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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***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.

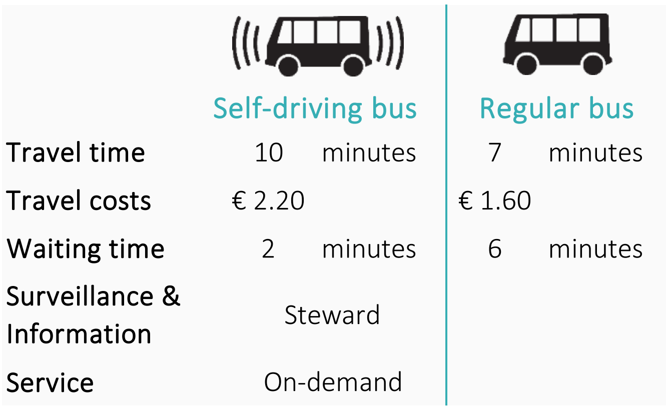

Fig. 1. EXAMPLE OF A CHOICE SET PROVIDED TO RESPONDENTS

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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