOR THE BUS

The waiting time that is considered in this choice experiment is the time that a traveller should wait at the bus stop until the bus arrives. The underlying assumption to this was that people arrive randomly at the bus stop regardless of the distance between their house and the bus stop. However, the way in which the waiting time is interpreted by respondents seemed to be ambiguous, since both an on-demand and scheduled service were considered. The presented waiting time for the scheduled (self-driving) bus could be ignored by travellers, they could imagine leaving their house just before the departure time of the bus. Nygaard & Tørset (2016) show that travellers who use real-time travel information arrive two to five minutes before the actual departure of the bus, taking delays into account. Other travellers arrived based on their knowledge of the scheduled departure times, with a similar planned waiting time at the bus stop. Also, the waiting time perception of respondents could be influenced by their perceived reliability of the service (Currie & Wallis, 2008), which was not included in this study. Khattak & Yim (2004) show that travellers were willing to wait longer for a taxi-like on-demand bus than their regular mode for commute trips, moreover due to the flexibility of pick-up times. Another explanation could be that travellers are able to wait for the on-demand bus at any location while continuing their daily tasks, in case door-to-door trips are offered. This outcome would be in line with the marginal utility of the waiting time of the self-driving bus, since the final model suggests that waiting time is perceived less negative for the self-driving bus than the waiting time for the regular bus, regardless the service. However, the waiting time for the on-demand self-driving bus could be different from the waiting time of a scheduled self-driving bus. The outcome of this study does not allow to draw an unambiguous conclusion on the influence of waiting time on the perceived utility of the buses.

SAMPLE

The collected sample is representative for this study, but only for a small sub-group of public transport users. In the sample, 70.2% of the respondents are below 30 years old who, predominantly, have a high level of education. Only 2.2% of the respondents were not employed or not a student, while the unemployed, retired and ‘other’ groups represent 42.4% of the daily public transport users in the Netherlands. It might be that the differences within the high educated commuters, that frequently or occasionally travel by public transport, are not extensive. Furthermore, the similarities of these characteristics of the respondents might be an explanation of the insignificant outcomes of many indicator variables for the socioeconomic characteristics, see Appendix E for the estimated insignificant indicator variables. In addition, the survey was distributed via online social networks. This might have influenced the type of people that responded to the survey, for example, people with a strong negative attitude towards self-driving vehicles could have been more interested in responding to the survey, which could have overestimated the disutility of travelling with the self-driving bus.

In the discussion of the results, possible explanations of the outcomes are discussed. In addition, some results are put in perspective of other studies to show the corroborations and contradictions found in this study. Furthermore, the limitations of this study are discussed, which limit the conclusions that can be drawn from this study.

9 RECOMMENDATIONS

With the following recommendations, more insight into the preferences of travellers regarding self-driving buses and possible operational features could be determined.

9.1 SCIENTIFIC RECOMMENDATIONS

The continuous development of automation technology makes it increasingly possible for travellers to gain experience with self-driving vehicles. Besides, attitudes towards self-driving vehicles are likely to change over time. Knowledge of the attitudes of travellers towards self-driving buses, in different stages of a public transport trip, is important for the development of a competitive service with self-driving buses. Therefore, it is recommended to continue research of traveller preferences for self-driving buses.

The findings in this study suggest that women tend to prefer the regular bus over the self-driving bus, which is in accordance with previous studies. Additionally, trust in automated vehicles is of more importance women than to men. Among other, a relationship between gender and surveillance was not found in the model estimation, which raises the question which factors increase the trust of women. Further research is required to understand these gender differences better, which could contribute to the development of measures to improve the trust in self-driving vehicles per gender.

This study considered mean sum scores that represented the attitudinal factors without an error term. This approach is not able to capture complex relations between socio-economic characteristics, attributes and attitudinal factors that could affect the perceived utility of self-driving buses. A further empirical research that extends the model estimation with an integrated choice and latent variable model will be able to get a clearer picture of the complex relations that are of influence on the choices of decision makers.

An on-demand self-driving bus driving from door-to-door could compete with the flexibility of the car and other modes, like the taxi and the bike. This study only provided insight into the relative preference of a self-driving bus compared to a regular bus and an opt-out alternative for an urban commuter trip, for the opt-out respondents could have several alternatives in mind. Increasing the understanding of relative user preferences could give a clearer view of the potential contributions of self-driving buses, and its position, in the (public) transportation market from the perspective of travellers. This study has found a strong nesting effect between the regular bus and the self-driving bus in the choice experiment opposing an opt-out option. How strong this nesting effect will be once more modes are added to the choice set should be subject of future research. This might improve the interpretation of the position of the self-driving bus.

Interpreting estimated values for waiting time, based on stated choice experiments, can be difficult. This is especially if on-demand transport services are included in the experiment. For an on-demand self-driving bus the waiting time could be considered the time a traveller must wait from the moment the bus is ordered until the bus arrives at their departure location. However, unexpected waiting time, resulting from an unreliable on-demand service for example, influences this perception of waiting time. Moreover, waiting at home might not be perceived as waiting time, it could be, for example, an alert phase until a person decides to leave home. In future experiments, these issues could be mitigated by, for example, a questionnaire to directly ask travellers how they perceive waiting time and which factors they think form their perception of waiting time. This could be limited to the perception of waiting time for an on-demand transport service. Furthermore, the perceptions of waiting time per service type could be grouped, either for a scheduled or on-demand self-driving bus, and between the time a person is waiting at home and leaving home could contribute to a wide view of waiting time. This way waiting time might be comprehended as constructs for specific services. From the perspective of this study, the following recommendation is given: For a better picture of waiting time, a study could look into the different perceptions of waiting time for different services, either on-demand or scheduled self-driving buses, different stages in the waiting period and factors that affect the perception of waiting time. In case of an on-demand service, the view of waiting time and public transport could change since more flexibility is offered for the traveller.

9.2 Practical recommendations

In this study, respondents tend to prefer a trip in the regular bus over the self-driving bus. However, according to previous research, the shared self-driving vehicle might improve the attractiveness of public transport. The pilot study offers multiple opportunities to compare the actual experience of a self-driving bus with the present research outcomes.

The pilot provides a possibility to design an ex-post study to investigate changing user preferences and attitudes towards the self-driving bus over time. For example, by investigating the individual preferences before, during and post the actual experience of the self-driving bus. This would allow exploring if there are causal relationships between for example trust and socioeconomic characteristics, and willingness to use self-driving buses. With knowledge of the actual changes in attitudes towards self-driving vehicles could be analysed if experience with travelling on a self-driving bus could contribute to travellers' willingness to use a self-driving bus.

Additional to the recommended study, it could be of interest to assess the actual experience of on-board surveillance. In regard to the preferences towards accompanying staff members on-board of automated buses, this study showed a negative influence on the perceived utility. The presence of a steward might induce different outcomes when a traveller experiences an actual trip with the self-driving bus. Additionally, it can be explored if people are ignorant regarding surveillance or that other factors than assessed in this study might affect their stated importance of surveillance in a self-driving bus. Therefore, it is proposed to enrich the findings from this survey by conducting further surveys regarding the surveillance in the self-driving bus.

In this study, the on-demand service did not contribute to an increased willingness to use the self-driving bus. Since the on-demand service is limited due to the fixed route and does not increase the attractiveness of the self-driving bus, it is recommended to focus on the development of the scheduled service, which allows for a clear comparison between the bus services offered in the pilot region.

9.3 Policy recommendations

The presence of a human staff member accompanying the self-driving bus is a prerequisite to this date. The outcomes of this study show that surveillance is however not important from the perspective of users. The elimination of human staff on-board self-driving vehicles could reduce the operation costs of the self-driving bus. Policy makers are advised to assess the policy in regard to surveillance in shared self-driving vehicles based on this and future studies considering the surveillance on-board self-driving buses. Standard surveillance, featuring camera surveillance, could be sufficient, which would prevent policy makers from making complex policies and unnecessary investments regarding presence of surveillance on-board self-driving vehicles. It needs to be noted that the attitude towards surveillance in a self-driving vehicle might change when travellers experience a self-driving bus or that outcomes are different from this study when other methodologies are used to assess the importance of surveillance in a self-driving bus.

In addition to the recommendation regarding the on-demand service in the pilot region, policy makers are advised to not consider the deployment of an on-demand self-driving bus when a scheduled bus service with a fixed route will be replaced or complemented. With an on-demand service of a self-driving bus, policy makers could implement an alternative to conventional cars or other flexible modes. To which extent an on-demand self-driving bus would compete with flexible modes should be subject for further study.

The application of the choice model gave an indication of the sensitivity of the travel time and travel costs and their impact on the modal shares of the choice situation in this study. For policy makers that wish to deploy a self-driving bus, developing a self-driving bus service as urban bus trips has potential. For example, as short connections within (sub) urban areas or as feeder services to greater transport nodes. In addition, policy makers could consider offering express services with a self-driving bus for longer distances, for example, with a low number of bus stops and a dedicated lane with the certainty to travellers that the travel times are low. Since a high value of travel time is found, such express services could allow to ask higher fares.

If policy makers attempt to offer a self-driving bus on a long route, it is required to reduce its travel costs for an attractive service. Offering a reduced fare could be a result of the introduction of a pricing policy for trips made by a self-driving bus. Moreover, it is expected that the operating costs of a self-driving bus reduce due to the elimination of costs for the current drivers. This would create more financial room to introduce a pricing policy with reduced travel costs. To which extent travel costs should decrease should be assessed by policy makers based on their intension with policy design for self-driving vehicles, since different travel costs give different modal shares.

Policy makers are advised to assess the investment and operation costs of a self-driving bus to compare the total costs with the costs of a regular bus. A start can be made by calculating the costs based on current self-driving buses. For example, the self-driving bus considered in the future pilot discussed in this study. Depending on the number of travellers for a bus connection, different seat capacities might become needed. Therefore, the assessment of the costs should be extended towards different self-driving bus sizes.

Recommendations are given to increase the understanding of user travel behaviour in regard to automated vehicles. Distinction is made between scientific, practical and policy recommendations, since self-driving vehicles and their potential operation in the future, require the attention from multiple perspectives.

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10 Conclusion

The development of automated vehicles offers advantages for the future transportation system. This results in increasing amount of uncertainties, among others within the behavioural responses of travellers. There is a lack of extensive knowledge of public transport user preferences regarding self-driving vehicles. In this study, the relative preferences for a trip with a self-driving bus were assessed compared to a trip with a regular bus. Therefore, factors that characterise the relative preferences for self-driving buses are estimated. Since the self-driving bus is currently not a common alternative within the public transportation market a stated preference experiment is conducted to quantify the relative preferences of travellers with a Mixed Logit discrete choice model.

The main conclusions from this study are discussed in this chapter by briefly addressing the research questions stated in section 1.5.

1. Which traveller characteristics influence the preference for a self-driving bus and to which extent?

In this study, it has been found that women are less willing to use a self-driving bus than men. This could moreover be explained by the fact that trust in automated vehicles is of more importance for women, the same level of trust in automated vehicles for women has a stronger effect on the perceived utility of a self-driving bus than for men. Furthermore, in this study, no significant differences were found between different age groups, which could be explained by the relatively young sample. To summarise, men are more likely to choose the self-driving bus, whereas younger respondents are not more willing to use a self-driving bus than the elder respondents in this study.

2. To which extent do attitudinal factors influence the perceived utility of a self-driving bus?

The results show that attitudinal factors influence the traveller preferences for the self-driving bus. With the factor analysis, two underlying factors were identified in the sample. The factors were trust in automated vehicles and technology interest. With the use of mean sum scores per individual, the latent factors were incorporated in the discrete choice models. Subsequently, the outcome of the model estimation showed a positive influence of the attitudinal factors on the perceived utility of the self-driving bus. An individual's trust in automated vehicles showed to have a more positive influence on the utility of the self-driving bus relative to an individual's interest in technology.

Additionally, the outcomes of this study show that the influence of trust in automated vehicles is stronger for women. Women that have no trust in automated vehicles are less likely to choose the self-driving bus than men with a similar level of trust. It can be concluded that increasing trust in automated vehicles and interest in technology significantly improves the perceived utility of the self-driving bus, whereas the influence of trust in automated vehicles of women enhances the utility of the self-driving bus even more.

3. How do mode attributes influence the preference of travellers for a self-driving bus?

The final model that is considered in this study, showed that the perceived disutility's of travel time and travel costs for the self-driving bus were stronger than for the regular bus. This outcome had a large effect on the estimate of the value of travel time for the self-driving bus, which was estimated to determine the willingness of respondents to pay for the self-driving bus. The respondents were willing to pay half the price for reducing travel time in a regular bus compared to a self-driving bus. However, in the model estimation heterogeneity was found in the perceived utility of travel time. This means that the willingness to use the buses varies across the individuals. Overall, from the expected values of travel time can be concluded that the respondents prefer to travel on a regular bus over travelling on a self-driving bus.

According to the outcomes of this study, the respondents were willing to wait longer for a self-driving bus than for a regular bus. However, the interpretation of waiting time could be different for an on-demand self-driving bus compared to a scheduled alternative. Since the potential differences lead to an ambiguous perception of waiting time from the perspective of the respondents, the outcome should be interpreted with care. Future studies could look into the perception of waiting time for different service types of self-driving buses.

4. *How does frequent public transport usage influence the preference for a self-driving bus?*

Several variables were estimated to assess the influence of public transport usage, which resulted in insignificant outcomes. Consequently, the result of the final model showed a positive effect, which however was insignificant. This suggests that travellers that use public transport at least once a month do not have a significantly higher preference for the self-driving bus than occasional public transport users. An explanation of the insignificant outcomes could be that the differences between the respondents are not that extensive. This could moreover be because most of the respondents travel by public transport every week. From this assessment, it can be concluded that a greater public transport usage has no significant effect on the willingness to use a self-driving bus.

5. *What are the differences between user preferences in the presence of a steward and an interactive system?*

The outcome of this study showed that a steward on-board of a self-driving bus is perceived as more negative than an interactive system or no extra surveillance. Moreover, respondents do not perceive utility in the presence of an interactive system. From the outcomes of this study can be concluded that surveillance on the self-driving bus does not improve the perceived utility of the self-driving bus. Respondents perceived more utility of a self-driving bus without the presence of extra surveillance.

6. *What is the relative preference for an on-demand self-driving bus compared to a scheduled self-driving bus?*

The model estimation found that respondents prefer a scheduled self-driving bus to an on-demand self-driving bus. In this study, the self-driving bus only operated on-demand without the option to travel from door-to-door, which could have influenced the perceived utility of an on-demand service. Consequently, travellers did not get additional advantageous when choosing the on-demand self-driving bus. From this study can be concluded that for an urban commute trip an on-demand self-driving bus with a fixed route is not preferred over a scheduled self-driving bus.

From these observations and findings, the main research question "*To which extent do public transport users prefer a self-driving bus relative to a regular bus for sub-urban trips?"* can be answered. It can be concluded that public transport users currently show a lower preference for the self-driving bus relative to the regular bus. Travellers perceive a trip with a self-driving bus as worse than with a regular bus since they are willing to pay more for travel time reduction for a self-driving bus. For an urban commute trip, the perceived utility of a self-driving bus is higher when it is operated as a scheduled service. An on-demand self-driving bus with a fixed route does not improve the utility of a self-driving bus. Moreover, travellers' preferences to travel on the self-driving bus improve when no extra surveillance is present compared to the presence of a steward or an interactive system. Extra surveillance did not increase the perceived personal safety in the self-driving bus, which was of influence on the trust in automated vehicles. Travellers with an increased level of trust are found to perceive more utility of a self-driving bus. This effect is stronger for women, an increased level of trust in automated vehicles of women enhances the perceived utility of the self-driving bus more than for men. The importance of trust in automated vehicles of women could explain the outcome that women are less likely to choose the self-driving bus than men. These relative preferences result in the self-driving bus being a competitive alternative for short urban trips, which allow for the increase of the travel costs for the self-driving bus compared to the travel costs for the regular bus. At last, the estimation and application outcomes of this study provide an increased understanding of the stated preferences of public transport users for self-driving vehicles operated as public transport services for urban trips.

11 Personal reflection

The beginning of the thesis project started with a different perspective on the expected subject that I would be investigating. In the first period of finding a relevant and state-of-the-art topic for a master thesis, I struggled the most from all phases. I had the intrinsic motivation to study the preferences of travellers for shared and on-demand mobility services that could enhance their flexibility. The topic could be combined with the development of a self-driving bus service in the south of the Netherlands.

After some iterations and the help of Peter Morsink and Konstanze Winter, the final proposal was changed a week before the kick-off meeting. The scope was narrowed down to a comprehensible level, the stated preferences of public transport users for a self-driving bus became the main subject of this study. After the kick-off meeting on April 10, 2018, I continued with the literature review and joined the Interregional Automated Transport project (I-AT) to become more accustomed to the project.

Afterwards, the design of the survey started to gather the responses needed to answer my research questions. I underestimated the time that was needed to design the final survey. A lot of iterations were done before the second preliminary survey was distributed. The design of the choice experiment demanded me to make choices. I did not expect that I would find it that hard to make choices for the survey. However, I can say that I learned from the different steps I took and that the making of choices improved throughout the thesis process.

Since a German survey was made as well, I needed more time to finish the final survey. The help of Konstanze with the translations was of great help. When the summary holiday came to an end the final survey was ready. The longer time that was needed for the design of the survey has probably helped in gathering a high number of respondents, which would be harder during the holidays.

The distribution of the surveys went rather smooth. The use of social media, like Facebook and LinkedIn, gave a lot of responses. Asking friends and colleagues to share the link to the survey was of great help. More than 200 respondents responded within three weeks. The additional help of the employees from different parties in the I-AT project pushed the total number of respondents to 305. However, it required several reminders to people before they actually helped. In the end, I am very pleased with the number of responses that were gathered without the use of, for example, expensive online panels. If other students intend to distribute a survey, they are advised to use social media as well, as long as they pay attention to the required sample characteristics.

In between the distribution of the preliminary surveys and the final survey, I attempted to get familiar with discrete choice modelling. This was a very helpful tip from the committee, which I highly recommend to students that attempt to apply a discrete choice model in their thesis. The modelling of the choices was an instructive time. The combination of reading theory and writing down the syntax for the model estimations gave me more understanding of choice modelling. This was one of my goals to learn in my thesis since I enjoyed the course of Statistical Analysis and Choice Behaviour at the beginning of the master. In addition, using a computer with 16 processors was very convenient for the simulation of the mixed logit models. The run of the final model took around 1 hour and 3 minutes, which would be substantially longer if fewer processors were available.

Overall, I enjoyed the learning process in this thesis and the enthusiastic responses of people about my thesis topic. This has motivated me a lot. The ups and downs that accompanied it increased my patience levels and also showed that dedication helped me through many situations.

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APPENDIX

A. EXPERIMENTAL DESIGN

With the software package NGENE (ChoiceMetrics, 2018), the experimental design has been constructed.

```
Design
;alts = ABUS, BUS, OPT-OUT
;rows = 24
;orth = sim
;block = 4
;model:

U(ABUS)= ASC + TC * travelcosts[1,1.6,2.2,2.8] + TT * traveltime[7,10,13,16] +
WT * waitingtime[2,4,6,8] + SURV * surveillance[2,1,0] + SERV * service[0,1] /

U(BUS) = TC * travelcosts + TT * traveltime + WT * waitingtime

$
```

B. Grouped statement responses

Table B.1 shows the grouped answers of the statements after recoding the answers for the negative phrased statements (statement 2, 5, 8, 9).

Table B.1 Distribution of statements - variables for factor analysis

Variable	*N*	*Min*	*Max*	*Mean*	*Median*	*Std. error*	*Std. dev.*	*Variance*
TRUST_1	282	1	5	3.06	3	0.06	1.05	1.11
TRUST_2	282	1	5	2.71	2	0.07	1.17	1.37
TRUST_3	282	1	5	2.82	3	0.06	1.06	1.13
TRUST_4	282	1	5	3.04	3	0.07	1.14	1.30
TRUST_5	282	1	5	3.03	3	0.08	1.31	1.73
TI_6	282	1	5	2.95	3	0.07	1.13	1.29
TI_7	282	1	5	3.97	4	0.06	1.02	1.03
TI_8	282	1	5	4.10	4	0.06	1.00	0.99
TI_9	282	1	5	3.81	4	0.06	0.93	0.86
CONV_10	282	1	5	3.60	4	0.06	1.01	1.02
CONV_11	282	1	5	3.24	3	0.07	1.23	1.51
CONV_12	282	1	5	2.94	3	0.06	1.02	1.03
CHAR_13	282	1	5	2.73	3	0.07	1.12	1.26
CHAR_14	282	1	5	2.76	3	0.07	1.16	1.35
CHAR_15	282	1	5	2.39	2	0.05	0.84	0.71

C. Distribution statement responses

Figure C.1 Distribution statement responses

	SA_1	SA_2	SA_3	SA_4	SA_5	ST_6	ST_7	ST_8	ST_9	SC_10	SC_11	SC_12	SV_13	SV_14	SV_15
	Trust in S-D vehicles					Technology interest				Convenience of S-D buses			Comfort of S-D bus		
	I am afraid that automa ted vehicles cannot fully detect what is happeni ng around them	I believe automa ted vehicles drive better than the average human driver	I think that an automa ted vehicle provide s me more safety compar ed to manuall y driving	I would entrust the safety of a close relative to a self-driving vehicle.	I think that an automa ted bus is only safe when a bus employ ee is present	I usually try new product s before my friends	I am excited by the possibili ties offered by new technol ogies	I have little to no interest in new technol ogy	Most of the times new technol ogies create more proble ms than they solve	Automa ted vehicles will make life easier	The best part of the automa ted bus is that it can be request ed on demand	I think that using an automa ted bus will be more conveni ent than using normal buses	I would feel more comfort able in a self-driving bus with several passeng ers than with a few passeng ers.	An interact ive screen is a good replace ment for a bus employ ee in the self-driving bus.	I would feel more comfort able in a self-driving bus than in a regular bus
FULLY DISAGREE	5%	5%	7%	8%	16%	10%	2%	42%	24%	3%	11%	8%	14%	15%	16%
	28%	29%	38%	30%	26%	28%	7%	35%	42%	12%	19%	26%	31%	32%	36%
NEUTRAL	31%	11%	28%	23%	16%	28%	16%	15%	24%	26%	21%	36%	30%	22%	43%
	27%	40%	19%	30%	28%	25%	39%	5%	9%	41%	34%	25%	18%	24%	5%
FULLY AGREE	9%	14%	7%	10%	13%	9%	35%	2%	1%	18%	15%	5%	7%	6%	1%

D. ITERATIONS WITH EFA – VARIMAX

Figure C.1 shows the distribution of the responses on the statements. The statements are used as indicators to determine underlying latent factors. Since a number of statements are negative, they are reversed, which improves the interpretation of the factors.

Iterations:
1. The first iteration is started with checking the communalities of the variables. Since the communality of CHAR_13 is 0.17 (< 0.25) the variable is eliminated in the next iteration.

2. Without CHAR_13 the second iteration gives a 3-factor solution with one variable (CHAR_11) having a communality of 0.19. Besides, CHAR_11 has a factor loading of 0.38 and is therefore removed in the next iteration. Additionally, the third factor has one factor loading above 0.5 for CONV_12. A check with a forced 2-factor solution shows low double loadings for CONV_12. Since this 2-factor solution also includes several other double loadings it is decided to continue with the elimination of CHAR_11 for the third iteration.

3. The third iteration gives a 2-factor solution with no communalities below 0.25. Some variables have double loadings, which are below 0.5. CHAR_14 is excluded in the fourth iteration since it has the lowest factor loadings and does not fit in the interpretation of the factor.

4. A 2-factor solution is kept in the fourth iteration. It is chosen to eliminate indicator CONV_12 which has double factor loadings below 0.5. A variable with a factor loading below 0.5 might only be kept when the variable has a single factor loading, which is not the case for CONV_12.

5. The fifth iteration has one variable loading on both the factors. CONV_10 shows relatively high double loadings and regarding the interpretation of the factors could be included in both factors. To minimize discrepancies in the factor interpretations, and because of the double loadings, CONV_10 is eliminated.

6. The sixth iteration gives a clear 2-factor solution with factor loadings above 0.5 for the first factor and two of the four variables for the second factor. Since the two variables TI_6 (0.498) and TI_9 (0.451) do not have double loadings and fit the interpreted factor it is decided to keep them. The factor solution gives the preferred simple structure and results in interpretable latent factors.

The initial Eigenvalues for the factors are 4.36 and 1.45, which is accepted for this study. Additionally, the scree-plot shows that the line flattens out at factor three. Based on the scree-plot criterion this suggests that the initial two factors should be considered as the final latent factors. With the two factors 58.1% percent of the variance is explained by the initial Eigenvalues, see Table D.2. The cumulative percentage of variance for the extraction sums of squared loadings and rotation sums of squared loadings is 49.27%.

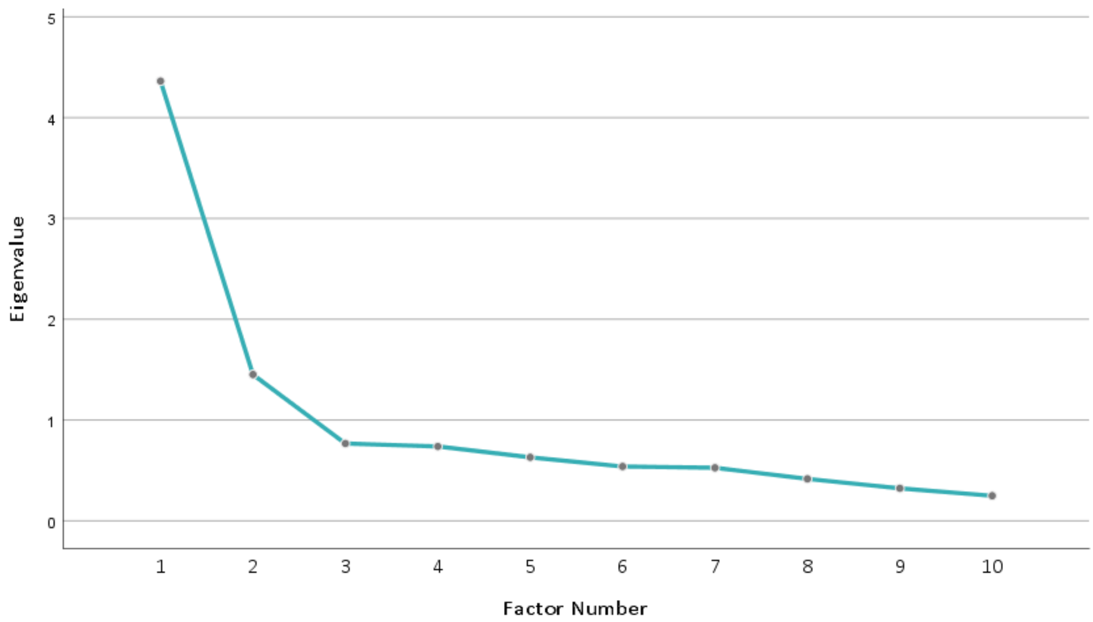

Figure D.1 Scree Plot, showing the eigenvalues of the factors

Table D.1 Explained variance by variables (communalities) - VARIMAX

	Initial	Extraction
TRUST_1	.55	.58
TRUST_2	.43	.49
TRUST_3	.59	.66
TRUST_4	.49	.56
TI_6	.33	.33
TI_7	.60	.90
TI_8	.42	.44
TI_9	.24	.25
CHAR_15	.38	.42
TRUST_5	.29	.30

Table D.2 Total Variance Explained by extracted factors

	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
Factor	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	4.36	43.62	43.62	3.90	38.97	38.97	2.92	29.24	29.24
2	1.45	14.51	58.13	1.03	10.30	49.27	2.00	20.03	49.27
3	.77	7.67	65.80						
4	.74	7.38	73.18						
5	.63	6.30	79.48						
6	.54	5.39	84.87						
7	.53	5.26	90.13						
8	.42	4.16	94.29						
9	.32	3.23	97.52						
10	.25	2.49	100.00						

Table D.3 Correlation matrix of variables considered

	TRUST_1	TRUST_2	TRUST_3	TRUST_4	TRUST_5	TI_6	TI_7	TI_8	TI_9	CHAR_15
TRUST_1	1.00	0.48	0.69	0.55	0.36	0.23	0.37	0.16	0.25	0.50
TRUST_2	0.48	1.00	0.53	0.56	0.44	0.27	0.31	0.19	0.28	0.45
TRUST_3	0.69	0.53	1.00	0.59	0.42	0.33	0.36	0.24	0.21	0.51
TRUST_4	0.55	0.56	0.59	1.00	0.43	0.32	0.38	0.21	0.25	0.46
TRUST_5	0.36	0.44	0.42	0.43	1.00	0.32	0.28	0.18	0.23	0.33
TI_6	0.23	0.27	0.33	0.32	0.32	1.00	0.53	0.33	0.29	0.33
TI_7	0.37	0.31	0.36	0.38	0.28	0.53	1.00	0.64	0.45	0.42
TI_8	0.16	0.19	0.24	0.21	0.18	0.33	0.64	1.00	0.33	0.22
TI_9	0.25	0.28	0.21	0.25	0.23	0.29	0.45	0.33	1.00	0.23
CHAR_15	0.50	0.45	0.51	0.46	0.33	0.33	0.42	0.22	0.23	1.00

a. Determinant = .021

D.1. Oblimin outcome

Table D.4 Pattern Matrix – Oblimin

	Factor 1	Factor 2
TRUST_3	,84	
TRUST_1	.79	
TRUST_4	.74	
TRUST_2	.70	
CHAR_15	.57	
TRUST_5	.51	
TI_7		.96
TI_8		.71
TI_6		.47
TI_9		.44

Extraction Method: Principal Axis Factoring.
Rotation Method: Oblimin with Kaiser Normalization.[a]
a. Rotation converged in 4 iterations.

Table D.5 Factor Correlation Matrix - Oblimin

Factor	1	2
1	1.00	.53
2	.53	1.00

Extraction Method: Principal Axis Factoring.
Rotation Method: Oblimin with Kaiser Normalization.

D.2. Cronbach's alpha

Trust in automated vehicles

Table D.6 Reliability Statistics Cronbach's Alpha - Factor Trust in automated vehicles

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.84	.85	6

Table D.7 Item-Total statistics Cronbach's Alpha – Factor Trust in automated vehicles

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
TRUST_1	13.99	17.71	.67	.53	.81
TRUST_2	14.34	17.14	.65	.42	.82
TRUST_3	14.24	17.26	.72	.58	.80
TRUST_4	14.01	17.05	.68	.48	.81
TRUST_5	14.02	17.48	.51	.27	.85
CHAR_15	14.66	19.76	.57	.35	.83

Technology interest

Table D.8 Reliability Statistics Cronbach's Alpha – Factor Technology Interest

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.75	.75	4

Table D.9 Item-Total Statistics Cronbach's Alpha – Factor Technology Interest

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
TI_6	11.88	5.63	.48	.28	.73
TI_7	10.86	5.10	.73	.55	.58
TI_8	10.73	5.86	.55	.41	.69
TI_9	11.01	6.56	.44	.21	.74

E. Overview of insignificant indicator variables

Table E.1 Overview of insignificant estimated indicator variables considered

	Indicator variable 1	Indicator variable 2	Indicator variable 3	Indicator variable 4
Age	50plus	35_49yo	25_34yo	
18 - 24 years old	-1	-1	-1	
25 - 34 years old	0	0	1	
35 - 49 years old	0	1	0	
> 50 years old	1	0	0	
Age below 30 years old	Under_30			
Older than 29 years old	-1			
Under 30 years old	1			
Occupation				
Full time	-1	-1	-1	
Part time	0	0	1	
Student	0	1	0	
Jobless or Retired	1	0	0	
Education	edu_high	edu_med		
Low	-1	-1		
Medium	0	1		
High	1	0		
Individual income	inc_high	inc_medi	inc_medi_low	
<€10.001	-1	-1	-1	
€10.001-€30.000	0	0	1	
€30.001-€50.000	0	1	0	
>€50.001	1	0	0	
Public transport usage	pt_yearly	pt_monthly	pt_weekly	
4 times or more per week	-1	-1	-1	
1 tot 3 times per week	0	0	1	
1 to 3 times per month	0	1	0	
twice or less per quarter	1	0	0	
Bus usage	bus_never	bus_yearly	bus_monthly	bus_weekly
4 times or more per week	-1	-1	-1	-1
1 tot 3 times per week	0	0	0	1
1 to 3 times per month	0	0	1	0
twice or less per quarter	0	1	0	0
never	1	0	0	0

F. ESTIMATION RESULTS OVERVIEW

The adjusted rho-squares show that the models fit the data better for every extended model. To confirm that the model fits the data significantly better, the Chi-square distribution table is used, see Table F.1. This table shows the threshold for the LRS value, for the respective degrees of freedom, for a significant improvement of the model fit. The degrees of freedom (df) represent the difference in number of estimated parameters between the compared models.

Table F.1 Chi-square distribution table

Critical Values of the χ^2 Distribution

df \ p	0.995	0.975	0.9	0.5	0.1	0.05	0.025	0.01	0.005	df
1	.000	.000	0.016	0.455	2.706	3.841	5.024	6.635	7.879	1
2	0.010	0.051	0.211	1.386	4.605	5.991	7.378	9.210	10.597	2
3	0.072	0.216	0.584	2.366	6.251	7.815	9.348	11.345	12.838	3
4	0.207	0.484	1.064	3.357	7.779	9.488	11.143	13.277	14.860	4
5	0.412	0.831	1.610	4.351	9.236	11.070	12.832	15.086	16.750	5
6	0.676	1.237	2.204	5.348	10.645	12.592	14.449	16.812	18.548	6
7	0.989	1.690	2.833	6.346	12.017	14.067	16.013	18.475	20.278	7
8	1.344	2.180	3.490	7.344	13.362	15.507	17.535	20.090	21.955	8
9	1.735	2.700	4.168	8.343	14.684	16.919	19.023	21.666	23.589	9
10	2.156	3.247	4.865	9.342	15.987	18.307	20.483	23.209	25.188	10
11	2.603	3.816	5.578	10.341	17.275	19.675	21.920	24.725	26.757	11
12	3.074	4.404	6.304	11.340	18.549	21.026	23.337	26.217	28.300	12
13	3.565	5.009	7.042	12.340	19.812	22.362	24.736	27.688	29.819	13
14	4.075	5.629	7.790	13.339	21.064	23.685	26.119	29.141	31.319	14
15	4.601	6.262	8.547	14.339	22.307	24.996	27.488	30.578	32.801	15

Table F.2 Model fit of six estimated models

	# of parameters	Final log likelihood	LRS with base model	LRS previous model	Adjusted ρ^2
Null	0	-1858.85	-	-	-
Base MNL	11	-1278.64	-	-	0.31
MNL socio-economic and LVs	18	-1197.70	161.88	161.88	0.35
ML ASC heterogeneity	20	-991.73	573.83	411.95	0.46
ML nesting effect	19	-977.43	602.42	28.59	0.46
ML nesting effect and travel time taste	21	-968.51	620.27	17.85	0.47
Combined ML nesting effect, ASC heterogeneity and travel time taste	23	-964.39	628.50	8.23	0.47

F.1. MNL – BASE

Table F.3 Estimation outcomes of the MNL base model

Parameter	Value	Std. err	Robust Std err	Robust t-test	p-value
ß Constant regular bus	5.80	0.34	0.35	16.63	0.00 ***
ß Constant self-driving bus	7.67	0.35	0.37	21.01	0.00 ***
ß Interactive system	-0.04	0.09	0.08	-0.51	0.61
ß Steward	-0.17	0.09	0.09	-1.83	0.07 *
ß DRT service SDB	-0.26	0.12	0.12	-2.22	0.03 **
ß Travel cost regular bus	-1.21	0.09	0.09	-13.30	0.00 ***
ß Travel cost self-driving bus	-1.46	0.10	0.10	-14.97	0.00 ***
ß Travel time regular bus	-0.10	0.02	0.02	-5.82	0.00 ***
ß Travel time self-driving bus	-0.26	0.02	0.02	-14.34	0.00 ***
ß Waiting time regular bus	-0.17	0.03	0.03	-6.67	0.00 ***
ß Waiting time self-driving bus	-0.12	0.03	0.03	-4.43	0.00 ***

**** = significant in 99% CI, ** = significant in 95% CI, * = significant in 90% CI*

Table F.4 Statistics MNL base model

Number of estimated parameters:	11
Sample size:	1692
Excluded observations:	0
Initial log likelihood:	-1858.85
Final log likelihood:	-1278.64
Likelihood ratio test for the init. model:	1160.42
Rho-square for the init. model:	0.31
Rho-square-bar for the init. model:	0.31
Akaike Information Criterion:	2579.28
Bayesian Information Criterion:	2639.06
Final gradient norm:	+5.232e-005
Diagnostic:	Trust region algorithm with simple bounds (CGT2000): Convergence reached...
Iterations:	9
Data processing time:	00:00
Run time:	00:01
Number of threads:	2

F.2. MNL – SOCIO-ECONOMIC AND LATENT VARIABLES

Table F.5 Estimation outcomes MNL socio-economic and latent variables model

Name	Value	Std err	Robust Std err	Robust t-test	p-value
Use PT every month SDB	0.23	0.11	0.10	2.37	0.02 **
Female REB	0.33	0.09	0.09	3.75	0.00 ***
Citizen pilot provinces SDB	0.14	0.07	0.07	1.91	0.06 *
ß Constant regular bus	6.14	0.35	0.36	17.03	0.00 ***
ß Constant self-driving bus	5.14	0.48	0.47	10.94	0.00 ***
ß DRT service SDB	-0.27	0.13	0.12	-2.18	0.03 **
ß Interactive system	-0.04	0.09	0.09	-0.42	0.67
ß Steward	-0.18	0.09	0.09	-1.89	0.06 *
ß Female TI SDB	-0.17	0.07	0.07	-2.38	0.02 **
ß Technology interest SDB	0.25	0.10	0.10	2.54	0.01 **
ß Travel cost regular bus	-1.30	0.10	0.09	-13.74	0.00 ***
ß Travel cost self-driving bus	-1.56	0.11	0.10	-15.25	0.00 ***
ß Travel time regular bus	-0.11	0.02	0.02	-5.91	0.00 ***
ß Travel time self-driving bus	-0.29	0.02	0.02	-14.49	0.00 ***
ß Female Trust in AVs SDB	0.33	0.09	0.09	3.67	0.00 ***
ß Trust in AVs SDB	0.78	0.10	0.09	8.25	0.00 ***
ß Waiting time REB	-0.18	0.03	0.03	-6.96	0.00 ***
ß Waiting time SDB	-0.14	0.03	0.03	-5.12	0.00 ***

**** = significant in 99% CI, ** = significant in 95% CI, * = significant in 90% CI, REB = Regular bus, SDB = Self-driving bus*

Table F.6 Statistics MNL socio-economic and latent variables model

Number of estimated parameters:	18
Sample size:	1692
Excluded observations:	0
Initial log likelihood:	-1858.85
Final log likelihood:	-1197.70
Likelihood ratio test for the init. model:	1322.30
Rho-square for the init. model:	0.36
Rho-square-bar for the init. model:	0.35
Akaike Information Criterion:	2431.40
Bayesian Information Criterion:	2529.21
Final gradient norm:	+1.733e-004
Diagnostic:	Trust region algorithm with simple bounds (CGT2000): Convergence reached...
Iterations:	8
Data processing time:	00:00
Run time:	00:02
Number of threads:	2

F.3. ML – ASC HETEROGENEITY

Table F.7 Estimation outcomes ML ASC heterogeneity model

Name	Value	Std err	Robust Std err	Robust t-test	p-value
Use PT every month SDB	0.28	0.20	0.19	1.44	0.15
Female REB	0.73	0.26	0.33	2.21	0.03 **
Citizen pilot provinces SDB	0.03	0.13	0.12	0.25	0.80
ß Constant regular bus	10.20	0.65	0.78	13.04	0.00 ***
ß Constant self-driving bus	8.87	0.89	1.00	8.87	0.00 ***
ß DRT service SDB	-0.40	0.16	0.17	-2.43	0.01 **
ß Interactive system	0.01	0.12	0.10	0.10	0.92
σ Constant REB	3.48	0.33	0.36	9.69	0.00 ***
σ Constant SDB	3.41	0.32	0.37	9.34	0.00 ***
ß Steward	-0.31	0.12	0.12	-2.57	0.01 **
ß Female TI SDB	-0.16	0.13	0.14	-1.09	0.27
ß Technology interest SDB	0.35	0.18	0.19	1.86	0.06 *
ß Travel cost regular bus	-1.85	0.14	0.16	-11.57	0.00 ***
ß Travel cost self-driving bus	-2.18	0.15	0.16	-13.29	0.00 ***
ß Travel time regular bus	-0.16	0.02	0.03	-6.23	0.00 ***
ß Travel time self-driving bus	-0.39	0.03	0.03	-13.04	0.00 ***
ß Female Trust in AVs SDB	0.45	0.16	0.17	2.62	0.01 ***
ß Trust in AVs SDB	0.98	0.17	0.17	5.70	0.00 ***
ß Waiting time REB	-0.26	0.04	0.04	-6.79	0.00 ***
ß Waiting time SDB	-0.19	0.04	0.04	-4.80	0.00 ***

**** = significant in 99% CI, ** = significant in 95% CI, * = significant in 90% CI, REB = Regular bus, SDB = Self-driving bus*

Table F.8 Statistics ML ASC heterogeneity model

Number of draws:	1000
Number of estimated parameters:	20
Sample size:	1692
Excluded observations:	0
Initial log likelihood:	-1858.85
Final log likelihood:	-991.73
Likelihood ratio test for the init. model:	1734.25
Rho-square for the init. model:	0.47
Rho-square-bar for the init. model:	0.46
Akaike Information Criterion:	2023.45
Bayesian Information Criterion:	2132.12
Final gradient norm:	+1.127e-003
Diagnostic:	Trust region algorithm with simple bounds (CGT2000): Convergence reached...
Iterations:	11
Data processing time:	00:00
Run time:	09:23
Number of threads:	16

F.4. ML – Nesting effects

Table F.9 Estimation outcomes ML nesting effects model

Name	Value	Std err	Robust Std err	Robust t-test	p-value
Use PT every month SDB	0.19	0.12	0.13	1.47	0.14
Female REB	0.85	0.28	0.35	2.41	0.02 **
Citizen pilot provinces SDB	0.09	0.08	0.09	0.90	0.37
ß Constant regular bus	10.80	0.79	0.91	11.83	0.00 ***
ß Constant self-driving bus	9.32	0.84	1.02	9.14	0.00 ***
ß DRT service SDB	-0.34	0.14	0.14	-2.36	0.02 **
ß Interactive system	-0.01	0.11	0.09	-0.11	0.91
σ nesting effects	4.54	0.56	0.62	7.37	0.00 ***
ß Technology interest SDB	0.30	0.11	0.15	2.05	0.04 **
ß Trust in AVs SDB	0.89	0.11	0.14	6.56	0.00 ***
ß Steward	-0.23	0.10	0.10	-2.29	0.02 **
ß Female TI SDB	-0.07	0.09	0.12	-0.55	0.59
ß Travel cost regular bus	-1.56	0.12	0.13	-11.72	0.00 ***
ß Travel cost self-driving bus	-1.80	0.12	0.13	-13.77	0.00 ***
ß Travel time regular bus	-0.13	0.02	0.02	-5.94	0.00 ***
ß Travel time self-driving bus	-0.32	0.02	0.02	-13.10	0.00 ***
ß Female Trust in AVs SDB	0.37	0.10	0.13	2.87	0.00 ***
ß Waiting time REB	-0.23	0.03	0.03	-7.07	0.00 ***
ß Waiting time SDB	-0.16	0.03	0.03	-4.81	0.00 ***

**** = significant in 99% CI, ** = significant in 95% CI, * = significant in 90% CI, REB = Regular bus, SDB = Self-driving bus*

Table F.10 Statistics ML nesting effects model

Number of draws:	1000
Number of estimated parameters:	19
Sample size:	1692
Excluded observations:	0
Initial log likelihood:	-1858.85
Final log likelihood:	-977.43
Likelihood ratio test for the init. model:	1762.84
Rho-square for the init. model:	0.47
Rho-square-bar for the init. model:	0.46
Akaike Information Criterion:	1992.86
Bayesian Information Criterion:	2096.10
Final gradient norm:	+4.607e-005
Diagnostic:	Trust region algorithm with simple bounds (CGT2000): Convergence reached...
Iterations:	13
Data processing time:	00:00
Run time:	09:50
Number of threads:	16

F.5. ML – NESTING EFFECTS AND TRAVEL TIME TASTE

Table F.11 Estimation outcomes ML nesting effects and travel time taste model

Name	Value	Std err	Robust Std err	Robust t-test	p-value
Use PT every month SDB	0.22	0.16	0.15	1.49	0.14
Female REB	0.77	0.31	0.38	1.99	0.05 **
Citizen pilot provinces SDB	0.09	0.11	0.11	0.87	0.39
ß Constant regular bus	11.10	0.77	0.96	11.62	0.00 ***
ß Constant self-driving bus	9.47	0.89	1.07	8.84	0.00 ***
ß DRT service SDB	-0.35	0.16	0.16	-2.19	0.03 **
ß Interactive system	0.06	0.12	0.10	0.59	0.56
σ nesting effects	-4.54	0.53	0.60	-7.56	0.00 ***
σ travel time REB	0.07	0.02	0.02	4.14	0.00 ***
σ travel time SDB	-0.04	0.02	0.02	-2.06	0.04 **
ß Steward	-0.31	0.11	0.11	-2.79	0.01 ***
ß Female TI SDB	-0.09	0.12	0.13	-0.69	0.49
ß Technology interest SDB	0.36	0.14	0.17	2.17	0.03 **
ß Travel cost regular bus	-1.75	0.14	0.16	-11.29	0.00 ***
ß Travel cost self-driving bus	-2.03	0.15	0.16	-13.14	0.00 ***
ß Travel time regular bus	-0.14	0.02	0.02	-6.02	0.00 ***
ß Travel time self-driving bus	-0.36	0.03	0.03	-12.67	0.00 ***
ß Female Trust in AVs SDB	0.37	0.13	0.14	2.61	0.01 ***
ß Trust in AVs SDB	0.97	0.14	0.16	6.14	0.00 ***
ß Waiting time REB	-0.26	0.04	0.04	-6.81	0.00 ***
ß Waiting time SDB	-0.18	0.04	0.04	-4.88	0.00 ***

**** = significant in 99% CI, ** = significant in 95% CI, * = significant in 90% CI, REB = Regular bus, SDB = Self-driving bus*

Table F.12 Statistics ML nesting effects and travel time taste model

Number of draws:	1000
Number of estimated parameters:	21
Sample size:	1692
Excluded observations:	0
Initial log likelihood:	-1858.85
Final log likelihood:	-968.51
Likelihood ratio test for the init. model:	1780.69
Rho-square for the init. model:	0.48
Rho-square-bar for the init. model:	0.47
Akaike Information Criterion:	1979.02
Bayesian Information Criterion:	2093.12
Final gradient norm:	+3.106e-003
Diagnostic:	Trust region algorithm with simple bounds (CGT2000): Convergence reached...
Iterations:	70
Data processing time:	00:00
Run time:	45:28
Number of threads:	16

F.6. Combined ML – Nesting effect, ASC heterogeneity and travel time taste

Table F.13 Estimation outcomes of final combined ML model with nesting effect, ASC heterogeneity and travel time taste

Parameter	Value	Std. error	Robust Std error	Robust t-test	p-value
Use PT every month SDB	0.22	0.16	0.15	1.48	0.14
Female REB	0.74	0.33	0.36	2.04	0.04 **
Citizen pilot provinces SDB	0.07	0.11	0.11	0.66	0.51
ß Constant regular bus	11.80	0.94	1.19	9.91	0.00 ***
ß Constant self-driving bus	10.20	1.04	1.28	7.95	0.00 ***
ß DRT service SDB	-0.37	0.16	0.16	-2.32	0.02 **
ß Interactive system	0.04	0.12	0.10	0.41	0.68
σ nesting effects	-4.88	0.61	0.67	-7.26	0.00 ***
σ Constant REB	0.57	0.32	0.32	1.78	0.07 *
σ Constant SDB	0.71	0.21	0.17	4.09	0.00 ***
σ travel time REB	0.06	0.02	0.02	3.10	0.00 ***
σ travel time SDB	0.05	0.02	0.01	3.33	0.00 ***
ß Steward	-0.30	0.11	0.11	-2.62	0.01 ***
ß Female TI SDB	-0.11	0.13	0.14	-0.83	0.41
ß Technology interest SDB	0.35	0.15	0.17	2.02	0.04 **
ß Travel cost regular bus	-1.80	0.14	0.17	-10.85	0.00 ***
ß Travel cost self-driving bus	-2.08	0.15	0.16	-12.80	0.00 ***
ß Travel time regular bus	-0.15	0.02	0.03	-6.07	0.00 ***
ß Travel time self-driving bus	-0.37	0.03	0.03	-12.49	0.00 ***
ß Female Trust in AVs SDB	0.40	0.14	0.15	2.62	0.01 ***
ß Trust in AVs SDB	0.96	0.15	0.16	5.98	0.00 ***
ß Waiting time REB	-0.26	0.04	0.04	-6.67	0.00 ***
ß Waiting time SDB	-0.19	0.04	0.04	-4.80	0.00 ***

**** = significant in 99% CI, ** = significant in 95% CI, * = significant in 90% CI, REB = Regular bus, SDB = Self-driving bus*

Table F.14 Statistics ML nesting effects, ASC heterogeneity and travel time taste model

Number of draws:	1000
Number of estimated parameters:	23
Sample size:	1692
Excluded observations:	0
Initial log likelihood:	-1858.85
Final log likelihood:	-964.39
Likelihood ratio test for the init. model:	1788.92
Rho-square for the init. model:	0.48
Rho-square-bar for the init. model:	0.47
Akaike Information Criterion:	1974.78
Bayesian Information Criterion:	2099.76
Final gradient norm:	+6.697e-004
Diagnostic:	Trust region algorithm with simple bounds (CGT2000): Convergence reached...
Iterations:	71
Data processing time:	00:00
Run time:	01h 02:54
Number of threads:	16

G. Biogeme syntax Combined ML model

```
from biogeme import *
from headers import *
from loglikelihood import *
from statistics import *

# Beta Parameters to be estimated
Constant_SDB            = Beta('Constant_SDB',0,-100,100,0)
Constant_REB            = Beta('Constant_REB',0,-100,100,0)
Constant_NOB            = Beta('Constant_NOB',0,-100,100,1)
Travelcost_SDB          = Beta('Travelcost_SDB',0,-100,100,0)
Travelcost_REB          = Beta('Travelcost_REB',0,-100,100,0)
Traveltime_SDB          = Beta('Traveltime_SDB',0,-100,100,0)
Traveltime_REB          = Beta('Traveltime_REB',0,-100,100,0)
Waitingtime_SDB         = Beta('Waitingtime_SDB',0,-100,100,0)
Waitingtime_REB         = Beta('Waitingtime_REB',0,-100,100,0)
Waitingtime_GEN         = Beta('Waitingtime_GEN',0,-100,100,0)
DRT_SDB                 = Beta('DRT_SDB',0,-100,100,0)
Steward_SDB             = Beta('Steward_SDB',0,-100,100,0)
Interactive_SDB         = Beta('Interactive_SDB',0,-100,100,0)

#Socio-economic variables
B_PT_every_month_SDB    = Beta('B_PT_every_month_SDB',0,-100,100,0)
B_provs_pilot_SDB       = Beta('B_provs_pilot_SDB',0,-100,100,0)
B_female_REB            = Beta('B_female_REB',0,-100,100,0)
#Latent variable betas
Trust_SDB               = Beta('Trust_SDB',0,-100,100,0)
Tech_SDB                = Beta('Tech_SDB',0,-100,100,0)
Trust_Female_SDB        = Beta('Trust_Female_SDB',0,-100,100,0)
Tech_Female_SDB         = Beta('Tech_Female_SDB',0,-100,100,0)

#Sigma Parameters to be estimated
SIGMA_Constant_SDB      = Beta('SIGMA_Constant_SDB',0,-100,100,0)
SIGMA_Constant_REB      = Beta('SIGMA_Constant_REB',0,-100,100,0)
SIGMA_TT_SDB            = Beta('SIGMA_TT_SDB',0,-100,100,0)
SIGMA_TT_REB            = Beta('SIGMA_TT_REB',0,-100,100,0)
NESTING_SIGMA           = Beta('NESTING_SIGMA',0,-100,100,0)
ZERO                    = Beta('ZERO',0,-100,100,1)

#Defined parameters
TRUST_FEMALE            = DefineVariable('TRUST_FEMALE', ( FEMALE * SUM_TRUST ))
TECH_FEMALE             = DefineVariable('TECH_FEMALE', ( FEMALE * SUM_TECH ))

#Random parameters for taste heterogeneity
SIGMA_SDB = Constant_SDB + SIGMA_Constant_SDB * bioDraws('SIGMA_SDB')
SIGMA_REB = Constant_REB + SIGMA_Constant_REB * bioDraws('SIGMA_REB')
SIGMA_TTA_SDB = Traveltime_SDB + SIGMA_TT_SDB * bioDraws('SIGMA_TTA_SDB')
SIGMA_TTB_REB = Traveltime_REB + SIGMA_TT_REB * bioDraws('SIGMA_TTB_REB')
#Random parameter for Nesting effect
ERRORCOMP = ZERO + NESTING_SIGMA * bioDraws('ERRORCOMP')

one = DefineVariable('one',1)

#Utility functions
SDB = SIGMA_SDB * one + TCA * Travelcost_SDB + TTA * SIGMA_TTA_SDB\
 + WTA * Waitingtime_SDB\
 + DRT * DRT_SDB + SURV_S * Steward_SDB + SURV_I * Interactive_SDB\
```

```
 + SUM_TRUST * Trust_SDB + SUM_TECH * Tech_SDB\
 + TECH_FEMALE * Tech_Female_SDB + TRUST_FEMALE * Trust_Female_SDB\
 + PT_EVERY_MONTH * B_PT_every_month_SDB + PROVS_PILOT * B_provs_pilot_SDB\
 + ERRORCOMP

REB = SIGMA_REB * one + TCB * Travelcost_REB + TTB * SIGMA_TTB_REB\
 + WTB * Waitingtime_REB\
 + FEMALE * B_female_REB + ERRORCOMP

NOB = Constant_NOB * one

# Associate utility functions with the numbering of alternatives
V = {1: SDB,
     2: REB,
     3: NOB}

AV1 = 1
AV2 = 1
AV3 = 1

# Associate the availability conditions with the alternatives
av = {1: AV1,
      2: AV2,
      3: AV3}

# The choice model is a logit, with availability conditions
prob = bioLogit(V,av,CHOICE)

#PANEL effects; groups observations per individual:
# Iterator on individuals, that is on groups of rows.
metaIterator('personIter','__dataFile__','panelObsIter','ID')
# For each item of personIter, iterates on the rows of the group.
rowIterator('panelObsIter','personIter')
#Conditional probability for the sequence of choices of an individual
condProbIndiv = Prod(prob,'panelObsIter')
# Integration by simulation
probIndiv = MonteCarlo(condProbIndiv)

# Define the likelihood function for the estimation
loglikelihood = Sum(log(probIndiv),'personIter')
BIOGEME_OBJECT.ESTIMATE = loglikelihood

# Simulation of draws
BIOGEME_OBJECT.PARAMETERS['NbrOfDraws'] = "1000"
# Optimization algorithm
BIOGEME_OBJECT.PARAMETERS['optimizationAlgorithm'] = "BIO"
BIOGEME_OBJECT.PARAMETERS['RandomDistribution'] = "HALTON"
BIOGEME_OBJECT.PARAMETERS['numberOfThreads'] = "16"
BIOGEME_OBJECT.DRAWS = {'ERRORCOMP': ('NORMAL','ID'),'SIGMA_SDB': ('NORMAL','ID'),\
'SIGMA_REB': ('NORMAL','ID'),'SIGMA_TTA_SDB': ('NORMAL','ID'),\
'SIGMA_TTB_REB': ('NORMAL','ID')}

# Statistics
nullLoglikelihood(av,'panelObsIter')
choiceSet = [1,2,3]
cteLoglikelihood(choiceSet,CHOICE,'panelObsIter')
availabilityStatistics(av,'panelObsIter')
```

H. MARKET SHARE VARIATIONS

H.1. PROBABILITIES OF ALTERNATIVES IN COMPETITION IN PILOT REGION WITH STEWARD FOR SELF-DRIVING BUS

Table H.1 Scenario 1: Fast and cheap with steward; probabilities of alternatives with changes in travel time for self-driving bus with on-board steward

SDB travel time	7 min.	10 min.	13 min.	16 min.
Self-driving bus	70.2%	48.4%	26.6%	11.5%
Regular bus	26.3%	46.7%	67.3%	81.8%
Opt-out	3.5%	4.9%	6.1%	6.7%

Table H.2 Scenario 2: Fast and cheap with steward; probabilities of alternatives with changes in travel costs for self-driving bus with on-board steward

SDB travel costs	€1.00	€1.60	€2.20	€2.80
Self-driving bus	52.2%	32.4%	17.0%	8.0%
Regular bus	43.1%	61.9%	76.6%	85.2%
Opt-out	4.7%	5.7%	6.5%	6.8%

Table H.3 Scenario 3: Slow and expensive with steward; probabilities of alternatives with changes in travel time for self-driving bus with on-board steward

SDB travel time	7 min.	10 min.	13 min.	16 min.
Self-driving bus	72.9%	54.3%	33.9%	17.5%
Regular bus	17.6%	32.9%	50.7%	65.6%
Opt-out	9.5%	12.7%	15.4%	17.0%

Table H.4 Scenario 4: Slow and expensive with steward; probabilities of alternatives with changes in travel costs for self-driving bus with on-board steward

SDB travel costs	€1.00	€1.60	€2.20	€2.80
Self-driving bus	59.3%	41.0%	24.3%	12.6%
Regular bus	28.5%	44.3%	59.4%	70.0%
Opt-out	12.3%	14.7%	16.4%	17.4%

H.2. Travel costs variation for buses with travel time of 7 minutes

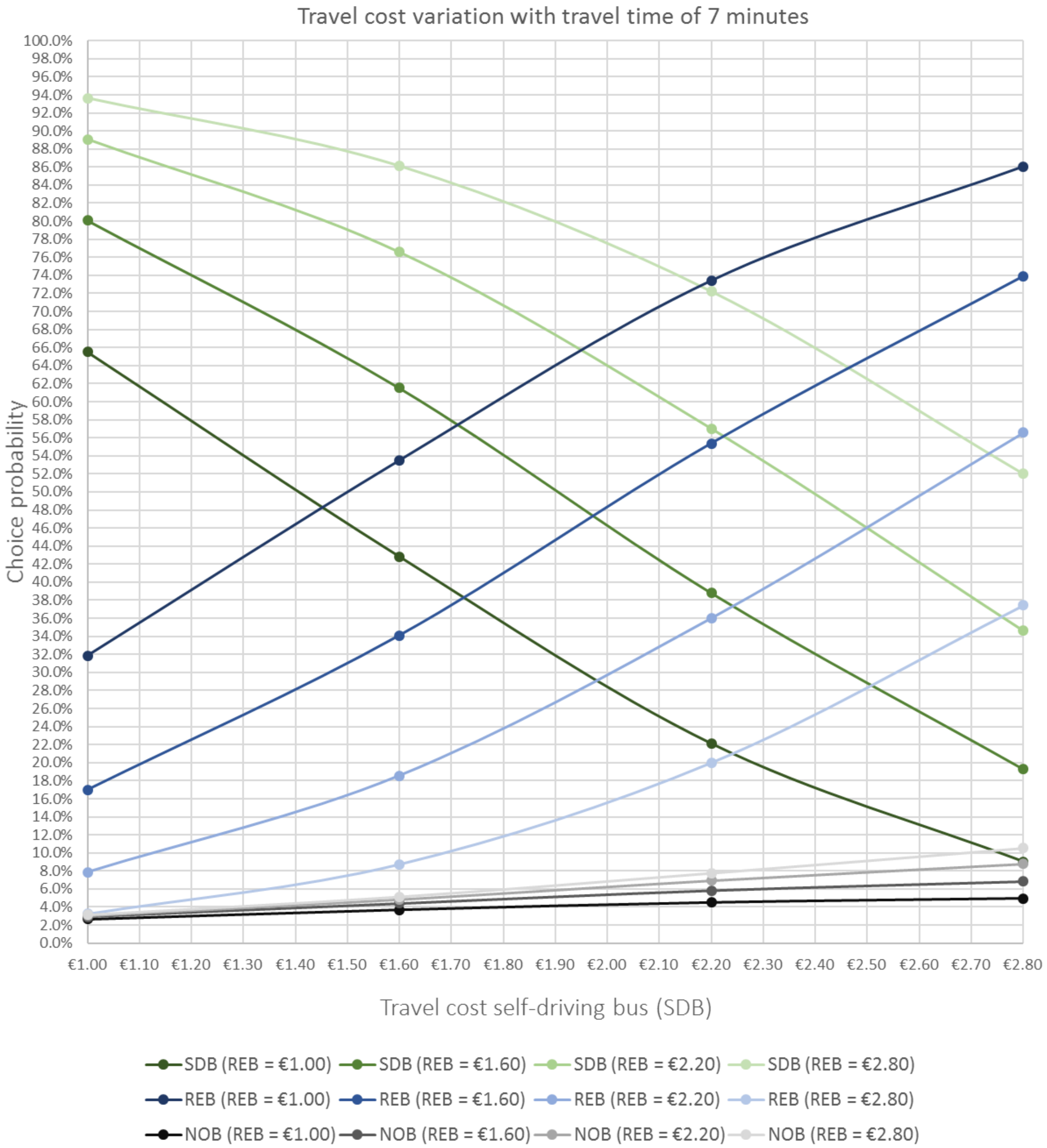

Figure H.1 Choice probabilities with travel cost variation for buses with travel time of 7 minutes (without on-board steward)

H.3. Travel costs variation for buses with travel time of 10 minutes

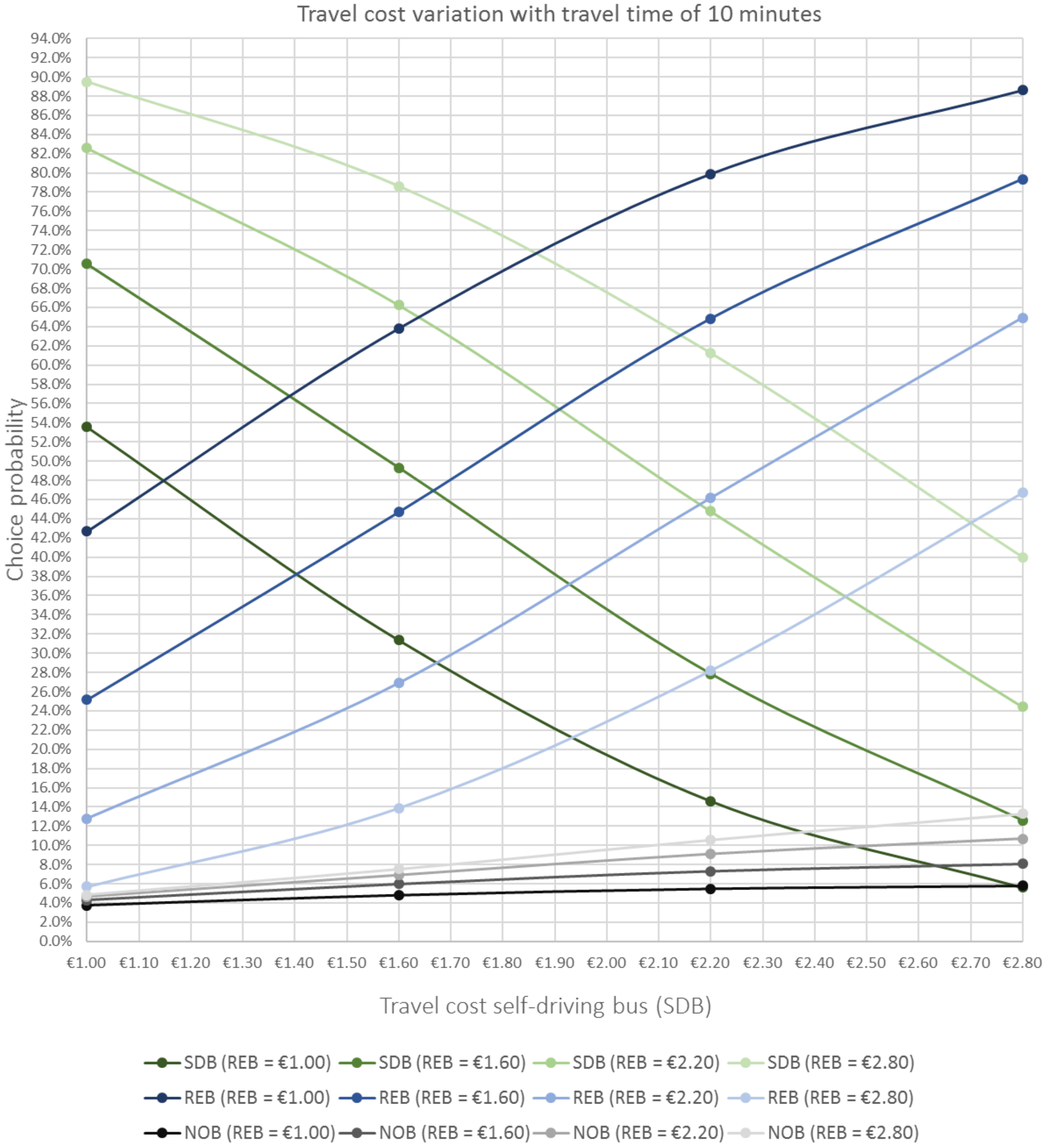

Figure H.2 Choice probabilities with travel cost variation for buses with travel time of 10 minutes (without on-board steward)

H.4. Travel costs variation for buses with travel time of 14 minutes

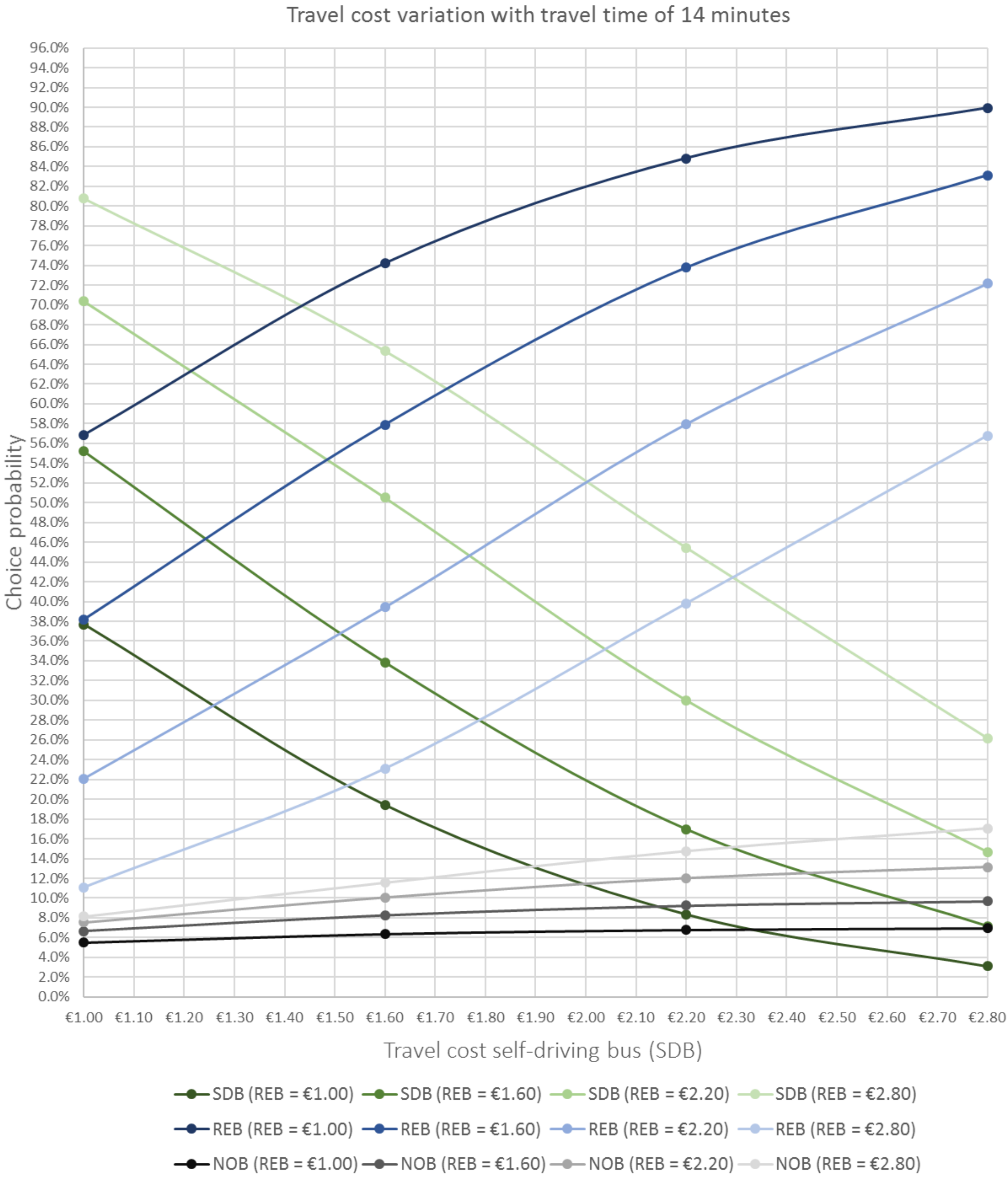

Figure H.3 Choice probabilities with travel cost variation for buses with travel time of 14 minutes (without on-board steward)

I. FIRST PRELIMINARY SURVEY

A preliminary survey was distributed to assess the level of understanding of the survey and to improve the survey for the final distribution.

I.1. CHOICE SETS

For the first survey, three alternatives were considered in the choice sets. The first alternative is the regular bus. Other alternatives are automated buses. To account for the different service types that are considered, the alternative of the automated bus is presented in two forms. The second alternative is a scheduled service, similar to the regular bus service; however, driven autonomously. The third alternative is the demand responsive automated bus, which enables the assessment of the relative preference for the service type of the automated bus. To inform the respondents, the differences between these types of services were clarified in the context description.

The design of the choice sets was based on an orthogonal design, which minimizes the correlation between attribute levels and creates attribute level balance. The attributes considered in the first survey were *travel time, travel cost, waiting time and surveillance type*. The attribute levels for travel time, travel costs and waiting time were based on existing bus trips in urban and suburban regions of the Netherlands, including the pilot region. The attributes and attribute levels are shown in Table I.1 and Table I.2, note that the attribute levels of the alternatives scheduled automated bus and demand responsive automated bus are similar.

Table I.1 First preliminary survey; Attributes and attribute levels for the automated buses, both on-demand and scheduled

Automated buses			
Attribute	Level 1	Level 2	Level 3
Travel time	6 minutes	8 minutes	10 minutes
Travel costs	€2.50	€4.00	€5.50
Waiting time	4 minutes	10 minutes	16 minutes
Type of surveillance	No surveillance	Information screen	Steward

Table I.2 First preliminary survey; Attributes and attribute levels for the regular bus

Regular bus			
Attribute	Level 1	Level 2	Level 3
Travel time	8 minutes	14 minutes	20 minutes
Travel costs	€2.00	€3.00	€4.00
Waiting time	4 minutes	8 minutes	12 minutes

I.2. ATTITUDINAL STATEMENTS

The attitudes towards public transport, technology, safety and convenience might be helpful indicators to estimate attitudinal factors affecting the choices. The attitudinal factors were quantified by presenting statements, which respondents are asked to rate to their level of agreement based on Likert scales.

The statements used in the first preliminary survey are shown in Table I.3.

Table I.3 Statements included in the first preliminary survey

Public Transport Attitude	
I prefer going by public transport than going by car.	Adapted from Abou-Zeid et al. (2010)
It makes me uncomfortable to ride on public transport with strangers.	Rubin (2011)
I feel safe to go by public transport.	Adapted from Abou-Zeid et al. (2010)
Traffic safety of automated vehicles	
I am afraid that the automated vehicle will not be fully aware of what is happening around him.	Adapted from Yap et al. (2016)
I believe an automated vehicle would drive better than the average human driver on populated streets.	Adapted from Casley et al. (2013)
I think that the automated driving system provides me with more safety compared to manually driving.	Adapted from Payre et al. (2014)
I would be comfortable entrusting the safety of a close family member to an automated vehicle.	Adapted from Casley et al. (2013)
I think that the automated shuttle only is safe when a steward is present.	
I try new products before my friends.	Adapted from Roehrich (2004)
Technology interest	
I am excited by the possibilities offered by new technologies.	Ewing and Sarigollu (2000)
I have little to no interest in new technology.	Adapted from Roehrich (2004)
I believe robot technology is in favour of society.	
New technologies create more problems than they solve.	Adapted from Jensen et al., 2014)
Convenience	
I think it is hard to understand how to use an automated shuttle.	Madigan et al. (2016)
Automated vehicles will make life easier.	Adapted from Haboucha et al. (2016)
I think that using the automated shuttle is more convenient than using normal busses.	Adapted from Madigan et al. (2016)
I like it that the automated shuttle can be used on-demand.	

I.3. Socio-economic characteristics

Table I.4 shows the socio-economic variables that were included in the first preliminary survey.

Table I.4 Socio-economic variables used in the first preliminary survey

Personal	(Travel) Behaviour
Age	Smartphone usage
Gender	Modes used to travel
Country of current residence	Use of public transport
Type of employment	Use of bus
Education level	Public transport cost reimbursement
Net annual income	Experience with ride sharing
	Measures that would change respondent's travel behaviour

I.4. Results first survey

In the first survey, 29 respondents completed the survey. One of the major concerns was the duration of the survey, filling out the survey took more than 20 minutes on average. For minimum respondent fatigue, the expected duration for the survey was aimed at a maximum of 15 minutes and an average of 10 minutes.

I.4.1. Choice sets

Respondents commented on a few parts of the survey. In the first survey, the payment method was discussed in the context description, a respondent mentioned the lack of the Dutch OV-chipcard as a payment method. Since the payment method is not of interest for this research, it was removed from the context description of the second preliminary survey to minimize the complexity of the context. Furthermore, the attributes describing the alternatives were almost clear, one comment was given about the high waiting times. The high waiting times seemed improbable when a person starts a trip from home and knows at what time the scheduled bus departs. For the second survey, the waiting times were slightly reduced. Since these are based on the average waiting times between the departure times of the scheduled buses from the pilot region, it was assumed that the new waiting times were correct.

Two respondents mentioned the trivial choice when the automated buses had the same attribute levels. In this context, one respondent chose for the scheduled automated bus since this was expected to be more reliable, but no reason was given specifically.

Multiple respondents mentioned their indifference regarding the type of surveillance, which would not affect their choice. These respondents were under 30 years old, which is as expected based on other research that found positive preferences regarding self-driving vehicles for younger people (for example Krueger et al., 2016). Interestingly, one (young) respondent mentioned the need of a present employee, which would be the only scenario for choosing the self-driving bus.

Realistic alternatives
The attribute levels that were considered for the travel costs represented unrealistic values of travel time. A maximum value of travel time (VoTT) of €90.00 per hour was present in the choice sets with a minimum of €10.00 per hour. An average commuter trip by bus ranges from €7.75 to €10.50 (Kouwenhoven et al., 2014). As a result of the high VoTTs of the attributes travel time and travel costs, the VoTTs of the parameter become high. The results gave a VoTT of €14.13/hour for the self-driving buses and a VoTT of €25.64/hour for the regular bus. Since the attribute levels do not represent realistic values of travel time, the levels were adapted for the second preliminary survey.

I.4.2. Base parameter estimation
From the first survey, parameter estimates were modelled with the use of PythonBiogeme. PythonBiogeme is an open source freeware designed for the maximum likelihood estimation of parametric models, which is based on an extension of the Python programming language, the models are developed by Michel Bierlaire (Bierlaire, 2016).

A few models were estimated to determine parameter values. Based on the parameter values, decisions could be made regarding the attribute levels and the need for any adjustments. For this estimation, the attributes were considered specific for the regular bus and generic for the automated buses. The model with all specific attributes did not fit the data significantly better than the model used in this base parameter estimation, see Table I.6. The specific betas of travel time for the scheduled and demand responsive automated buses are insignificant as well as the alternative specific constants, see Table I.6. The parameter estimations used in this section are depicted in Table I.5 below.

Table I.5 Base parameter values first preliminary survey – MNL generic for automated bus attributes

	Value	Std. error	t-test	p-value	Robust Std error	Robust t-test	p-value
Scheduled self-driving bus	-1.39	1.12	-1.24	0.21*	1.14	-1.22	0.22*
On-demand self-driving bus	-1.49	1.13	-1.32	0.19*	1.17	-1.27	0.20*
Communication screen	0.56	0.29	1.96	0.05*	0.27	2.10	0.04
Employer	0.54	0.28	1.94	0.05*	0.29	1.87	0.06*
Travel costs self-driving buses	-0.64	0.10	-6.12	0.00	0.11	-6.07	0.00
Travel costs regular bus	-0.65	0.21	-3.12	0.00	0.21	-3.11	0.00
Travel time self-driving buses	-0.15	0.08	-1.99	0.05	0.07	-2.02	0.04
Travel time regular bus	-0.28	0.04	-7.26	0.00	0.04	-7.54	0.00
Waiting time self-driving buses	-0.22	0.03	-7.46	0.00	0.03	-7.06	0.00
Waiting time regular bus	-0.19	0.05	-3.43	0.00	0.05	-3.59	0.00

The values for *travel cost, travel time and waiting time* are of expected sign. An increase in cost or time will decrease the utility of the alternative, the probability that the respective alternative is chosen will decrease. The alternative specific constants for both the automated buses and the presence of a steward were found not to be significant. The indicator variable for steward (*Employer*) is not significantly different from zero. The communication screen is significant and has the expected positive sign. According to the first survey data, the presence of a form of surveillance with a communication screen increases the utility of the automated bus.

Table I.6 Statistics of MNL models from parameter estimations of first preliminary survey

Estimation information	MNL generic automated bus attributes	MNL specific for all attributes
Number of estimated parameters	9	13
Number of observations	261	261
Null log likelihood	-286.74	-286.74
Final log likelihood	-198.81	-198.64
Likelihood ratio test for the null model	175.86	176.20
Rho-square-bar for the model	0.28	0.26

Table I.7 Parameter estimation MNL specific for all attributes

Parameter (beta)	Value	Standard error	t-test	p-value	Robust Std error	Robust t-test	p-value
Scheduled self-driving bus	-1.42	1.42	-1.00	0.32*	1.47	-0.97	0.33*
On-demand (DRT) self-driving bus	-1.49	1.29	-1.15	0.25*	1.33	-1.12	0.26*
Communication screen	0.58	0.30	1.92	0.05*	0.27	2.15	0.03
Employer	0.55	0.28	1.95	0.05*	0.29	1.88	0.06*
Travel costs Scheduled self-driving bus	-0.63	0.14	-4.60	0.00	0.14	-4.42	0.00
Travel costs DRT self-driving bus	-0.65	0.15	-4.26	0.00	0.15	-4.41	0.00
Travel costs regular bus	-0.65	0.21	-3.11	0.00	0.21	-3.11	0.00
Travel time Scheduled self-driving bus	-0.15	0.10	-1.47	0.14*	0.11	-1.41	0.16*
Travel time DRT self-driving bus	-0.14	0.11	-1.27	0.21*	0.11	-1.27	0.20*
Travel time regular bus	-0.28	0.04	-7.26	0.00	0.04	-7.55	0.00
Waiting time Scheduled self-driving bus	-0.22	0.04	-5.98	0.00	0.04	-6.04	0.00
Waiting time DRT self-driving bus	-1.42	1.42	-5.66	0.00	0.04	-5.42	0.00
Waiting time regular bus	-1.49	1.29	-3.43	0.00	0.05	-3.57	0.00

I.4.3. STATEMENTS

For the first preliminary survey, the responses on the statements were used to verify if the respondents answered similarly, see the statements in Figure I.1. This is important to represent a latent variable. It was decided to remove the public transport statements since the sample group consists of public transport users. Their attitudes towards public transport were assumed to be similar and are not relevant for this research specifically. The statement “I believe robot technology is in favour of society.” was removed. The statement was not clear according to some respondents, and the remaining statements are analysed by Haboucha et al. (2016) that formed a latent factor from the confirmatory factor analysis.

The statement “I like that the automated shuttle can be used on-demand.” was revised to a more specific statement regarding the on-demand service of the self-driving bus with the intention to get a clearer picture of the attitude towards the on-demand service.

	S_1	S_2	S_3	S_4	S_5	S_6	S_7	S_8	S_9	S_10	S_11	S_12	S_13	S_14	S_15	S_16	S_17
	I prefer going by public transport than going by car	It makes me uncomfortable to ride on public transit with strangers	I feel safe to go by public transport	I am afraid that automated vehicles are not fully aware of what is happening around them	I believe an automated vehicle would drive better than the average human driver on populated streets	I think that the automated driving system provides me more safety compared to manually driving	I would be comfortable entrusting the safety of a close family member to an automated vehicle	I think that the automated shuttle only is safe when a steward is present	I usually try new products before my friends	I am excited by the possibilities offered by new technologies	I believe robot technology is in favour of society	I have little to no interest in new technology	New technologies create more problems than they solve	I think it is hard to understand how to use an automated shuttle	Automated vehicles will make life easier	I like that the automated shuttle can be used on-demand	I think that using the automated shuttle is more convenient than using normal busses
DISAGREE	6	13	0	2	2	0	1	8	5	1	1	12	7	9	2	1	2
	7	7	2	7	7	6	5	7	9	1	3	7	13	12	1	2	4
	6	3	2	9	6	9	7	3	4	3	12	2	4	3	7	3	10
	3	2	8	5	7	8	10	5	6	13	8	3	1	1	11	6	6
AGREE	3	0	13	2	3	2	2	2	1	7	1	1	0	0	4	13	3

Figure I.1 Grouped answers on statements first preliminary survey

I.4.4. Socio-demographic questions

Some questions regarding socio-demographics were unclear. For a proper picture of the modes used by the respondents, they were asked to arrange the modes. This question was adapted in the second survey to avoid as much confusion as possible. Furthermore, the question about cost reimbursement was adapted for bus subscriptions specifically, and the question about measures that would change people's behaviour was replaced by a new question to limit the focus to self-driving buses. Other questions were slightly adapted with different answer categories.

J. Second preliminary survey

A second survey was conducted for a final assessment of the survey. The second preliminary survey included the new choice set design and the adapted statements and questions.

J.1. Updated survey design

Based on the comments and modelling of the first preliminary survey the attributes and attribute levels were adjusted, see the considered levels in Table J.1.. In Figure J.1, an example of a choice set is given, which was presented to the respondents.

The attributes were similar for both alternatives. The choice for similar attribute levels was made to simplify the choice sets for the respondents. With different attribute levels between the alternatives, the alternative specific constants could be influenced by these differences. By eliminating these differences, the specific preferences for the alternatives themselves are emphasized. However, alternatives with the same attribute levels potentially limit the trade-off information from the design, which could be overcome by adding more choice sets (Johnson et al., 2013).

Table J.1 Attributes and attribute levels of second preliminary survey

Attribute	Level 1	Level 2	Level 3
Travel time	8 minutes	12 minutes	16 minutes
Travel cost	€ 1.30	€ 2.00	€ 2.70
Waiting time	2 minutes	8 minutes	14 minutes
Surveillance	Standard	Communication screen	Bus employee
Service	Scheduled	On-demand	

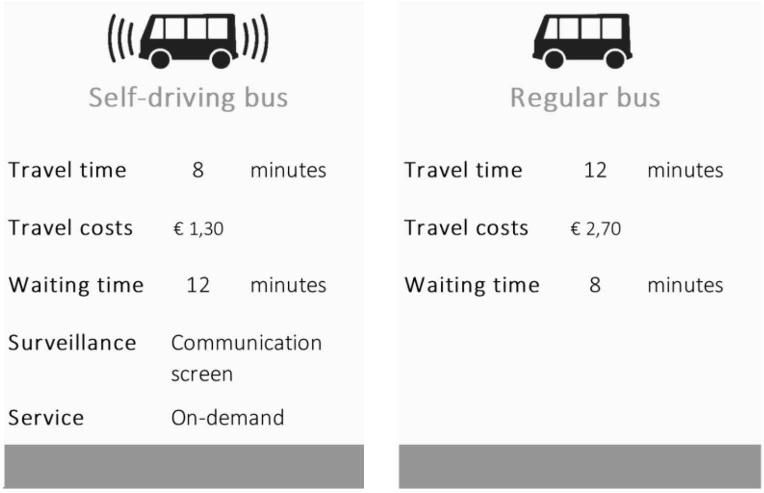

Figure J.1 Choice set example second preliminary survey

The values of travel time represented realistic values, around the range of €7,75 and €10,50, see Table J.2.

Table J.2 Values of travel time from attribute levels in second preliminary survey

	VoT (€/hour)
Max. VoT:	€ 21.00
	€ 10.50
Min. VoT:	€ 5.25

In Table J.3 the socio-demographic variables used in the second preliminary survey are shown.

Table J.3 Socio-demographic variables used in the second preliminary survey

Personal	(Travel) Behaviour related
Gender	Smartphone usage
Age	Use of public transport
Type of employment	Use of bus
Education level	Modes used to travel
Net annual income	Situation in which respondents use the bus
	Considering more bus use
	Subscription for bus trips
	Experience with ride sharing

J.2. Results second preliminary survey

In total 25 people filled out the second preliminary survey. In the first survey, the duration of the survey was about 20 minutes, the aim was to have a duration of 10 minutes on average. With the second survey, the average duration was 11 minutes. This suggested that the survey content should not increase for the final survey.

There were no comments regarding the content of the choice sets, statements and socio-demographic questions. However, the text of the choice sets appeared to be too small for the respondents. For the final survey, the text size was increased for readability.

J.2.1. Base parameter estimation

For the second preliminary survey, an MNL model was estimated with the attributes presented to the respondents, see Table J.4. The values for *travel costs, travel time and waiting time* are of expected sign. An increase in cost or time will decrease the utility of the alternative, the probability that the respective alternative is chosen will decrease.

The findings from the model estimation are shortly discussed. Changes made to the final design are discussed in chapter 5.
The alternative specific constant for the self-driving bus is not significant, similar to the first survey estimation outcomes. The service type was found not to be significant, which indicates that the service of a self-driving bus, either scheduled or on-demand, does not influence the utility of the self-driving bus significantly. Contrary to the first survey results, the parameter of the communication screen is not significant and the presence of a bus employee is significant with a positive parameter value. For the final survey the attribute level 'communication screen' was rephrased as an 'interactive screen' to emphasize the interactive alternative to a bus employee.

A preliminary estimation of the parameters shows that the values of travel time reduction are in the range of the bus VoTT for the self-driving bus (€7.84/hour) and slightly below the range for the regular bus (€7.15/hour).

Table J.4 Model estimation second preliminary survey

Parameter (beta)	Value	Std. error	t-test	p-value	Robust Std. error	Robust t-test	p-value
Constant self-driving bus	-1.81	1.18	-1.53	0.13*	1.24	-1.47	0.14*
Communication screen	-0.04	0.55	-0.07	0.94*	0.54	-0.07	0.94*
Bus employee	1.41	0.59	2.40	0.02	0.63	2.23	0.03
Service type	0.15	0.58	0.26	0.80*	0.60	0.25	0.80*
Travel costs self-driving bus	-2.57	0.62	-4.17	0.00	0.57	-4.47	0.00
Travel costs regular bus	-2.82	0.70	-4.02	0.00	0.74	-3.83	0.00
Travel time self-driving bus	-0.34	0.10	-3.51	0.00	0.08	-4.03	0.00
Travel time regular bus	-0.34	0.10	-3.42	0.00	0.09	-3.56	0.00
Waiting time self-driving bus	-0.37	0.09	-4.30	0.00	0.07	-5.25	0.00
Waiting time regular bus	-0.47	0.11	-4.47	0.00	0.11	-4.50	0.00

Table J.5 Statistics second preliminary survey model estimation

Number of estimated parameters	10
Number of observations	225
Null log likelihood	-155.96
Final log likelihood	-80.80
Likelihood ratio test for the null model	150.32
Rho-square-bar for the init. model	0.42

J.2.2. Statements

Figure J.2 shows the grouped answers of the statements. The statement "I think using an automated bus will be easy" was removed from the list of statements for the final survey because it was expected that the description of the choice experiment would have a large influence on the level of agreement. Moreover, the level of agreement should represent the current attitude towards self-driving buses and should not be based on the way in which the self-driving bus was introduced in the choice experiment.

	1	2	3	4	5	6	7	8	9	10	11	12	13
	I am afraid that automated vehicles cannot fully detect what is happening around them	I believe automated vehicles drive better than the average human driver	I think that an automated vehicle provides me more safety compared to manually driving	I would entrust the safety of a close relative to a self-driving vehicle.	I think that an automated bus is only safe when a bus employee is present	I usually try new products before my friends	I am excited by the possibilities offered by new technologies	I have little to no interest in new technology	Most of the times new technologies create more problems than they solve	I think using an automated bus will be easy	Automated vehicles will make life easier	The best part of the automated bus is that it can be requested on demand	I think that using an automated bus will be more convenient than using normal busses
DISAGREE	4	0	1	1	4	4	1	7	10	1	3	3	3
	3	9	9	4	9	4	2	8	6	4	3	6	8
	9	6	6	7	0	10	5	3	6	7	8	5	9
	7	8	7	9	9	5	10	5	2	9	9	9	4
AGREE	1	1	1	3	2	1	6	1	0	3	1	1	0

Figure J.2 Grouped answers on statements second preliminary survey

J.2.3. Socio-economic variables

For the final survey, some questions were slightly adapted. One question was added asking the postal code number to assess the urban or non-urban living area of the respondents. The answer categories for the consideration of bus usage were divided based on service types. This allows assessing the willingness to use the self-driving bus and to compare the answers with the parameter estimates. Furthermore, the question about the way in which people use the bus was adapted to gather more insight in the trip stage in which the bus is used.

K. FINAL SURVEY

The survey is shown on the next page.

Vernieuwingen in het busvervoer

Introductie

Deze enquête wordt uitgevoerd als onderdeel van mijn afstudeeronderzoek aan de Technische Universiteit Delft in samenwerking met Royal HaskoningDHV. De resultaten van deze enquête worden gebruikt voor onderzoek naar de voorkeuren van openbaar vervoer gebruikers met betrekking tot busvervoer in stedelijk en randstedelijk gebied.

Alle informatie wordt **anoniem** verzameld en zal **uitsluitend** worden gebruikt **voor dit onderzoek**. De gegevens worden **niet gedeeld met derden**.

Als dank voor uw deelname worden vijf bol.com bonnen ter waarde van €20,- verloot, hiervoor kunt u vrijwillig uw e-mailadres invullen.

Het invullen van de enquête duurt **ongeveer 10 – 15 minuten**. U kunt de enquête tussentijds pauzeren totdat u de enquête volledig hebt ingevuld. Indien gewenst kunt u de enquête altijd voortijdig beëindigen door rechtsboven op 'Afsluiten' te klikken, uw informatie zal dan worden verwijderd.

Joost Wien

Bij vragen kunt u contact opnemen via:

joost.wien@rhdhv.com

TU Delft Delft University of Technology

Royal HaskoningDHV Enhancing Society Together

Vernieuwingen in het busvervoer

Onderdeel 1 -
Introductie

In het eerste onderdeel krijgt u verschillende reisalternatieven voor een busrit te zien.
U wordt gevraagd het reisalternatief te kiezen dat uw voorkeur heeft.

De reisalternatieven worden kort toegelicht, gelieve de uitleg door te nemen voordat u naar de vragen gaat.

Onderdeel 1 -
Introductie

Stelt u zich een busrit voor naar een werkplek of studieplek in uw regio. De bus vertrekt dichtbij uw huis en stopt op loopafstand (50 m) van de bestemming.

U kunt kiezen uit een rit met een **reguliere bus**, een **zelfrijdende bus** of aangeven dat u liever voor een ander vervoermiddel kiest.

VII. De **Reguliere bus** wordt bestuurd door een buschauffeur. De bus rijdt volgens een vaste route en op vaste tijden, op basis van een dienstregeling. Een reguliere bus beschikt over ongeveer **45** stoelen en een rolstoelvriendelijke ingang, daarbij is er een informatiescherm aanwezig die u van reisinformatie voorziet en camera's voor toezicht.

2. De **Zelfrijdende bus** rijdt automatisch, daarom is er geen buschauffeur aanwezig. De zelfrijdende bus heeft **15** zitplaatsen en een rolstoelvriendelijke ingang. Ook rijdt de zelfrijdende bus volgens een vaste route, maar de **service** kan verschillen:

- De zelfrijdende bus kan rijden met een ***dienstregeling*** op vaste tijden of;
- rijdt alleen wanneer u de bus ***aanvraagt***. Bij uw *aanvraag* zal de zelfrijdende bus u bij de bushalte ophalen.
  - U vraagt de zelfrijdende bus aan via de website of de reis-app van de busmaatschappij
  - Na de eerste aanvraag kunnen ook andere mensen de zelfrijdende bus aanvragen

Toezicht & Informatie

Verder kunnen er in de zelfrijdende bus maatregelen voor toezicht en informatie getroffen worden. Standaard maatregelen zijn een informatiescherm en camera's, net als in de reguliere bus. Daarnaast kan een *busmedewerker* worden ingezet of een *interactief scherm* worden geplaatst.

- Een ***busmedewerker***
  - Zal de controle over het zelfrijdende voertuig overnemen in gevaarlijke situaties
  - Kan u voorzien van reisinformatie

-

- Een ***interactief scherm***
  - Laat u zien wat de sensoren van de zelfrijdende bus onderweg zien
  - Geeft u de mogelijkheid contact op te nemen met de busmaatschappij, zij kunnen u in een videogesprek te woord staan voor reisinformatie of helpen in geval van nood.

3. Wanneer u met geen van de bussen wilt reizen, kunt u als derde optie kiezen voor een ander vervoermiddel, bijvoorbeeld de auto, fiets of taxi.

Vernieuwingen in het busvervoer

Onderdeel 1 - Voorbeeldvraag busrit en alternatieven

U krijgt 6 reisalternatieven van verschillende busritten te zien, voordat u wordt gevraagd uw voorkeur voor de busritten aan te geven, wordt een voorbeeldvraag getoond.

DIT IS EEN VOORBEELD

Stelt u zich een busrit voor naar een werkplek of studieplek in uw regio. De bus vertrekt dichtbij uw huis en stopt op loopafstand (50 m) van de bestemming.

Welk alternatief zou u kiezen voor de rit?

	Zelfrijdende bus	Reguliere bus
Reistijd	10 minuten	7 minuten
Reiskosten	€ 2,20	€ 1,60
Wachttijd	2 minuten	6 minuten
Toezicht & Informatie	Busmedewerker	
Service	Op aanvraag	

◯ Zelfrijdende bus

◯ Reguliere bus

◯ Ik zou een ander vervoermiddel kiezen

Voor elk reisalternatief zullen de eigenschappen verschillen, dit zijn '*reistijd', 'reiskosten', 'wachttijd', 'toezicht & informatie' en 'service'*. De eigenschappen worden kort toegelicht:

- **Reistijd** is de tijd in het voertuig vanaf de bushalte naar de bushalte dichtbij uw bestemming.

- **Reiskosten** zijn de kosten voor een enkele reis.

- **Wachttijd** is de tijd die u moet wachten totdat de reguliere of zelfrijdende bus bij de bushalte aankomt.

- **Toezicht & Informatie** geeft weer of er een *busmedewerker* aanwezig is, een *interactief scherm* is geplaatst of dat er alleen *standaard* maatregelen in de zelfrijdende bus aanwezig zijn. In de reguliere bus zijn alleen de standaard maatregelen en de buschauffeur aanwezig.

- **Service** geeft aan of de zelfrijdende bus met een *dienstregeling* (vaste tijden) rijdt of alleen wanneer u de zelfrijdende bus *aanvraagt*. De reguliere bus rijdt altijd met een dienstregeling op vaste tijden.

Vernieuwingen in het busvervoer

Onderdeel 1/3

Stelt u zich een busrit voor naar een werkplek of studieplek in uw regio. De bus vertrekt dichtbij uw huis en stopt op loopafstand (50 m) van de bestemming.

Let op: De eigenschappen verschillen voor ieder alternatief.

** Op deze vragen wordt een antwoord vereist.*

* 1. Welk alternatief zou u kiezen voor de rit?

	Zelfrijdende bus		Reguliere bus	
Reistijd	7	minuten	7	minuten
Reiskosten	€ 1,00		€ 1,00	
Wachttijd	2	minuten	2	minuten
Toezicht & Informatie	Busmedewerker			
Service	Dienstregeling			

- Zelfrijdende bus
- Reguliere bus
- Ik zou een ander vervoermiddel kiezen

* 2. Welk alternatief zou u kiezen voor de rit?

	Zelfrijdende bus		Reguliere bus	
Reistijd	16	minuten	10	minuten
Reiskosten	€ 2,20		€ 2,20	
Wachttijd	6	minuten	6	minuten
Toezicht & Informatie	Busmedewerker			
Service	Dienstregeling			

- Zelfrijdende bus
- Reguliere bus
- Ik zou een ander vervoermiddel kiezen

* 3. Welk alternatief zou u kiezen voor de rit?

	Zelfrijdende bus		Reguliere bus	
Reistijd	10	minuten	16	minuten
Reiskosten	€ 1,60		€ 1,00	
Wachttijd	4	minuten	6	minuten
Toezicht & Informatie	Interactief scherm			
Service	Op aanvraag			

- ◯ Zelfrijdende bus
- ◯ Reguliere bus
- ◯ Ik zou een ander vervoermiddel kiezen

* 4. Welk alternatief zou u kiezen voor de rit?

	Zelfrijdende bus		Reguliere bus	
Reistijd	13	minuten	10	minuten
Reiskosten	€ 1,60		€ 2,20	
Wachttijd	8	minuten	4	minuten
Toezicht & Informatie	Interactief scherm			
Service	Dienstregeling			

- ◯ Zelfrijdende bus
- ◯ Reguliere bus
- ◯ Ik zou een ander vervoermiddel kiezen

* 5. Welk alternatief zou u kiezen voor de rit?

	Zelfrijdende bus		Reguliere bus	
Reistijd	7	minuten	16	minuten
Reiskosten	€ 2,20		€ 1,60	
Wachttijd	8	minuten	2	minuten
Toezicht & Informatie	Standaard			
Service	Op aanvraag			

- ◯ Zelfrijdende bus
- ◯ Reguliere bus
- ◯ Ik zou een ander vervoermiddel kiezen

* 6. Welk alternatief zou u kiezen voor de rit?

	Zelfrijdende bus	Reguliere bus
Reistijd	16 minuten	13 minuten
Reiskosten	€ 1,60	€ 2,80
Wachttijd	6 minuten	2 minuten
Toezicht & Informatie	Standaard	
Service	Op aanvraag	

- ◯ Zelfrijdende bus
- ◯ Reguliere bus
- ◯ Ik zou een ander vervoermiddel kiezen

Einde van het eerste onderdeel.

Vernieuwingen in het busvervoer

Onderdeel 1/3

Stelt u zich een busrit voor naar een werkplek of studieplek in uw regio. De bus vertrekt dichtbij uw huis en stopt op loopafstand (50 m) van de bestemming.

Let op: De eigenschappen verschillen voor ieder alternatief.

** Op deze vragen wordt een antwoord vereist.*

* 7. Welk alternatief zou u kiezen voor de rit?

	Zelfrijdende bus		Reguliere bus	
Reistijd	16	minuten	7	minuten
Reiskosten	€ 1,60		€ 1,00	
Wachttijd	2	minuten	8	minuten
Toezicht & Informatie	Standaard			
Service	Op aanvraag			

- Zelfrijdende bus
- Reguliere bus
- Ik zou een ander vervoermiddel kiezen

* 8. Welk alternatief zou u kiezen voor de rit?

	Zelfrijdende bus		Reguliere bus	
Reistijd	7	minuten	10	minuten
Reiskosten	€ 2,20		€ 2,20	
Wachttijd	4	minuten	8	minuten
Toezicht & Informatie	Standaard			
Service	Op aanvraag			

- Zelfrijdende bus
- Reguliere bus
- Ik zou een ander vervoermiddel kiezen

* 9. Welk alternatief zou u kiezen voor de rit?

	Zelfrijdende bus	Reguliere bus
Reistijd	16 minuten	16 minuten
Reiskosten	€ 2,80	€ 1,60
Wachttijd	8 minuten	8 minuten
Toezicht & Informatie	Busmedewerker	
Service	Dienstregeling	

- Zelfrijdende bus
- Reguliere bus
- Ik zou een ander vervoermiddel kiezen

* 10. Welk alternatief zou u kiezen voor de rit?

	Zelfrijdende bus	Reguliere bus
Reistijd	7 minuten	13 minuten
Reiskosten	€ 1,60	€ 2,80
Wachttijd	4 minuten	4 minuten
Toezicht & Informatie	Busmedewerker	
Service	Dienstregeling	

- Zelfrijdende bus
- Reguliere bus
- Ik zou een ander vervoermiddel kiezen

* 11. Welk alternatief zou u kiezen voor de rit?

	Zelfrijdende bus	Reguliere bus
Reistijd	13 minuten	7 minuten
Reiskosten	€ 2,20	€ 1,60
Wachttijd	6 minuten	4 minuten
Toezicht & Informatie	Interactief scherm	
Service	Op aanvraag	

- Zelfrijdende bus
- Reguliere bus
- Ik zou een ander vervoermiddel kiezen

* 12. Welk alternatief zou u kiezen voor de rit?

	Zelfrijdende bus	Reguliere bus
Reistijd	10 minuten	13 minuten
Reiskosten	€ 2,20	€ 2,80
Wachttijd	2 minuten	6 minuten
Toezicht & Informatie	Interactief scherm	
Service	Dienstregeling	

- ◯ Zelfrijdende bus
- ◯ Reguliere bus
- ◯ Ik zou een ander vervoermiddel kiezen

Einde van het eerste onderdeel.

Vernieuwingen in het busvervoer

Onderdeel 1/3

Stelt u zich een busrit voor naar een werkplek of studieplek in uw regio. De bus vertrekt dichtbij uw huis en stopt op loopafstand (50 m) van de bestemming.

Let op: De eigenschappen verschillen voor ieder alternatief.

** Op deze vragen wordt een antwoord vereist.*

* 13. Welk alternatief zou u kiezen voor de rit?

	Zelfrijdende bus		Reguliere bus	
Reistijd	7	minuten	13	minuten
Reiskosten	€ 2,80		€ 2,20	
Wachttijd	6	minuten	8	minuten
Toezicht & Informatie	Busmedewerker			
Service	Op aanvraag			

- ◯ Zelfrijdende bus
- ◯ Reguliere bus
- ◯ Ik zou een ander vervoermiddel kiezen

* 14. Welk alternatief zou u kiezen voor de rit?

	Zelfrijdende bus		Reguliere bus	
Reistijd	16	minuten	13	minuten
Reiskosten	€ 2,20		€ 1,00	
Wachttijd	4	minuten	4	minuten
Toezicht & Informatie	Standaard			
Service	Dienstregeling			

- ◯ Zelfrijdende bus
- ◯ Reguliere bus
- ◯ Ik zou een ander vervoermiddel kiezen

* 15. Welk alternatief zou u kiezen voor de rit?

	Zelfrijdende bus		Reguliere bus	
Reistijd	10	minuten	7	minuten
Reiskosten	€ 1,00		€ 1,60	
Wachttijd	8	minuten	8	minuten
Toezicht & Informatie	Busmedewerker			
Service	Op aanvraag			

- Zelfrijdende bus
- Reguliere bus
- Ik zou een ander vervoermiddel kiezen

* 16. Welk alternatief zou u kiezen voor de rit?

	Zelfrijdende bus		Reguliere bus	
Reistijd	13	minuten	7	minuten
Reiskosten	€ 2,80		€ 1,60	
Wachttijd	4	minuten	6	minuten
Toezicht & Informatie	Interactief scherm			
Service	Dienstregeling			

- Zelfrijdende bus
- Reguliere bus
- Ik zou een ander vervoermiddel kiezen

* 17. Welk alternatief zou u kiezen voor de rit?

	Zelfrijdende bus		Reguliere bus	
Reistijd	13	minuten	16	minuten
Reiskosten	€ 1,00		€ 2,80	
Wachttijd	2	minuten	8	minuten
Toezicht & Informatie	Interactief scherm			
Service	Op aanvraag			

- Zelfrijdende bus
- Reguliere bus
- Ik zou een ander vervoermiddel kiezen

* 18. Welk alternatief zou u kiezen voor de rit?

	Zelfrijdende bus	Reguliere bus
Reistijd	10 minuten	10 minuten
Reiskosten	€ 2,80	€ 2,80
Wachttijd	2 minuten	4 minuten
Toezicht & Informatie	Standaard	
Service	Dienstregeling	

- ◯ Zelfrijdende bus
- ◯ Reguliere bus
- ◯ Ik zou een ander vervoermiddel kiezen

Einde van het eerste onderdeel.

Stelt u zich een busrit voor naar een werkplek of studieplek in uw regio. De bus vertrekt dichtbij uw huis en stopt op loopafstand (50 m) van de bestemming.

Let op: De eigenschappen verschillen voor ieder alternatief.

** Op deze vragen wordt een antwoord vereist.*

* 19. Welk alternatief zou u kiezen voor de rit?

	Zelfrijdende bus	Reguliere bus
Reistijd	13 minuten	16 minuten
Reiskosten	€ 2,80	€ 1,00
Wachttijd	2 minuten	2 minuten
Toezicht & Informatie	Busmedewerker	
Service	Op aanvraag	

- ◯ Zelfrijdende bus
- ◯ Reguliere bus
- ◯ Ik zou een ander vervoermiddel kiezen

* 20. Welk alternatief zou u kiezen voor de rit?

	Zelfrijdende bus	Reguliere bus
Reistijd	10 minuten	16 minuten
Reiskosten	€ 1,00	€ 1,00
Wachttijd	6 minuten	4 minuten
Toezicht & Informatie	Interactief scherm	
Service	Dienstregeling	

- ◯ Zelfrijdende bus
- ◯ Reguliere bus
- ◯ Ik zou een ander vervoermiddel kiezen

* 21. Welk alternatief zou u kiezen voor de rit?

	Zelfrijdende bus	Reguliere bus
Reistijd	10 minuten	7 minuten
Reiskosten	€ 2,80	€ 2,20
Wachttijd	8 minuten	2 minuten
Toezicht & Informatie	Interactief scherm	
Service	Op aanvraag	

- [ ] Zelfrijdende bus
- [ ] Reguliere bus
- [ ] Ik zou een ander vervoermiddel kiezen

* 22. Welk alternatief zou u kiezen voor de rit?

	Zelfrijdende bus	Reguliere bus
Reistijd	13 minuten	13 minuten
Reiskosten	€ 1,00	€ 2,20
Wachttijd	8 minuten	6 minuten
Toezicht & Informatie	Standaard	
Service	Dienstregeling	

- [ ] Zelfrijdende bus
- [ ] Reguliere bus
- [ ] Ik zou een ander vervoermiddel kiezen

* 23. Welk alternatief zou u kiezen voor de rit?

	Zelfrijdende bus	Reguliere bus
Reistijd	16 minuten	10 minuten
Reiskosten	€ 1,00	€ 2,80
Wachttijd	4 minuten	2 minuten
Toezicht & Informatie	Busmedewerker	
Service	Op aanvraag	

- [ ] Zelfrijdende bus
- [ ] Reguliere bus
- [ ] Ik zou een ander vervoermiddel kiezen

* 24. Welk alternatief zou u kiezen voor de rit?

	 Zelfrijdende bus		 Reguliere bus	
Reistijd	7	minuten	10	minuten
Reiskosten	€ 1,60		€ 1,60	
Wachttijd	6	minuten	6	minuten
Toezicht & Informatie	Standaard			
Service	Dienstregeling			

- Zelfrijdende bus
- Reguliere bus
- Ik zou een ander vervoermiddel kiezen

Einde van het eerste onderdeel.

In het tweede onderdeel wordt u gevraagd uw mening over stellingen te geven.
Geef aan in hoeverre u het eens bent met de onderstaande stellingen van 1 tot en met 5.
1 = Volledig mee oneens,
2 = Enigszins mee oneens,
3 = Neutraal,
4 = Enigszins mee eens,
5 = Volledig mee eens

Voor elke stelling kunt u het bolletje slepen of een getal van 1 tot en met 5 invoeren.

** Op deze vragen wordt een antwoord vereist.*

* 25. Ik denk dat zelfrijdende voertuigen beter rijden dan de gemiddelde bestuurder.

Volledig mee oneens | Neutraal | Volledig mee eens

* 26. Ik ben bang dat zelfrijdende voertuigen niet volledig kunnen detecteren wat er om hen heen gebeurt.

Volledig mee oneens | Neutraal | Volledig mee eens

* 27. Ik denk dat een zelfrijdend voertuig mij meer veiligheid biedt dan handmatige besturing.

Volledig mee oneens | Neutraal | Volledig mee eens

* 28. Ik zou de veiligheid van een naaste toevertrouwen aan een zelfrijdende auto.

Volledig mee oneens | Neutraal | Volledig mee eens

* 29. Ik denk dat een zelfrijdende bus alleen veilig is als een busmedewerker aanwezig is.

Volledig mee oneens | Neutraal | Volledig mee eens

* 30. Ik probeer meestal nieuwe producten voordat anderen dat doen.

Volledig mee oneens | Neutraal | Volledig mee eens

* 31. Ik ben enthousiast over de mogelijkheden die nieuwe technologieën bieden.

Volledig mee oneens | Neutraal | Volledig mee eens

* 32. Ik heb weinig tot geen interesse in nieuwe technologie.

Volledig mee oneens | Neutraal | Volledig mee eens

* 33. Meestal creëren nieuwe technologieën meer problemen dan dat ze oplossen.

Volledig mee oneens | Neutraal | Volledig mee eens

* 34. Zelfrijdende voertuigen zullen het leven makkelijker maken.

Volledig mee oneens | Neutraal | Volledig mee eens

* 35. Het beste van de zelfrijdende bus is dat het op verzoek kan worden aangevraagd.

Volledig mee oneens | Neutraal | Volledig mee eens

* 36. Ik denk dat het gebruik van een zelfrijdende bus handiger is dan het gebruik van reguliere bussen.

Volledig mee oneens | Neutraal | Volledig mee eens

* 37. Ik zou mij prettiger voelen in een zelfrijdende bus met vele passagiers dan met een paar passagiers.

Volledig mee oneens | Neutraal | Volledig mee eens

* 38. Een interactief scherm is een goede vervanging voor een busmedewerker in de zelfrijdende bus.

Volledig mee oneens | Neutraal | Volledig mee eens

* 39. Ik zou mij prettiger voelen in een zelfrijdende bus dan in een reguliere bus.

Volledig mee oneens | Neutraal | Volledig mee eens

Einde van het tweede onderdeel.

Vernieuwingen in het busvervoer

Achtergrondinformatie - Onderdeel
3/3

Dit is het laatste onderdeel, hier wordt u gevraagd achtergrondinformatie in te vullen. ***Alle antwoorden*** *worden* ***vertrouwelijk*** *en* ***anoniem*** *behandeld.*

** Op deze vragen wordt een antwoord vereist.*

40. Wat is uw geslacht?

- Vrouw
- Man

41. Wat is uw geboortejaar?

42. Wat is uw huidige beroep?

- Werkend full time
- Werkend part time
- Student
- Ik heb op dit moment geen werk
- Vrijwilligerswerk
- Met pensioen

43. Wat is uw hoogst behaalde, of huidige, opleidingsniveau?

- VMBO (MAVO)
- HAVO
- VWO
- MBO
- HBO
- WO
- Overige (geef nadere toelichting)

44. Wat zijn de eerste 4 cijfers van uw postcode?

Wanneer u in Duitsland woont gelieve uw 5 cijferige postcode te geven.

45. Wat is uw individuele netto jaarinkomen?

- Minder dan €10.000
- €10.001 - €20.000
- €20.001 - €30.000
- €30.001 - €40.000
- €40.001 - €50.000
- €50.001 - €60.000
- €60.001 - €70.000
- €70.001 - €80.000
- €80.001 - €90.000
- €90.001 - €100.000
- €100.001 en meer
- Hier antwoord ik liever niet op

* 46. Hoe vaak kijkt u op uw smartphone? Maak een schatting.

- Elke paar minuten
- Een paar keer per uur
- Ongeveer eens per uur
- Een paar keer per dag
- Ongeveer een keer per dag
- Minder dan 1 keer per dag
- Ik heb geen smartphone

* 47. Hoe vaak reist u met het openbaar vervoer?

- (vrijwel) Elke dag
- 5 dagen per week
- 4 dagen per week
- 3 dagen per week
- 2 dagen per week
- 1 dag per week
- Een paar keer per maand
- Een keer per maand
- Een paar keer per jaar
- Nooit

* 48. Hoe vaak reist u met de bus?

- (vrijwel) Elke dag
- 5 dagen per week
- 4 dagen per week
- 3 dagen per week
- 2 dagen per week
- 1 dag per week
- Een paar keer per maand
- Een keer per maand
- Een paar keer per jaar
- Nooit

* 49. Voor welke ritten gebruikt u voornamelijk de bus?

- Als vervoer vanaf en/of naar een treinstation (of ander station)
- Als vervoer naar bestemmingen in mijn woonplaats
- Als vervoer naar bestemmingen buiten mijn woonplaats
- Ik maak geen gebruik van de bus
- Anders, namelijk:

* 50. Sorteer de vervoersmiddelen naar gebruik *per week* door ze te schuiven.
Schuif het vervoersmiddel dat u *het meest gebruikt per week naar 1,* en het vervoersmiddel dat u het minst gebruikt naar 7. Selecteer "N.v.t." wanneer u een vervoersmiddel niet gebruikt. Het tekstvak wordt automatisch ingevuld.

- Bus — N.v.t.
- Tram — N.v.t.
- Metro — N.v.t.
- Trein — N.v.t.
- Fiets — N.v.t.
- Auto — N.v.t.
- Lopen — N.v.t.

* 51. Zou u overwegen meer van het busvervoer gebruik te maken wanneer de zelfrijdende bus als optie wordt aangeboden?

- Ja, zowel met een vaste dienstregeling als op aanvraag
- Ja, alleen bij een zelfrijdende bus met een vaste dienstregeling
- Ja, alleen als zelfrijdende bus op aanvraag
- Misschien
- Nee

* 52. Heeft u een abonnement voor het reizen met de bus (en/of voor tram en metro)?

- Ja, ik kan onbeperkt reizen met de bus / tram / metro
- Ja, ik heb korting voor reizen met de bus / tram / metro
- Nee

* 53. Maakt u gebruik van ritdeeldiensten (zoals Uber, BlaBlacar)?

- Nee, ik ben niet bekend met deze diensten
- Nee, ik heb die nog nooit gebruikt
- Zelden
- Ja, maandelijks
- Ja, wekelijks
- Ja, dagelijks

Einde van de vragen.

Deelname verloting

Om kans te maken op een van de 5 *bol.com*-bonnen, wordt u gevraagd uw e-mailadres in te vullen. Uw e-mailadres zal slechts worden gebruikt om met u contact op te nemen bij winst, na de uitreiking worden de e-mailadressen verwijderd.

54. Wilt u kans maken op een van de *bol.com* bonnen?

- ○ Nee
- ○ Ja

Zo ja, voer hier uw e-mailadres in:

Vernieuwingen in het busvervoer

Einde van de enquête

Bedankt voor het invullen van de enquête, uw antwoorden zijn opgestuurd.

Het wordt zeer op prijs gesteld wanneer u deze enquête wilt doorsturen naar andere openbaar vervoer gebruikers.
Hier vindt u de link naar de enquête: https://nl.surveymonkey.com/r/dutchmission

Heeft u Duitse kennissen die gebruik maken van het openbaar vervoer? Dan is er een aparte link: https://de.surveymonkey.com/r/germission

Bedankt!

Joost Wien

TUDelft Delft University of Technology

Royal HaskoningDHV Enhancing Society Together