Travel Behaviour and Society 22 (2021) 252–261

Contents lists available at ScienceDirect

Travel Behaviour and Society

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

Longitudinal interactions between experienced users' service valuations and willingness-to-use a first-/last-mile automated bus service

Pei Nen Esther Chee [a,b,*], Yusak O. Susilo [c], Yiik Diew Wong [d]

[a] School of Civil and Environmental Engineering, Nanyang Technological University, 50 Nanyang Avenue 639798, Singapore
[b] School of Architecture and Built Environment, Integrated Transport Research Lab, KTH Royal Institute of Technology, SE-100 44 Stockholm, Sweden
[c] Institute for Transport Studies, University of Natural Resources and Life Sciences (BOKU), Peter Jordan St 82, 1190 Vienna, Austria
[d] School of Civil and Environmental Engineering, Nanyang Technological University, 50 Nanyang Avenue 639798, Singapore

ARTICLE INFO

Keywords:
Automated Bus Service
Service Valuation
Willingness-to-Use
Panel Data
Longitudinal Analysis
Stockholm

ABSTRACT

Successful implementation of a first-/last-mile automated bus (AB) service depends on consumers' actual adoption of the service. Consumers, when decided to take an AB ride for the first time, shall rely on their expectation of the service and capabilities of the technology. After the first ride of the vehicle, their value assessments of the service are further refined based on their actual ride experiences. Whether the operators can retain the users highly depend on such assessment. Thus, it is immensely important, when investigating users' adoption behaviour of a first-/last-mile AB service, we take into account the longitudinal changes of the users' valuation of the service. This is the research gap that this study is contributing. During a first-/last-mile AB service trial in Stockholm, Sweden, a panel data involving 185 respondents was available for analysis. The first survey was shortly after the launch of the trialled AB service and the second one was four months later. Structural Equation Modelling was used to investigate the changes of users' judging criteria across different socio-demographic groups, due to initial usage and the subsequent usage. The results show that the concerns affecting the users to continue with the service change with an increase in the ride experience. Willingness-to-use of the experienced users was initially affected by their level of appreciation with the safety and travel time with the service. However, ride comfort became a dominant factor with increasing ride experiences.

1. Introduction

Recently, first-/last-mile service on an automated bus (AB) has been propositoned as a better alternative to contribute the long term urban development strategies than personal use of an automated vehicle (AV) (Fraedrich et al., 2019). Some studies (Pakusch et al., 2018) argued that the AB can be more economical than personal use AV and ridesharing AV in urban areas. Unlike personal use AV with small capacity, AB with larger capacity increases people's accessibility to public transport service (Meyer et al., 2017). Whilst current public transport fleets can serve the high demand routes well, AB is a very good alternative to serve low demand routes. It can provide a locally tailored service to serve the demand better and generate higher profit per kilometre for the operator (Shen, Zhang, & Zhao, 2018).

Automated bus feeder services have been trialled in many European cities including *La Rochelle, Trikala, Lausanne, Oristano, Vantaa,* and *San Sebastian* under CityMobil2 project. The project aimed to assess the feasibility of integrating first-/last- mile feeder service into public transport network for better door-to-door experience (McDonald et al, 2018). The findings show that users appreciated the comfort and safety of the automated bus. Performance expectancy (the degree of belief if the service can perform up to one's expectation from the transport service), effort expectancy (the level of ease of using the service), and social influence (the likelihood one is susceptible to others' influences to use the automated bus) also affect the users' behavioural intentions to use the service (Madigan et al., 2016).

Successful implementation of a first-/last-mile AB service depends on people's actual adoption rate of the service (Bansal et al., 2016). Within the field of industrial design and services, consumers' perception of a product/service is important. Consumer buys a product or uses a service that matches his (both genders) perceived value of using the product/service, and not necessarily based on the objective value of the product

* Corresponding author at: School of Civil and Environmental Engineering, Nanyang Technological University, 50 Nanyang Avenue 639798, Singapore and School of Architecture and Built Environment, Integrated Transport Research Lab, KTH Royal Institute of Technology, SE-100 44 Stockholm, Sweden.
E-mail addresses: pnchee@kth.se (P.N.E. Chee), yusak.susilo@boku.ac.at (Y.O. Susilo), cydwong@ntu.edu.sg (Y.D. Wong).

https://doi.org/10.1016/j.tbs.2020.10.004
Received 14 May 2019; Received in revised form 25 September 2020; Accepted 7 October 2020

or service. Consumer value is built upon consumer's perceived preference of a product from evaluating the product attributes, its performances and the outcomes from using the product to achieve the intended purposes (Woodruff, 1997). Consumer values are related to or inherent in the use of a product (Jensen, 2002). Customer's value of a product/service and value assessment criteria change over time with use experiences (Mick & Fournier, 1996; Youn & Lee, 2019). This consumers' adoption behaviour also applies to the introduction of new transport technology, such as a first-/last-mile AB service, where the longitudinal evolution of users' valuation of the service should be considered to forecast the demand of the service.

Most acceptance studies of AV or AV technology as reviewed by (Becker & Axhausen, 2017) and (Gkartzonikas & Gkritza, 2019) focused on pre-use users' value, and rarely on post-use users' value. (Xu et al., 2018) found private automated car use experience affects users' perceived usefulness, trust and perceived ease-of-use of the automated car. (Distler et al., 2018) investigated the changes of 14 participants' UTAUT (Unified Theory of Acceptance and Use of Technology) constructs after experiencing a simulated on-demand automated shuttle service. None of these studies, however, examined the impact of the users' value changes, due to the subsequent usage after the first usage. This study aims to address this research gap by investigating the changes in the valuation of a first-/last-mile AB service of experienced users with increasing ride experiences and their impacts on the willingness-to-use of the service. The data is collected on a real, open-for-public, service deployment in Stockholm, Sweden. This research was conducted in conjunction with the trial operation of a first-/last-mile AB service in Kista area in Stockholm, Sweden. The trial operation started in January 2018 and ended in June 2018. Two automated EZ10 buses, which each can carry up to 11 standing passengers, were used in the operation. The ABs went back and forth along 800 m route on a flexible timetable from 6 am to 6 pm. There are designated stops where the ABs can pick-up and drop-off passengers. In compliance with the safety regulations from the municipality, the ABs have an operating speed limit of 20 km/h. The AB service was offered free-of-charge during the trial. Also, worthy to note, the AB service maintained the same set of operational procedures throughout the trial period i.e. no changes were made along the course of the trial. On the whole, there were no other changes in the general transport situation during this trial period.

In the following section, a literature review is carried out to construct a conceptual framework to analyse the transition of users' value of the service after initial usage and the subsequent usage. Descriptions of the case study, data set and analysis method are presented in *section 3*, followed by the results and discussion in *section 4*. This paper ends with conclusions in *section 5*.

2. Literature review

Willingness-to-use is an early indicator of people's actual usage behaviour (Ajzen, 1991). Users' acceptance and technology adoption have been studied for several decades. To the authors' knowledge, there are at least seven streams of acceptance models, namely:

1. Theory of Reasoned Action (Hill, Fishbein, & Ajzen, 1977) and the models derived from it:
   i. Theory of Planned Behaviour (Ajzen, 1991),
   ii. Technology Acceptance Model (TAM) (David, 1989) with its successors TAM 2 (Venkatesh & David, 2000) and Igbaria's Model (Igbaria, Schiffman, & Wieckowski, 1994),
   iii. Theory of Interpersonal Behaviour (Triandis, 1979),
2. Diffusion of Innovations Theory (Rogers, 2003),
3. Social Cognitive Theory (Rana & Dwivedi, 2015),
4. Motivational Model (Davis et al., 1992),
5. Usage and Gratification Theory (Grellhesl & Punyanunt-Carter, 2012),
6. Model of Personal Computer Utilisation (Chang et al., 2015), and
7. Unified Theory of Acceptance and Use of Technology (UTAUT) (Venkatesh & Zhang, 2010).

All, except the motivational model which does not consider attitudes, agree that attitudes or perceived values of a product/service affect one's willingness-to-use the product/service. Therefore, understanding users' valuation of a first-/last-mile AB service is important to understand their willingness-to-use the service. In the following section 2.1, a literature review is performed to identify the indicators which influence users' valuation of a first-/last-mile AB service that we have known to date. In section 2.2, the literature review aims to investigate the effects of actual usage experience on acceptance of a product or service. Lastly, section 2.3 explains how the variables used in this study are selected and the reasons underlying the constructs of the proposed model.

2.1. Users' valuation of first-/last-mile automated bus service

There is yet a study that investigates changes in the willingness-to-use of a first-/last-mile AB service when users gain actual experience with the service. However, there were studies which investigated the effect of experience on willingness-to-use personal use AV (Xu et al., 2018) and on-demand automated shuttle service (Distler et al., 2018). (Xu et al., 2018) extended technology acceptance model (TAM) to model intention-to-use and willingness-to-ride personal use AV. Two factors, i. e. trust in automated driving technologies and perceived safety when taking the AV ride, were added into the extended TAM model. The results found ride experience increases riders' perceived usefulness, perceived ease-of-use and trust in the AV service by a little amount. (Distler et al., 2018) asked participants to rank the needs from an on-demand automated mobility service. Competence of the on-demand service, security and relatedness (being connected and having a sense of social interactions) from using the service were considered more important after the experience. However, domain-specific attitudes such as users' perceived value of AB services were yet to be explored. Such objective measures were argued as being stronger predictors of acceptance of AB than socio-demographic variables (Nordhoff et al., 2018).

In general, what are the factors that affect users' perceived value of a product or service? How can we understand users' perceived value of first-/last-mile AB service? Past literature is reviewed to answer these questions. Customer's perceived value can be interpreted from the perspectives of consumer surplus (the difference between the price that consumers pay and the price which they are willing to pay (Bishop Jr., 1984), benefit (overall evaluation of the trade-off between perceived benefits and perceived sacrifices (Zeithaml, 1988)), quality (the difference between the quality received versus the money paid for a product (Bishop Jr., 1984)), and social psychology (generation of social-self concepts from purchasing a product (Sweeney & Soutar, 2001; Wang, Lo, & Yang, 2004)).

In the context of a first-/last-mile AB service, users' perceived value can be assessed from the perspective of quality of service as demonstrated by Citymobil2 project (McDonald et al, 2018). The service quality was assessed through the availability of information, users' satisfaction of the ticketing methods, perceived cleanliness, perceived comfort, perceived level of privacy and perception of safety, which are in-line with the service quality attributes used to assess customers' satisfaction of public transport service. Service quality attributes found to be significant in past acceptance studies of AB are: reliability, on-board safety (Piao et al., 2016; Salonen, 2018), comfort (Eden et al., 2017), and travel time (Bansal et al., 2016; Scheltes & de Almeida Correia, 2017).

2.2. Changes in the relationships of users' perceived values with willingness-to-use due to experience

Within the field of consumer research, consumers' pre-purchase values and post-purchase values are different (Jensen, 2002). The perceived value of a first-time buyer towards a product is mainly based on his expectations of the product (Simintiras, Diamantopoulos, & Ferriday, 1997); post-use valuation is an important indicator of the continuous use of a service (Yu & Lee, 2019). Repeat buying is associated with the post-purchase value which is realised through actual use of a product (Boztepe, 2007).

Satisfaction arises from users' multiple interactions with a service (Gogan, Zhang, & Matemba, 2018). Users' satisfaction varies with their experiences with a service. Users' satisfaction and dissatisfaction affect their decision to continue or abandon a service (Lemon, White, & Winer, 2002). Users with higher satisfaction are more willing to continue with a service (Chiou, 2004). Users' satisfaction has a positive effect on their continuance intention (Chen, Hsiao, & Li, 2020).

Users' satisfaction evolves over repeated consumption experiences (Homburg, Koschate, & Hoyer, 2006). Habit gives a positive emotional association to a specific behaviour, and increases the intention to maintain the behaviour (Phua, Jin, & Kim, 2017). Expectations before the adoption of a service shape the post-adoption perceptions (Zhou, 2011). Also, satisfaction is generated from users' interactions with service up to the present time and is used to predict future experiences (Crosby, Evans, & Cowles, 1990). This means post-use satisfaction after initial usage can be used as a reference point to shape the valuation for further usage. Also, initial valuation affects continuous usage in terms of difference between the expectations and reality with experiences of a product/service (Bhattacherjee & Premkumar, 2004; Venkatesh et al., 2011).

Experience influences the variables which contributes to the acceptance of a new technological product such as an electric vehicle (Peters & Dütschke, 2014). People's evaluation of a new technological product such as electric vehicle changes after using it (Burgess et al., 2013). The variables which contribute to acceptance before experiencing a service can change after the experience. When users have no prior experience or information, their expectations are uncertain and tentative, due to the absence of usage information (Crompton & Love, 1995). Under these circumstances, using the expectations as firm criteria against which to make evaluative judgments is likely to be fallacious (Crompton & Love, 1995).

3. Methodology

3.1. Model formation

When it comes to attitudes towards an AB service, sociodemographic characteristics that are found to be significant in affecting acceptance of AV or automated bus include age (Bansal et al., 2016; Rödel et al., 2014), gender (Payre et al., 2014; Rödel et al., 2014; Salonen, 2018; Schoettle & Sivak, 2014), income (Sanbonmatsu et al., 2018), and technology awareness (Schoettle & Sivak, 2014). These variables are included in the present analyses as controlled variables.

Service quality attributes influencing users' acceptance of an AB service investigated in past studies included: on-board safety (Piao et al., 2016; Salonen, 2018), the existence of steward (Piao et al., 2016), comfort (Eden et al., 2017), and travel time (Bansal et al., 2016; Scheltes & de Almeida Correia, 2017). These attributes are considered in the proposed model. In this study, three perceptions of service quality attributes are included in the model, namely:

1. Safety;
2. Ride comfort; and
3. Travel time reliability.

Table 1 shows the list of indicator variables used for the perceptions of service quality attributes. Fig. 1 shows the conceptual model explaining the transition of users' perceived service qualities and their effects on continuance intention of first-/last-mile AB service of the experienced users who had used the service at least once. The model is applied to analyse the changes in users' valuation of a first-/last mile AB service of two user groups: 1. adopters (the experienced users who continued with the service) and 2. quitters (the experienced users who discontinued with the service). The model is developed with reference to the findings found from the literature review of the changes in the relationships of users' perceived values with willingness-to-use due to experience as explained in section 2.2.

3.2. Case study and data set

A free, first-/last-mile automated bus (AB) service consisting of two small EZ10 buses was operating along Kistagången from January 2018 to June 2018 in Kista neighbourhood, Stockholm, Sweden. The route of the trial operation and the picture of the small EZ10 are shown in Fig. 2 and Fig. 3, respectively. The data analysed in this study came from a panel survey conducted in two periods:

1. Period 1: February to March 2018 (shortly after the service started its trial operation in January 2018), and
2. Period 2: April to May 2018 (after the service had been operating for about 4 months) in Kista.

The perception survey was administrated by a Swedish survey company recruited by the research project team. The participants who

Table 1
List of indicator variables used to represent selected service quality attributes.

Indicator variable	Description	List of responses				
		Safety				
Safety_Item1:SafetyOnRoad	safety perception about ability of an AB to interact safely with other vehicles on the road	1-Extremely Unsafe	2-Unsafe	3-Neutral	4-Safe	5-Extremely Safe
Safety_Item2:SafetyNoSteward	on-board safety without a steward on AB	1-Extremely Unsafe	2-Unsafe	3-Neutral	4-Safe	5-Extremely Safe
		Ride Comfort				
RideComfort_Item1: RideComfortTech	ride comfort due to driving speeds and driving patterns of AB	1-Extremely Uncomfortable	2-Uncomfortable	3-Neutral	4-Comfortable	5-Extremely Comfortable
RideComfort _Item2: RideComfortFacility	ride comfort due to the facilities on AB	1-Extremely Uncomfortable	2-Uncomfortable	3-Neutral	4-Comfortable	5-Extremely Comfortable
		Travel Time Reliability				
TravelTimeReliability_Item1: TravelTimeBus	time saving/loss travelling by AB in comparison to taking a regular bus service	1-Much Longer than the alternative option	2-Longer than the alternative option	3-Neutral	4-Shorter than the alternative option	5-Much Shorter than the alternative option
TravelTimeReliability_Item2: Frequency	frequency of AB service in comparison to the frequency of a regular public bus service	1-Not at all Better	2-Somewhat Better	3-Same Frequency	4-Better	5-Much better

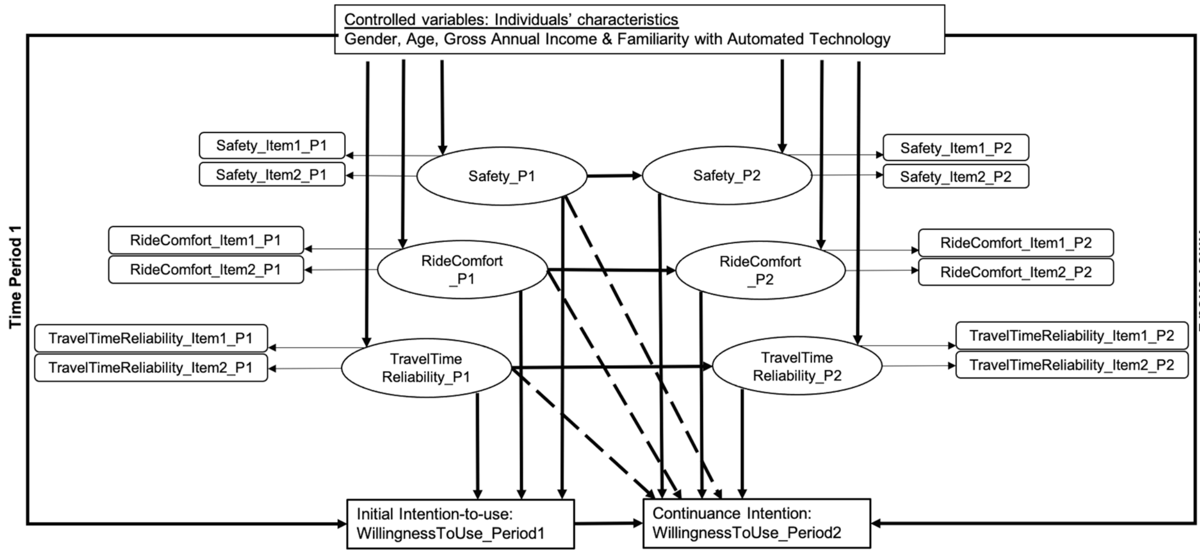

Fig. 1. Conceptual framework to examine the changes of perceived service qualities influencing continuance intention of first-/last-mile automated bus service of the experienced users who had used the service at least once.

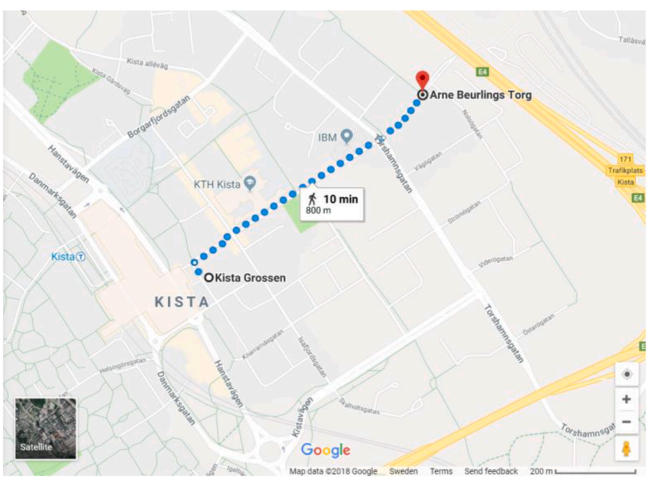

Fig. 2. Route in which EZ10 operated during the Feb-May 2018 trial operation period (map source: Google Maps, 2020).

Fig. 3. Picture featuring EZ10, the small automated bus used in the trial operation in Kista, Stockholm [source: photo taken on 4th May 2018 by SARA1 research team]

completed the surveys are entitled to participate in the contest to win one of ten cash prizes of 1,500 Swedish Kronor (equal to 140 Euro/150 USD). The survey targeted potential users of the service, primarily those who live, work or study in or around Kista Science City and Helenelund commuter train station. The area is a science and technology park which hosts many prominent technology companies and a couple of leading national universities.

A panel survey was deployed for which respondents were enlisted by simple random selection, and 604 responses were collected in period P1 and 532 responses in period P2. A total of 483 respondents completed both rounds of surveys. Out of the 483 respondents, 116 are experienced users who continued with the service in period P2 (the adopters) and 69 are the experienced users who discontinued with the service in period P2 (the quitters). Table 2 shows the descriptions of the two experimental groups.

Table 3 shows the percentage of socio-demographic characteristics of the respondents in each experimental group. Group 1–1 has fewer student population (about 20% less) than group 1–0. Also, there are more respondents with high annual income in group 1–1. This skewness should be noted in the interpretation of the results.

Table 2
Experimental groups in this study.

Time period	Group 1–1 (Adopters)	Group 1–0 (Quitters)
Period P1 (Feb/Mar '18)	Have taken at least one AB ride	Have taken at least one AB ride
Period P2 (Apr/May '18)	With increase in ride experience	Without increase in ride experience
Sample count, n	116	69

Questionnaire

In the first round of the survey, the following information was collected through the questionnaire:

1. socio-demographic characteristics including gender, age, employment status, yearly income, and familiarity with automated driving technology

Table 3
Percentage of socio-demographic characteristics of the respondents.

	Adopters: Group 1–1	Quitters: Group 1–0	
Characteristics/ sample group	With AB ride experience in period P1 and gain experience in period P2 (n = 116), %	With AB ride experience in period P1 and gain no experience in period P2 (n = 69), %	Total (n = 185), %
Gender			
Male	75	72	68
Female	24	27	31
Age (years)			
Young Adult (aged 15–24)	16	32	15
Adult (aged 25–44)	45	40	44
Middle-age Adult (aged 45–64)	35	24	36
Elderly (aged above 65)	4	4	5
Employment Status			
Employed	74	53	75
Unemployed	3	5	4
Student	23	42	21
Education Background			
Above bachelor's degree	82	31	83
Below bachelor's degree	18	68	17
Gross Monthly Income (before tax) in Swedish Kronor (SEK)			
Low-income (≤200,000 SEK)	13	22	14
Middle-income (200,000–699,000 SEK)	62	34	58
High-income (≥700,000 SEK)	25	18	28
Technology Awareness			
Tech-savvy: well informed about or know how to use computers, mobile phones and electronic devices	97.4	95	96
Familiar with the technologies used to enable automated road vehicle to drive without human driver	50.0	57	52

2. perceptions about various service quality aspects of the AB service:
   i. safety perception about the ability of an AB to interact safely with other vehicles on the road
   ii. on-board safety without a steward on AB
   iii. ride comfort due to driving speeds and driving patterns of AB
   iv. ride comfort due to the facilities on AB
   v. time saving/loss travelling by AB in comparison to taking a regular bus service
   vi. frequency of AB service in comparison to the frequency of a regular public bus service
3. willingness-to-use first-/last mile automated bus service

The same series of questions except the social-demographics characteristics were asked again in the second round of the survey.

Data analytic approach

The following social demographics variables are included in the analyses as controlled variables:

1. Age (years)
   - *Young Adult* (aged 15–24)
   - *Adult* (aged 25–44)
   - *Middle-age Adult* (aged 45–64)
   - *Elderly* (aged above 65)
2. Gender
   - *Male*
3. Gross Annual Income
   - *Low-income* (less than 200,000 SEK)
   - *High-income* (above 700,000 SEK)
4. Familiarity with automated driving technology
   - *FamiliaritywithAutomatedTechnology*

The proposed model as shown in Fig. 1 was used to analyse the changes in users' valuation of the adopters (group 1–1) and the quitters (group 1–0). The analyses were performed by structural equation modelling (SEM) with SPSS AMOS. SEM was selected because it allows testing of the model with complex patterns of relationship among the multitude of variables in the proposed model. The results for the two groups were compared and contrasted to find the effects of increasing ride experiences. Assumption checking of maximum likelihood estimation of SEM and model fit of the models were evaluated, and estimates of the significant factors are reported in section 4.

4. Results and discussion

Table 4 shows the means statistics of the indicator variables and willingness-to-use first-/last-mile AB service for the two experimental groups used in the SEM analysis, in period 1 (P1) and period 2 (P2). Willingness-to-use was maintained for the experienced users who continued with the service (group 1–1) while willingness-to-use dropped for the experienced users who discontinued service (group 1–0). Members of group 1–0 were more dissatisfied by the travel time with the AB service.

4.1. Measurement model

Maximum likelihood estimation of SEM was used based on two assumptions: 1. multivariate normal distribution of the indicator variables, and 2. large enough sample size. IBM's SPSS was used for statistical checks of the assumptions.

4.1.1. Assumptions checking

4.1.1.1. Multicollinearity. The correlation matrix of the variables was assessed to check on the multicollinearity assumption. All the variables did not have a bivariate correlation of 0.7 or more in the analysis. Secondly, two indicators: tolerance and variance inflation factor (VIF) of each variable are checked. Tolerance needs to be above 0.1 while VIF needs to be below 3 to rule out multicollinearity. Upon assessing the tolerance and VIF of the variables as shown in Tables A1 and A2, the assumption of not having multicollinearity is fulfilled.

4.1.1.2. Outliers, normality, linearity, homoscedasticity, independence of residuals. Upon assessing the normal probability plot (P-P plot) of the regression standardised residuals as shown in Figs. A1 and A2, normality assumption was fulfilled since the points lie along the diagonal line from bottom left to top right reasonably. The assumptions of multiple regressions are fulfilled.

4.1.2. Confirmatory factor analysis

Confirmatory factor analysis was performed to check the factor structure used in the models. The factor structure has a good model fit. Table 5 shows the model fit of the factor structure. The cmin/df value is less than 3, indicating a good model fit. Also, the factor structure model has p-value bigger than 0.05, CFI value more than 0.95 and RMSEA value less than 0.05. All these values indicate a good model fit. Table 6 shows the factor loadings of the indicator variables, and the composite reliability (CR) value and average variance extracted (AVE) value of the constructs. The factor loadings show the correlation coefficient of the variable with the latent construct. Ride comfort has good CR value which is larger than 0.7 and AVE value which is larger than 0.5. The other two constructs: safety and travel time reliability have CR values

Table 4
Means of indicator variables and willingness-to-use first-/last-mile AB service for various groups.

		Group 1–1		Group 1–0	
		With AB ride experience in period 1 and gain experience in period 2 (n = 116), %		With AB ride experience in period 1 and gain no experience in period 2 (n = 69), %	
		Period 1	Period 2	Period 1	Period 2
Independent Variable					
Perception		Mean	Mean	Mean	Mean
(1) safety perception about ability of an AB to interact safely with other vehicles on the road	(1-Extremely Unsafe; 2-Unsafe; 3-Neutral; 4-Safe; 5-Extremely Comfortable)	3.30	3.36	3.41	3.32
(2) onboard safety without a steward on AB	(1-Extremely Unsafe; 2-Unsafe; 3-Neutral; 4-Safe; 5-Extremely Comfortable)	3.42	3.37	3.38	3.20
(3) ride comfort due to driving speeds and driving patterns of AB	(1-Extremely Uncomfortable; 2-Uncomfortable; 3-Neutral; 4-Comfortable; 5-Extremely Safe)	3.44	3.41	3.42	3.51
(4) ride comfort due to the facilities on AB	(1-Extremely Uncomfortable; 2-Uncomfortable; 3-Neutral; 4-Comfortable; 5-Extremely Safe)	3.37	3.33	3.41	3.17
(5) time saving/loss travelling by AB in comparison to taking a regular bus service	(1-Much Longer than taking a non-autonomous bus ride; 2-Longer than taking a non-autonomous bus ride; 3-Neutral; 4-Shorter than taking a non-autonomous bus ride; 5-Much Shorter than taking a non-autonomous bus ride)	2.75	2.51	2.8*	2.38*
(6) frequency in comparison to the frequency of a regular public bus service	(1-Not at all Better; 2-Somewhat Better; 3-Same Frequency; 4-Better; 5-Much better)	3.79*	2.66*	3.65*	2.48*
Dependent Variable					
		Period 1	Period 2	Period 1	Period 2
		Mean	Mean	Mean	Mean
Willingness to use the first-/last-mile SAB	(1-definitely not taking the autonomous bus ride, 2-probably not taking the autonomous bus ride, 3-neutral, 4-probably will take the autonomous bus ride, 5-definitely will take the autonomous bus ride)	4.06	3.99	3.93	3.64

* Means are statistically different from independent samples T-test (with a p-value less than 0.05)

Table 5
Model fit indicators of the factor structure tested in confirmatory factor analysis.

Minimum discrepancy (cmin/df)	p-value	Comparative fit index (CFI)	Root mean square error of approximation (RMSEA)
1.161	0.226	0.988	0.024

Table 6
Factor loadings of the indicator variables used in model 1 and model 2.

Item descriptive, and loadings		
Construct	Item (Code)	Factor Loading
Safety_P1	safety perception about ability of an AB to interact safely with other vehicles on the road (SafetyOnRoad)	0.633
AVE = 0.403	on-board safety without a steward on AB (SafetyNoSteward)	0.636
CR = 0.574		
RideComfort_P1	ride comfort due to driving speeds and driving patterns of AB (RideComfortTech)	0.753
AVE = 0.546	ride comfort due to the facilities on AB (RideComfortFacility)	0.724
CR = 0.706		
TravelTimeReliability_P1	time saving/loss travelling by AB in comparison to taking a regular bus service (TravelTimeBus)	0.576
AVE = 0.350	frequency of AB service in comparison to the frequency of a regular public bus service (Frequency)	0.607
CR = 0.518		
Safety_P2	safety perception about ability of an AB to interact safely with other vehicles on the road (SafetyOnRoad)	0.592
AVE = 0.326	on-board safety without a steward on AB (SafetyNoSteward)	0.549
CR = 0.491		
RideComfort_P2	ride comfort due to driving speeds and driving patterns of AB (RideComfortTech)	0.783
AVE = 0.540	ride comfort due to the facilities on AB (RideComfortFacility)	0.684
CR = 0.701		
TravelTimeReliability_P2	time saving/loss travelling by AB in comparison to taking a regular bus service (TravelTimeBus)	0.464
AVE = 0.375	frequency of AB service in comparison to the frequency of a regular public bus service (Frequency)	0.731
CR = 0.533		

less than 0.7 and AVE values less than 0.5. Even though these two constructs do not have as good CR values and AVE values, they are deemed satisfactory because they are new measures which are still not well-established. The validity test is viewed as an exploratory test.

4.1.3. Model fit

Model fit of the models (model 1 for group 1–1 and model 2 for group

Table 7
Model fit measures of the tested models.

Model Fit Indicators	Minimum discrepancy (CMIN/df)	Root mean square error of approximation (RMSEA)	Standardised root mean square residual (SRMR)
Model 1 (group 1–1)	1.249	0.046	0.076
Model 2 (group 1–0)	1.486	0.085	0.080

1–0) adopted in this study was examined. Table 7 shows the model fit measures of the tested models. CMIN/df, RMSEA, and SRMR were used to examine the model fit of the SEM models. CMIN/df should be less than 5 to indicate a good fit. Both models have CMIN/df value less than 5. RMSEA value which is equal to or less than 0.08 indicates a reasonable error of approximation. Model 1 has RMSEA value less than 0.08 and model 2 has RMSEA value slightly more than 0.08. SRMR is the square root of the difference between the hypothesised model and the residuals of the sample covariance matrix. A SRMR value which is less than 0.08 indicates a good fit. Both models have SRMR value less than or equal to 0.08 The three indicators support that the models have a good model fit.

4.2. Changes in experienced users' valuations with increasing ride experiences

Willingness-to-use was maintained for the experienced users who continued with the service (group 1–1) while willingness-to-use dropped for the experienced users who discontinued service (group 1–0). Fig. 4 shows the significant variables identified from model 1 in which the changes in users' valuation from period 1 to period 2 of the adopters (group 1–1) were investigated. Fig. 5 shows the significant variables identified from model 2 in which the changes in users' valuation from period 1 to period 2 of the quitters (group 1–0) were investigated. Estimations with a p-value less than 0.1 are presented in Fig. 4 and Fig. 5, except for those with dotted line. The dotted lines show the relationships found to be insignificant in the analyses but are presented in the diagram to give a better overview of their relationship within the overall relationships.

The judging criteria of the adopters (group 1–1) changed with increasing ride experiences. Before the additional ride experiences, willingness-to-use of the adopters was affected by their level of satisfaction with the safety and travel time reliability of the service. However, the two perceptions did not contribute to the adopters' continuance intention with additional ride experiences. Continuance intention of the adopters was affected by their level of satisfaction with the ride comfort of the service instead of safety and travel time reliability of the service with increasing ride experiences. On the other hand, without additional ride experiences, the continuance intention expressed by the quitters (group 1–0) in period 2 was mainly related to their expressed willingness-to-use in period 1.

Users' perceptions of service quality attributes positively affect willingness-to-use, as demonstrated by the positive relationships of the

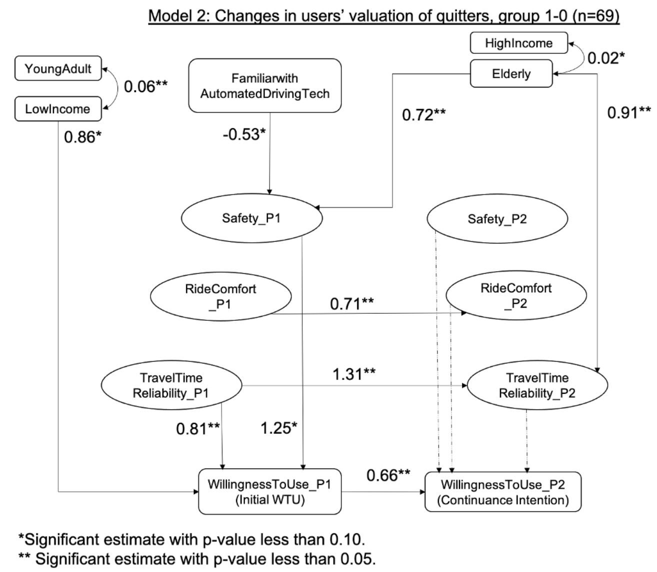

Fig. 5. Changes in users' valuations of the quitters (group 1–0).

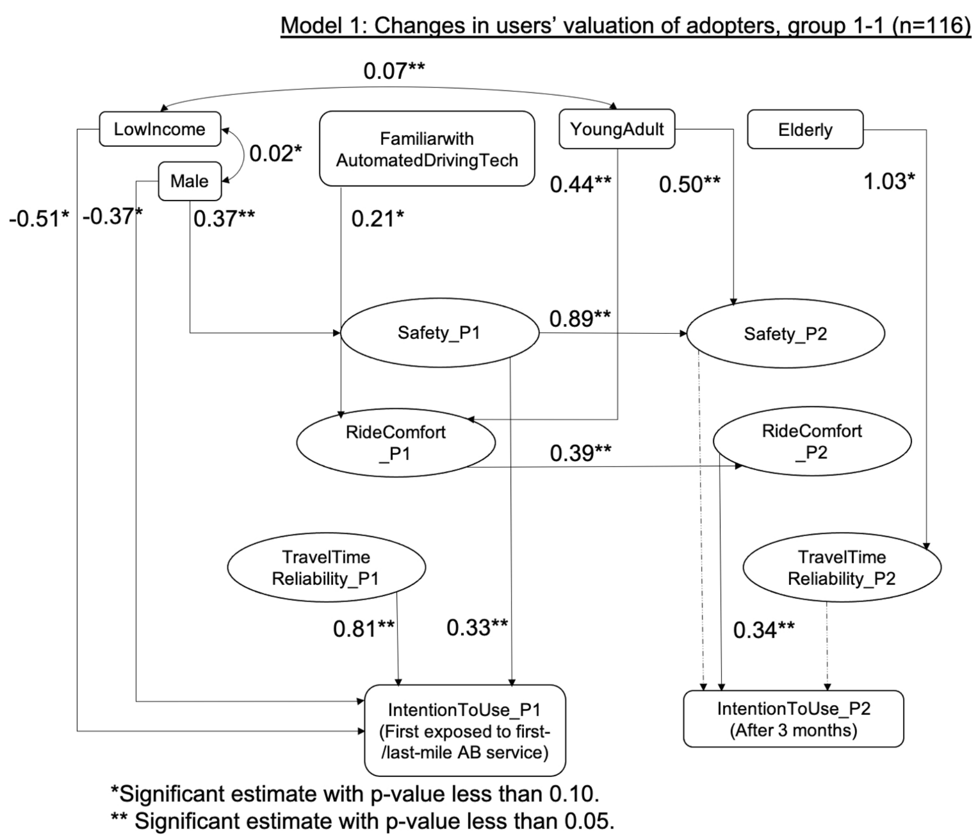

Fig. 4. Changes in users' valuations of the adopters (group 1–1).

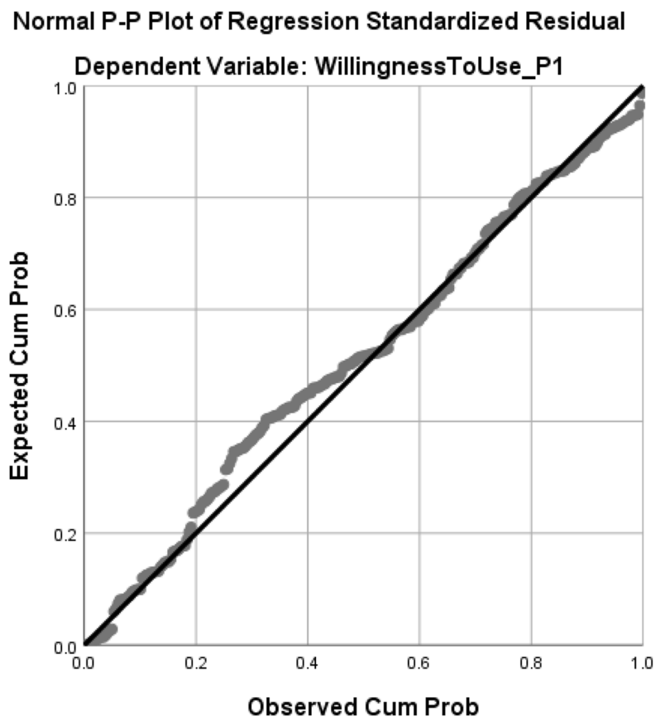

Fig. A1. Normal P-P plot of service attribute perceptions versus willingness-to-use in period 1.

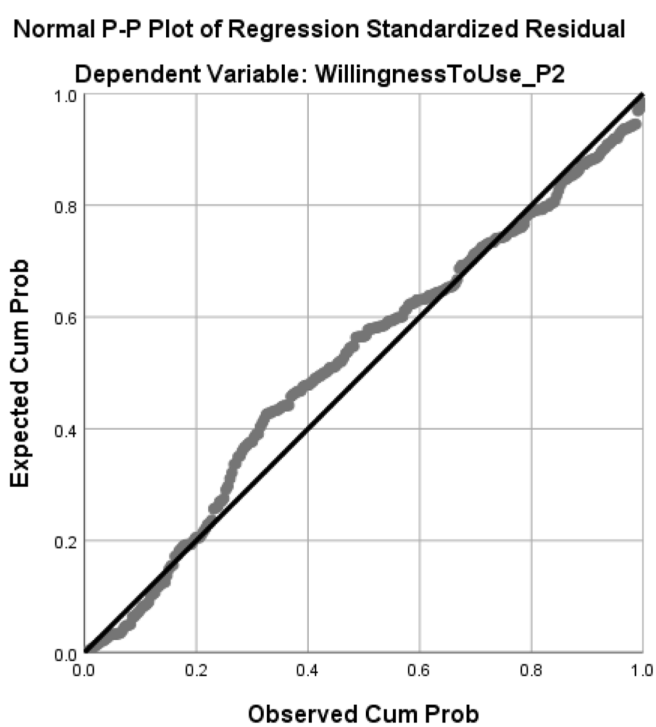

Fig. A2. Normal P-P plot of service attribute perceptions versus willingness-to-use in period 2.

service quality attribute perceptions with willingness-to-use. The result aligns with the findings from (Chiou, 2004) and (Chen, Hsiao, & Li, 2020) stating that users' satisfaction has a positive effect on users' continuance intention. Besides, the adopters' level of satisfaction with the safety and travel time reliability in period 1 affects the respective level of satisfaction after gaining additional ride experiences. Similarly, the quitters' level of satisfaction with the ride comfort and travel time reliability in period 1 affects the respective level of satisfaction in period 2.

Table 8 shows the direct and total effects of age, gender, annual income, and familiarity with automated driving technology on initial willingness-to-use and continuance intention of the adopters (group 1–1). The values were extracted from the direct and total effects table generated by SPSS AMOS. Only the significant estimates are shown on the table. Since willingness-to-use has no unit like willingness-to-pay, the coefficients generated vary when another Likert-scale is used. The main objective of the coefficients is to compare the strength of the effects. Hence, these coefficients shall be interpreted carefully.

Male adopters have higher trust on safety of the AB service and expressed higher continuance intention with the service. Yong adult adopters have higher appreciation of the safety and ride comfort of the service. Low income adopters have lower willingness to use the AB service.

In summary, actual experience with a new technology/service is important to provide the users more accurate information about the technology/service to make well-informed decision. The decision made without having an actual experience with the service is subject to changes, as demonstrated by the significant drop in willingness-to-use of the quitters (the users who discontinued with the service after the initial ride experience). Moreover, actual experience provides an opportunity for the users to learn about the technology/service. For example, the group of users who continued with the service after the initial trial learned about the strengths and limitations of the technology/service. They learned to accept the travel time by using the service and appreciate the ride comfort of the service.

5. Conclusion

This study examines the impacts of the changes of experienced users' service attribute valuation with an increase in first-/last-mile automated bus service ride experience, to the continuance intention to use the service. Results show that once users have gained more experience with first-/last-mile automated service, there is little change in terms of their willingness-to-use the service and their level of satisfaction with the quality of the service. However, the driving force which attracts the experienced users to continue with the service may change with an increase in ride experiences. For example, the experienced users were attracted to use the service because they perceived the safety and travel time reliability of the service to be good but chose to continue with the service after gaining additional ride experiences due to their appreciation with the ride comfort of the service. With an increase in ride experiences, the service quality needs of the experienced users evolved from the basic needs such as travel time reliability and safety to the higher level of need: ride comfort. This result shows that the forecasting of demand for such service solely based on the perceptions before the users have gained adequate experiences with the service may result in bias of the prediction.

The data analysed in this study were collected from the respondents who live, work or study in Kista area, a neighbourhood which hosts many technological oriented companies and institutions. As a result, the socio-demographics of the respondents are skewed towards being tech-savvy (defined as the ones who are well informed about or know how to use computers, mobile phones and electronic devices). Also, the treatment group in model 1, group 1–1, has fewer student population (about 20% less), and more respondents with high annual income, than the comparison group in model 2, group 1–0. This poses a limitation to the interpretation of the results.

Meanwhile, practitioners shall be aware that the coefficients of the standardised total effects of the socio-demographic characteristics are meant for comparison of the effect strengths, and not for actual demand prediction. Looking ahead, future works shall continue to investigate whether after-use willingness-to-use of the inexperienced user is

Table 8
Standardised direct and total effects in the SEM: effects between endogenous variables and socio-demographic characteristic variables.

Standardised direct and total effects in model 1 (group 1–1): Effects between endogenous variables and socio-demographic characteristic variables									
	Model	Effects	Male	YoungAdult	MiddleAgeAdult	Elderly	LowIncome	HighIncome	FamiliarWithAutomatedTech
Safety_P1	Model 1	Direct	0.248**			0.167*			
		Total	0.248**			0.167*			
Safety_P2	Model 1	Direct		0.245**					
		Total	0.296**						
RideComfort_P1	Model 1	Direct			0.215*				
		Total			0.215*				
RideComfort_P2	Model 1	Direct		0.264*					
		Total		0.356**					
TravelTimeReliabilility_P1	Model 1	Direct							
		Total							
TravelTimeReliabilility_P2	Model 1	Direct							
		Total							
WillingnessToUse_P1	Model 1	Direct					−0.204*		
		Total							
WillingnessToUse_P2	Model 1	Direct							
		Total	0.186*						

Note: Bootstrapped standardized estimates:
Others mean p less than 10%. p greater than 10% is not presented.
* Means p less than 10%, ** Means p less than 5%

Table A1
Report of multicollinearity check for data set 1.

	Collinearity Statistics	
	Tolerance	Variance inflation factor (VIF)
Frequency_P1	0.758	1.319
SafetyNoSteward_P1	0.697	1.435
SafetySteward_P1	0.829	1.206
SafetyOnRoad_P1	0.728	1.374
RideComfortTech_P1	0.637	1.570
RideComfortFacility_P1	0.637	1.570
CustomerService_P1	0.872	1.147
TravelTimeBus_P1	0.783	1.277
Frequency_P2	0.798	1.253
SafetySteward_P2	0.765	1.307
SafetyNoSteward_P2	0.667	1.498
SafetyOnRoad_P2	0.759	1.317
RideComfortTech_P2	0.625	1.601
RideComfortFacility_P2	0.676	1.480
CustomerService_P2	0.837	1.195
TravelTimeBus_P2	0.829	1.206
Dependent Variable: WillingnessToUse_P1		

Table A2
Report of multicollinearity check for data set 2.

	Collinearity Statistics	
	Tolerance	Variance inflation factor (VIF)
Frequency_P1	0.758	1.319
SafetyNoSteward_P1	0.697	1.435
SafetySteward_P1	0.829	1.206
SafetyOnRoad_P1	0.728	1.374
RideComfortTech_P1	0.637	1.570
RideComfortFacility_P1	0.637	1.570
CustomerService_P1	0.872	1.147
TravelTimeBus_P1	0.783	1.277
Frequency_P2	0.798	1.253
SafetySteward_P2	0.765	1.307
SafetyNoSteward_P2	0.667	1.498
SafetyOnRoad_P2	0.759	1.317
RideComfortTech_P2	0.625	1.601
RideComfortFacility_P2	0.676	1.480
CustomerService_P2	0.837	1.195
TravelTimeBus_P2	0.829	1.206
Dependent Variable: WillingnessToUse_P2		

correlated with their pre-use willingness-to-use. Also, future works shall focus on investigating the changes of users' perceived value of different configurations of AV services before and after use so as to give insights on how such services can be delivered to better meet people's actual needs and assess whether intervention is needed to speed up the adoption process.

Acknowledgments

This study is part of first author's research programme while reading a joint NTU-KTH PhD degree, with scholarship funded by Nanyang Technological University, Singapore. The case study is based on a project funded by the Vinnova strategic innovation program Drive Sweden (grant number 2016-05313) which ended in October 2018. It has been coordinated by ITRL Integrated Transport Research Lab at KTH Royal Institute of Technology, and the research activities are conducted by KTH researchers in collaboration with Nobina AB. This work is also supported by Cost Action CA16222 (WISE-ACT), a European-wide network that explores the wider impacts of Autonomous and Connected Transport, and also by the Austrian FFG/BMK Endowed Professor DAVeMoS project.

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