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Can autonomous vehicles enable sustainable mobility in future cities? Insights and policy challenges from user preferences over different urban transport options

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Abstract
Creating sustainable urban futures partly requires reducing car-use and transport induced stresses on the environment and society. New transport technologies such as autonomous vehicles are increasingly assuming prominence in debates about the transition towards sustainable urban futures. Yet, enormous uncertainties currently exist on how autonomous vehicles might shape urban mobility. To address this gap, this paper examines the latent behavioural and socio-demographic factors that will drive the adoption of and preferences for different use options of autonomous vehicles, utilizing survey data from Dublin, Republic of Ireland. Based on this, it explores how autonomous vehicles might shape travel behaviors through mode choice and the potential sustainability implications. The findings show that regarding preferences for a specific alternative (i.e. sharing, ownership and public transport), attitudes towards these use options matter the most, rather than overall perceived benefits of autonomous vehicles. Moreover, for single mode options, shared-autonomous vehicles remain the least popular, while preference for ownership of autonomous vehicles, either as a single option or in combination with sharing and public transport, is high. Across the different autonomous vehicles options, there is high preference for clean engine fuel sources (i.e. electric and hybrid). Given the embeddedness of preferences for autonomous vehicles in attitudes and choices regarding existing forms of motorized transport, it is possible that the current modal split and the large share of private car-based transport, might not change in the era of autonomous mobility. However, urban transport policy can leverage the overall positive attitudes towards the environment, sharing and public transit to nudge choices towards achieving the normative goals of sustainable urban transport.

Key words: autonomous vehicles; self-driving cars; sharing; ownership; public transport; urban sustainability; urban futures.

1 Introduction

Reducing car-use, traffic congestion, $C0_2$ emissions and transport induced stresses on the environment and public health is critical in the transition towards sustainable urban futures. In recent years, the role of technological advancements and new innovations has assumed prominence in the search for sustainable urban development pathways (Cugurullo, 2020; Duarte and Ratti, 2018; Karvonen et al., 2018). In the transportation sector, digital technologies are enabling new and emerging forms of mobility paradigms, including shared-mobility (e.g. car-sharing and bike-sharing), with the promise of reducing car-ownership and associated negative environmental and public health impacts (Becker et al., 2018; Liao et al., 2018). Urban transportation systems are also expected to become cleaner through widespread adoption of electricity as engine fuel source in both private cars and public transport (see e.g. Jensen, et al., 2014; Casals et al., 2016)**.**

A key technological innovation that is expected to radically shape urban passenger and freight transportation is the autonomous vehicle (Paddeu and Parkhurst, 2020; Cugurullo and Acheampong, 2020; Milakis et al, 2017). On the one hand, aside the promise of making motorized transport safe, driverless vehicles are expected to integrate clean technologies and support flexible, free-floating car-sharing, thereby helping to reduce car-ownership, congestion, travel-related energy consumptions and $C0_2$ emissions (Guériau et al., 2020; Milakis et al, 2017; Chan, 2017)**.** On the other hand, however, initial exploratory studies suggest that driverless vehicles could trigger urban form and travel behaviour changes with potentially negative social and environmental consequences by increasing car-use, vehicle miles of travel, energy use and pollution (Thomopoulos and Givoni, 2015; Wadud et al., 2016; Harper et al., 2016; Stead and Vaddadi, 2019; Legacy et al., 2019).

While the debate about the potential costs and benefits of self-driving cars rages on, the technology itself has not been fully deployed yet, although trials in real-world environments are on-going across North America, Europe, Australia and Asia. This means that any predictions with respect to their potential impacts is fraught with uncertainty. That said, for close to seventy years now, the conventional car has been around, shaping the way cities are built and how people choose to meet their travel needs. Except for automating critical safety functions, driverless vehicles will essentially materialize in forms and use alternatives that are already established or emerging with the conventional car. The options to share, own or use public transit either individually or as part of an integrated bundle of services (i.e. Mobility-as-a-Service), for example, would be available in the age of fully-autonomous vehicles. Indeed, emerging evidence suggests that relations exist between attitudes towards conventional alternatives of motorized transport and perceptions of the extent to which autonomous vehicles could be beneficial (see e.g. Acheampong and Cugurullo, 2019). Therefore, understanding public attitudes and preferences regarding autonomous vehicles could open-up possibilities for exploring potential travel behaviour changes and sustainability implications of the technology.

The objective of this paper is to apply a set of theory-grounded and behaviourally realistic models to understand the ways in which people will choose to use autonomous vehicles to meet their travel needs. Drawing on a large sample survey data (n = 1233), the paper systematically models the factors underpinning the adoption of three possible use options of autonomous vehicles namely (a) sharing[1] (b) ownership (private autonomous car) and (c) public transit. These individual modal choice outcomes are examined within the context of the interactions among complex sets of factors, covering the personal and socio-demographic attributes of potential users as well as their wider attitudes in relation to automation and technology, the environment, different travel options and sharing/collaborative consumption as an emerging consumption paradigm. From this fundamental understanding, travel behaviour changes that may occur, as a driverless vehicles become a diffused form of transportation, are explored.

The current paper builds on initial work by Acheampong and Cugurullo (2019), in which we developed four interrelated conceptual models, by integrating concepts from social psychology, technology adoption and diffusion studies, and travel behaviour studies. In this initial work, we also empirically tested for scale reliability, discriminant and convergent validity of the frameworks' latent variables, using confirmatory factor analysis with a sample of 507 respondents. It is worth clarifying that given

[1] Sharing here refers to the typical on-demand, ICT-mediated mobility options of car-sharing and ride-sharing, whereby users can request a car from a service provider when needed to travel alone or with other passengers, instead of owning a car.

its theoretical and methodological focus, the first study (Acheampong and Cugurullo, 2019) focused only on measuring the explanatory latent variables that are depicted in the conceptual models **(see Fig 1)** and tested various theoretical assumptions, using confirmatory factor analysis—the first step to specifying a structural equation model. This previous work did not include and measure the outcome variables presented in the current study, which are the Likert scale-based evaluation of adoption intention, and preferences for different use options of autonomous vehicles. The overall research approach was deemed necessary mainly because the hybrid conceptual models underpinning the empirical work were new and therefore needed testing and validation before employing them to predict adoption and use intentions. Thus, by collecting new data (n = 1233) that is separate from that used in the initial work, we utilize the validated conceptual models to now model autonomous vehicles adoption intentions and modal preferences (i.e. sharing, ownership and public transport). The current paper also addresses an additional subject, which is individuals' willingness to pay for autonomous vehicles of different engine fuel sources (i.e. electric, hybrid and fossil-fuel).

In addition to the above, the current paper contributes to the evolving literature on autonomous vehicles adoption and their wider socio-spatial and environmental impacts in the following ways. Previous studies on user adoption of driverless vehicles have focused either on statements of adoption intentions or stated preferences for specific use alternatives (see e.g. Liu et al., 2019; Liu et al., 2018; Haboucha et al., 2017; Krueger et al., 2016). In the latter category of empirical studies, the focus also tends to be on single use cases, such as stated preferences for shared autonomous vehicles. However, as we show in this paper, within the same sample population, there could be differences in responses to statements of adoption intention and stated preferences for specific use alternatives of autonomous vehicles. In addition, the behavioural factors behind adoption intention and modal preferences are not exactly the same. Thus, this paper contributes to the literature by systematically examining the behavioural factors behind the adoption of this new technology that are relevant at the levels of statements of adoption intentions and stated preferences for specific mode, respectively. Moreover, focusing on preferences for single autonomous vehicles use options ignores the fact that, in reality, these preferences and actual use of motorized transport manifest as multi-modal choices. The current paper responds to this imperative by examining preferences not only for single options (i.e. sharing, ownership and public transport), but also for possible combinations of those options in a multi-modal sense. In doing so, the analysis reveals the relative importance of determining factors in the different choice options. Finally, this paper accounts for environmental and motorized transport attitudes in addition to factors that are specific to driverless technology itself and examines engine fuel source preferences for autonomous vehicles. Based on the insights from these analyses, we explore the possible implications of individuals' preferences and lends critical empirical evidence, which could inform sustainable future transport and mobility policies targeting autonomous vehicles transitions.

The remainder of the paper is structured as follows. Following this introduction section, the next section provides a brief overview of previous studies on the topic. **Section 3** outlines the conceptual models applied in this paper to explore the drivers of adoption intention and public preferences for public transport, sharing and ownership of driverless vehicles. The methodology of the research is presented next in **section 4**. The results of the study are presented in **section 5**, followed by a discussion of the findings and their implications for transport policy and practice in **section 6**, as well as the limitations and directions for further research in **section 7** and a conclusion.

2 Autonomous vehicles adoption and preferences—overview of previous research

Several empirical studies exploring public opinions, attitudes and preferences regarding autonomous vehicles have emerged over the last few years. As summarised in **Table 1,** these initial exploratory studies use two main methodological designs. Some studies adopt stated preference design, which draws on discrete choice and random utility theory. In a typical stated choice design, participants are presented with discrete choice alternatives that are constructed from multiple combinations of some identified attributes of the choice object (see e.g. Rose and Bliemer, 2009). Daziano et al. (2017) explore preferences and willingness to pay for driverless vehicles, using a discrete choice design in which choice alternatives are characterised by attributes including purchase price, fuel costs, driving range, recharging time, and levels of hybridization of automation. In Jiang et al.'s (2018) stated preference study of autonomous vehicle ownership behaviour, study participants are presented with three choice sets of driverless vehicles (i.e. conditional, high, and full automation), differentiated from each other by different levels of attributes that include the purchase cost, rate of insurance and rate of permanent parking cost.

While the majority of stated preference studies construct choice experiments using attributes that relate specifically to autonomous vehicles, a handful of studies have sought to include latent attitudinal factors. For example, Haboucha et al. (2017) elicit a range of underlying attitudinal sentiments with respect to AVs, technology, the environment, driving and public transit use, in addition to presenting discrete choice scenarios to the participants.

The majority of empirical research adopt a methodological design that attempts to capture a range of behavioural factors to reflect individuals' subjective evaluation of various aspects of autonomous vehicles (**Table 1**). These subjective perceptions and attitudes are then used in various multi-variable statistical models (e.g. Acheampong and Cugurullo, 2019; Zhang et al., 2019; Lavieri, et al., 2017; Hohenberger et al., 2016) or by using basic descriptive statistics (e.g. Woldeamanuel and Nguyen 2018; Shabanpour et al., 2018; Kyriakidis et al., 2015; Schoettle and Sivak, 2014) to understand perceptions, interests and adoption decisions regarding autonomous vehicles.

The current study draws on the insights from previous exploratory studies that use multiple latent behavioural concepts, to examine user perceptions and preferences regarding autonomous vehicles. In the next section, an overview of four interrelated conceptual models and their underlying theoretical concepts are presented.

Table 1: Previous empirical research on public opinions and preferences regarding driverless vehicles

Authors	**Case study and sample size**	**Discrete choice, stated preference design**	**Behavioural approach with latent variables**
Abraham et al., 2017	USA (N = 2954)		√
Acheampong and Cugurullo (2019)	Ireland, Dublin (N=507)		√
Bansal, P., & Kockelman (2017)	USA, Texas (N=1364)	√	
Bansal et al., (2016)	USA, Austin (N = 347)		√
Brell et al., (2018)	General (N= 516)		√
Daziano et al., (2017)	USA (N= 1260)	√	
Haboucha et al., (2017)	Isreal and USA (N = 721)	√	√
Hohenberger et al., (2016)	Germany (N = 1603)		√

Howard and Dai (2014)	USA, Berkeley, California (N= 107)		√
Hulse et al., (2018)	UK (N = 1048)		√
Jiang et al., (2018)	Japan (N=1728)	√	
Kaur and Rampersad (2018)	Australia (N = 101)		√
König, & Neumayr (2017)	Multiple countries (N = 460)		√
Krueger et al., (2016)	Australia (N=435)	√	
Kyriakidis et al., (2015)	International, 109 countries: (N= 5000)		√
Lavieri, et al., (2017)	General (N = 1,832)*		√
Liljamo et al., (2018)	Finland (N = 2,036)		√
Liu et al., (2019)	China, Tianjin (N = 568)		√
Liu et al., (2019)	China, Tianjin (n =586) and Xi'an (n =769)		√
Liu et al., (2018)	China, Tianjin (*N* = 441)		√
Nair et al., (2018)	General (N = 1365)*		√
Nordhoff et al., (2018)	116 countries (N = 7,755)		√
Nielsen and Haustein (2018)	Denmark (N= 3040)		√
Pakusch et al., (2018)	Germany (N = 302)		√
Panagiotopoulos and Dimitrakopoulos (2018)	General (N = 966)		√
Payre et al., (2014)	France (N = 421)		√
Schoettle and Sivak (2014)	Multiple countries: China (N = 610); India (N= 527); Japan (N= 585); US (N = 501) UK (N=527); Australia (N=505)		√
Shabanpour et al., (2017)	USA (N= 1,253)		√
Shabanpour et al.,(2018)	USA (N = 1,253)		√
Shin et al., (2015)	Six metropolitan cities of South Korea: Seoul, Busan, Daegu, Inchon, Gwangju, and Daejeon (N = 675)	√	
Sanbonmatsu et al., (2018)	USA (N = 114)		√
Stoiber et al., (2019)	Sweden (N= 709)	√	
Talebian and Mishra (2018)	USA (N= 327)		√
Woldeamanuel and Nguyen (2018)	USA, California (N = 919)		√
Xu et al., (2018)	China, Chang'an University Campus (N = 300)		√
Yap et al., (2015)	General (N = 761)*	√	
Zhang et al., (2019)	China, Shenzhen (N = 216)		√

*no specific case study mentioned

3 Conceptual models of preferences for public transport, sharing and ownership of driverless vehicles

3.1 Overview of underlying theories

Relevant concepts from established theoretical models in social psychology, technology adoption and diffusion studies and travel behaviour studies are mobilised to develop four interrelated conceptual models. First, an overview of the main theories underpinning the four frameworks is presented as follows.

The Theory of Planned Behaviour (TPB) (Ajzen, 1991) which has been applied extensively in travel behaviour studies (see e.g. Acheampong and Siiba, 2019; Krueguer and Rashidi, 2018; Haustein 2012; Salva et al., 2015; Donald et al., 2014), constitutes the core of the theoretical framework underpinning this research. TPB postulates that intentions precede behaviour. Behavioural intentions are also linked to three concepts, namely attitude toward the behaviour, perceived behavioural control (PBC) and subjective norm (SN). Attitudes reflect an individual's expectation of the outcomes of an activity, and the personal values that are attached to them (Ajzen, 1991; Sutton et al., 2003). PBC reflects one's perception of the extent to which taking an action is under their volitional control, while SN captures the role of the external social environment, such as how individuals perceive social pressure as an influence on their behaviour.

The current paper also integrates concepts from Technology Acceptance Model (TAM) (Davis et al., 1989; Venkatesh et al., 2003) and Technology Diffusion Theory (TDT) (Rogers, 1962, 2000). In TAM, Perceived Usefulness/benefits and Perceived Ease of Use are posited to influence the acceptance of new technology. The former reflects an individual's belief of the extent to which adopting a new technology will enhance the performance of specific tasks or activities, while the latter refers to an individual's belief about the extent to which interacting with the new technology will be free of effort. Moreover, Rogers' technology diffusion theory identifies different categories of adopters of technological innovation. It also identifies various attributes of the innovation, including relative advantage, status, image, compatibility and trialability that influence adoption decisions. In this study, we integrate image as a distinct concept in the conceptual models, to capture possible reputational/status benefits that individuals might associate with using autonomous vehicles.

Emerging empirical work on user acceptance, adoption and diffusion of autonomous vehicles tends to apply concepts from one of the theoretical models outlined above (see e.g. Liu et al., 2019; Talebian and Mishra, 2018; Panagiotopoulos and Dimitrakopoulos, 2018). For example, Panagiotopoulos and Dimitrakopoulos (2018) demonstrate that adoption intentions regarding autonomous vehicles are influenced by perceived usefulness and ease of use, with the former exerting the largest effect on intention. Moreover, Talebian and Mishra's (2018) implementation of the technology diffusion framework, using an agent-based model, shows that social networks which act as communication channels could eliminate barriers to adoption of autonomous vehicles over time.

Integrated theoretical frameworks that bring together relevant concepts from different theoretical models could be useful in better understanding individuals' modal choices (see e.g. Acheampong et al., 2020; Ghasri et al., 2019; Krueger and Rashidi, 2018). For example, Krueguer and Rashidi (2018) demonstrated the utility of integrating concepts from socio-psychological models of behaviour and lifestyle-oriented approach to understand individuals' use of different modes of transport. Ghasri et al. (2019) also demonstrate the benefits of an integrated discrete choice and latent variable model drawing on Rogers' original technology diffusion model in understanding electric vehicles adoption decisions. However, in the emerging literature on user adoption and modal preferences regarding autonomous vehicles, such integrated approaches are rare (see e.g. Haboucha et al., 2017). The current paper, which builds on our initial work (Acheampong and Cugurullo, 2019), thus seeks to provide this comprehensive and integrated approach to better understand adoption intentions and modal preferences regarding fully autonomous vehicles.

3.2 The four interrelated conceptual models

The conceptual models **(see Fig 1)** bring together multiple concepts used to examine (a) people's general interest and adoption intentions regarding autonomous vehicles, and (b) user adoption decisions regarding three specific use options of autonomous vehicles, namely ownership, sharing and public transport. As indicated earlier in the introduction section, a detailed description of these conceptual models was first documented in Acheampong and Cugurullo (2019). An overview of each of the conceptual models is presented in this paper as follows:

The first conceptual model (i.e. CM-1) identifies seven latent variables for understanding and predicting the behavioural determinants of *general interest and adoption intentions* regarding driverless vehicles **(see Fig 1a).** From TAM (Davis et al., 1989), CM-1 integrates two latent concepts that reflect individuals' perceptions of the benefits, perceptions of ease of use of autonomous vehicles. The role attitude, the external social environment (subjective norm, image), fears and anxieties, and individuals perceptions of the extent to which they consider adoption decisions as being under their volitional control, are drawn from the theoretical insights of TPB (Ajzen, 1991), Socio-Ecological Model of behaviour (McLeroy et al., 1988) and TDT (Rogers, 1962, 2000).

Building on CM-1, the second conceptual model (i.e. CM-2) focuses specifically on predicting preferences with respect to shared autonomous vehicles **(Fig 1b).** In view of this, two additional latent concepts that capture individuals' attitudes towards *collaborative consumption/sharing* and the *environment* are introduced in CM-2. The third (CM-3) and fourth (CM-4) conceptual models which are applied to understand autonomous vehicles adoption through public transport services and ownership, respectively, integrate relevant variables capturing individuals' attitude towards public transit (**Fig 1c**) and car ownership/use **(Fig 1d).** All four conceptual models also include the role of socio-demographic factors in explaining preferences and adoption of different use alternatives of autonomous vehicles. Moreover, while mode-related attitudes have been captured in each of the conceptual models depending on the outcome variable of interest, these attitudes are expected to correlate in practice. Thus, in modelling the data based on these conceptual models, as presented later in **section 5.4**, relevant interactions among the mode-related latent attitudinal variables are included to take into account these correlations and to integrate the three models that focus on the determinants of ownership, sharing and public transport use of autonomous vehicles.

In addition to the overview provided here of the conceptual models, detailed explanations of the role of each of the variables in the series of SEM analysis presented in this paper, will be provided later in the results and discussion sections**.**

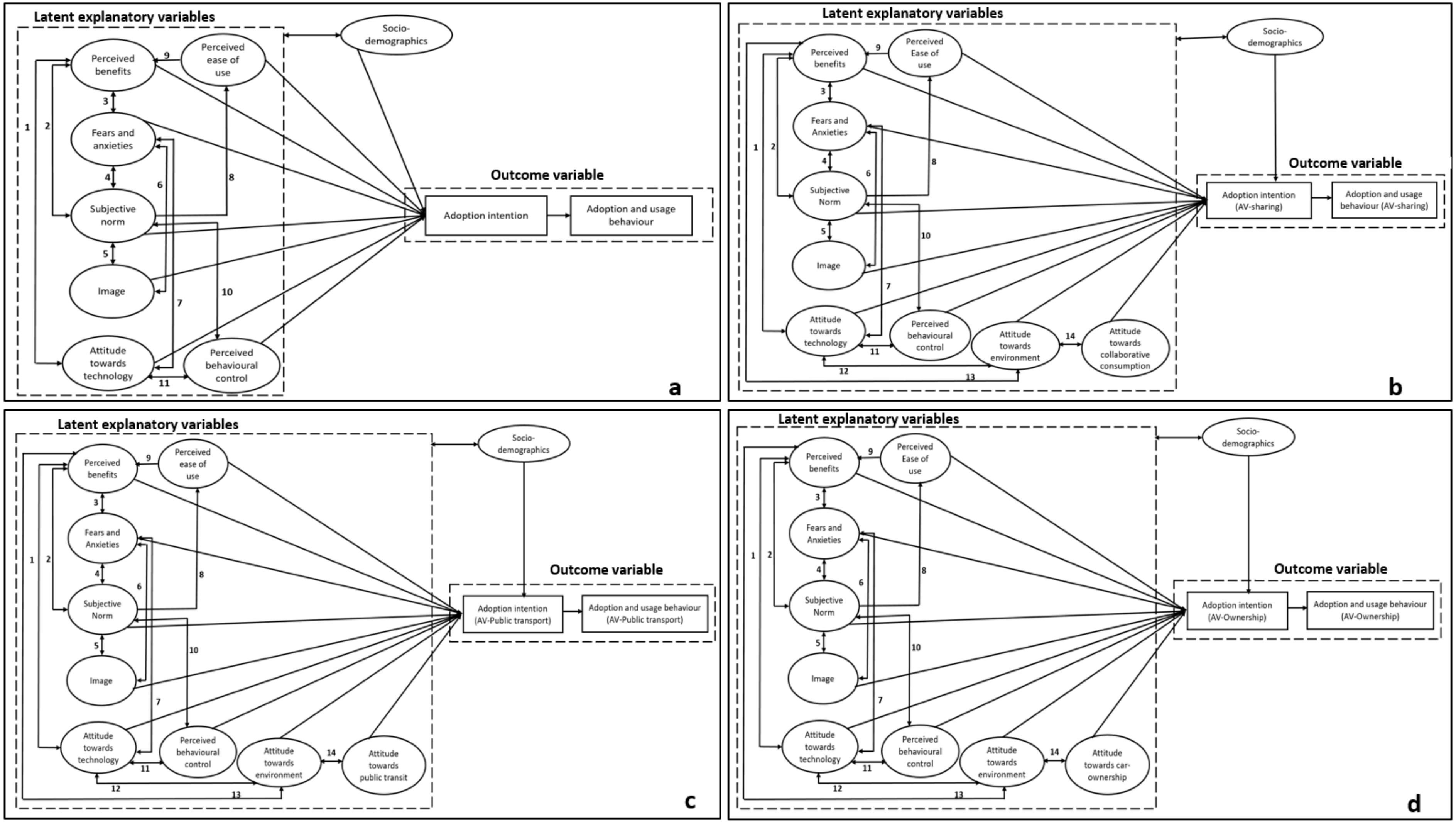

Fig 1: Conceptual model of (a) AV interest and adoption intentions (CM-1); (b) AV-sharing intentions (CM-2); (C) AV- public transport use intentions (CM-3); and (d) AV-ownership intentions (CM-4);

NB: hypothesized associations are depicted using double-headed arrows. Direct effects, which indicate the predictive effect of one variable on the other are shown with single-headed arrows.

4 Methodology

4.1 Case study context—Dublin, Ireland

Dublin, the capital of the Republic of Ireland is used as case study to explore the question of multi-modal preferences regarding autonomous vehicles and their potential sustainability impacts. It is a city in transition, which has recently started a number of initiatives to reduce urban pollution and traffic, establish a knowledge-based economy, and cultivate creative start-ups (Cugurullo et al., 2020). Dublin also has a smart-city agenda (see Kitchin et al., 2018). Dubbed the 'Smart Dublin Initiative', local authorities are experimenting with new and emerging technologies to address a number of priority challenges, including transport and mobility, waste, energy and emergency management[2].

The city's experimentation with smart technologies has so far included the trial of autonomous vehicles. In September 2018, Dublin City Council approved the first driverless passenger-carrying shuttle trial in Dublin. The trials in Dublin, also coincided with those in several other European countries, as part of activities marking the 17th edition of the European Mobility Week—an annual flagship campaign organized by the European Commission, to promote clean mobility and sustainable urban transport. In Dublin, the electrically-powered, 15-passenger, fully-autonomous shuttle operated in a controlled environment along a section of the Dublin Docklands, a regenerated part of the city's Central Business District.

The Dublin autonomous vehicle trial was seen by stakeholders involved in the initiative, including Dublin City Council, as a measure to demonstrate the future of mobility and to show some of the use cases of autonomous vehicles, such as being used for passenger transport[3]. Thus, from the perspective of the city authorities, autonomous vehicles are expected to become part of the portfolio of future smart mobility solutions for the city. This research, therefore, aims partly to contribute to the ongoing policy debates by exploring the factors that will drive adoption and diffusion of different use options of autonomous vehicles, and to interrogate the potential urban sustainability implications.

4.2 Questionnaire design

A structured questionnaire[4] was designed and used to measure the variables of the conceptual models presented in **section 2.1. Part I** of the survey questionnaire comprised questions to obtain background socio-demographic information and statements formulated to measure the latent concepts. Items used to measure the latent variables were of two main categories, namely (a) those that relate specifically to driverless vehicles and (b) relevant general attitudinal variables covering the environment, car-ownership and sharing/collaborative consumption. Throughout the survey and in this paper, the terms 'driverless', 'autonomous' and 'self-driving' vehicles are used interchangeably to refer to full automation (i.e. Level-5). In the questionnaire, the concept of fully autonomous vehicles or driverless vehicles was first explained in a preamble to the respondents as follows: *"a new technology that will enable cars, using advance sensing and communication technology, to take over all safety-critical control functions. Fully-autonomous vehicles are expected to be able to drive under*

[2] More information about the Smart Dublin Initiative can be found here: https://smartdublin.ie/about/
[3] Further information about the trial can be found in this report by the Irish Times newspaper https://www.irishtimes.com/news/ireland/irish-news/driverless-shuttle-takes-to-the-streets-of-dublin-1.3636947
[4] The survey questionnaire for this study is available from the authors, upon request

all road conditions without a human driver". They would then evaluate on a 7-point Likert Scale the items measuring the first category of latent variables presented in the conceptual models, such as individual's perceived benefits, ease of use and safety risks regarding autonomous vehicles.

With respect to the questions included under the second category of latent variables, the concept of collaborative consumption/sharing was first explained to the respondents as follows: *"a form of consumption where you do not have to own an asset or product. Instead, you and others in your community can book and use the product only when you need to do so. After using it, the product(s) must be returned for others to use"*. Since the focus of the survey is on mobility, we followed this broad definition with specific shared-mobility examples such as car-sharing and bike-sharing, with the aim of enabling the respondents to relate the concept of sharing to mobility options in general and autonomous vehicles in particular. Moreover, items were formulated on a 7-point Likert Scale to elicit individuals' attitude towards technology, the environment, car ownership and public transit. Finally, interest in and adoption intention with respect to autonomous vehicles were elicited by the participants indicating the extent to which they agree or disagree with the following statements "*I am interested in driverless cars/autonomous vehicles"* and *"I intend to use driverless cars/autonomous vehicles when they become available"*. Responses for these were elicited on a 5-point Likert scale as presented later in **Fig 3**.

In **Part II** of the survey questionnaire participants were presented with specific autonomous/driverless vehicle use options to indicate their preferences. The aim here was not to administer a discrete choice experiment. Therefore, modal options were not constrained into discrete choice options. Instead, first, respondents were asked to assume that autonomous vehicles were available to be used for their most recent commute trips (i.e. school and University or work journeys). From this premise, the survey proceeded in two steps. In **step 1**, all the respondents who had completed Part I of the survey, chose between (a) not willing to use any of the autonomous vehicles modal options presented to them and (b) willing to use at least one of the autonomous vehicles options presented. Those who opted for the latter did so by indicating their preferences for one of six possible mode options. The first three alternatives were (a) sharing (b) ownership and (c) public transport, and the remaining options comprised a combination of these three alternatives, namely (d) ownership and sharing (e) sharing and public transport, and (f) ownership and public transport.

To reduce the level of abstraction and make this part of the survey as relatable as possible, the questionnaire included a picture of a standard five-seater, unbranded saloon driverless car (**see appendix Fig A1**), as a reference for those who would opt for AV ownership and/or sharing. A picture of the standard double-decker bus operating in Dublin was also presented to those who would opt for using autonomous public transit and we asked participants to imagine that it was fully autonomous. For each chosen autonomous vehicle mode, the respondents would indicate in sequential questions their preferred engine type (i.e. electric, hybrid or petrol/diesel fuelled) and how much they are willing to pay for them.

Ultimately, the research design enabled us to identify the differences in individuals' responses when Likert Scale-based statement of adoption intention are used **(survey Part I)** and when individuals are presented with specific use options of autonomous vehicles, such as ownership, sharing and public transit **(survey Part II)**. These differences are shown later in the analysis in **section 5.4,** and elaborated further in **section 6.2** of the discussion.

4.3 Data collection

The survey was administered between November 2017 and February 2018, using a combination of methods which included (a) distribution of printed leaflets with scannable QR-codes[5] and questionnaire URL; (b) personal interviews conducted by field assistants using tablets; (c) emails invitations and (d) links shared on social media networks including Twitter and Facebook. Participants had to be at least 18 years old and live in the Greater Dublin Area (Ireland). We also encouraged our respondents to forward the survey to other individuals in their network. The data collection approach adopted was not without limitations, since we eventually reached more young people and relatively fewer older adults. We further reflect on these limitations later in **section 7**. The final dataset comprising a total of 1,233 valid responses is used for the analysis. In the next section, results of the analysis are presented.

5 Results

5.1 Background socio-demographic and travel characteristics of respondents

As summarised in **Table 2**, females constituted 55% of the sample, while 2% of the respondents preferred not to indicate their gender. The respondents' age ranged between 18 and 84 years, with the average age being 33 years (compared to the average age of 37 years in Ireland). The proportion of individuals aged between 18 and 24 years in the sample (i.e. 45%) is significantly higher than that of the general population (10%) while there are fewer individuals aged between 65-84 years in the sample (i.e. 3%) compared to the general population (i.e. 31%). Nonetheless, there are also significantly higher proportions of individuals aged 25-44 (28%) and 45-64 (25%) in the sample as there are in the general population (i.e. 20% and 30% respectively).

Moreover, about 70% of the respondents frequently use motorized forms of transport, including car (29%) and public transport (40%), while 31% use non-motorized forms namely bicycling (15%) and walking (16%) for work or school and University-related journeys. Only a few of the respondents (3%) indicated having experienced a test-ride in an autonomous vehicle. Fully-autonomous vehicles are being built on already available Advanced Driver Assisted (ADA) technologies. In the survey, we asked respondents who can drive (n = 514) to indicate their familiarity with twelve of these technologies. The results show that on the average, respondents have used two of the ADA technologies. **Fig 2** shows a summary of self-reported familiarity with ADA technologies by the respondents.

Table 1: Background characteristics of study respondents (N= 1233)

	Variable	Distribution
Gender	Female: Male: Prefer not to say	55%: 43%: 2%
Age-groups	18-24	45%
	25-44	28%
	45-64	25%
	65-84	3%
	Family size	

[5] QR-code is a machine-readable optical label. We embedded the URL of our online questionnaire as a QR-code label and printed them as leaflets that were given to the respondents. Using their smartphones, they could scan the code which took them directly to URL of the online questionnaire for them to fill the survey on their smartphones at their own convenience.

Household composition		4(SD=1.57)
	Households with children	30%
Education	Primary school	1%
	Secondary/High school	20%
	Bachelors (enrolled)	29%
	Bachelors (completed).	20%
	Graduate (Master's or higher)	30%
Ethnicity	White Irish	76%
	Irish Travellers	0.4%
	Other White	18%
	Black Irish or Black African	1.6%
	Chinese	0.6%
	Other Asian	2%
	Others	1.5%
Employment	Full-time employment	40%
	Home-maker	2%
	Part-time employment	16%
	Retired	3%
	Student	37%
	Unemployed, actively looking for work	2%
Income € (n= 1, 196)	<20,000	20%
	20,000-40,000	8%
	41,000-60,000	14%
	61,000-80,000	14%
	81,000-100,000	14%
	>100,000	29%
Car-ownership	Households owning car(s)	81%
	Cars per household	2(SD= 0.95)
Driver's license	Yes: No	65%:35%
Travel mode choice (work/school(University); n= 1,149)	Private-car	28%
	Public transit	40%
	Car-sharing service	0.4%
	Bicycle	15%
	Walking	16%
	Other	0.6%
Disability	Yes: No: Rather not say	2%: 96%: 2%

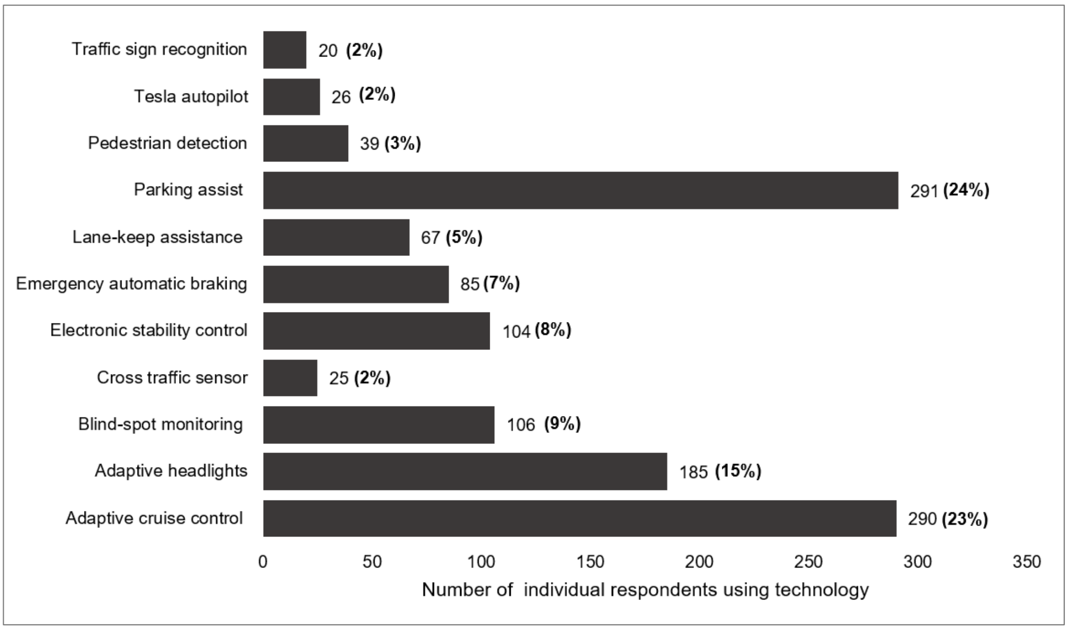

Fig 2: Self-reported familiarity with advanced driver assisted technologies
Note: the plot shows a total of 1,238 choices, made by 514 respondents.

5.2 Descriptive analysis of responses to latent concept items

Descriptive summary of the responses to the items used to measure latent concepts is presented in **Table 3,** and outlined as follows:

5.2.1 Attitude and perceptions of the benefits of driverless vehicles

Overall, there are positive *attitudes* towards autonomous vehicles with more than half (57%) and as high as 75% of the respondents agreeing that driverless cars are a good idea and an exciting prospect, respectively. The respondents' *perception of the benefits* of AVs are grouped into two broad categories, based on how the individual items loaded in an initial exploratory factor analysis. The first category reflect the instrumental utility or hedonic benefits associated with using self-driving vehicles as a form of motorized transport, including people's perception of the likelihood of autonomous vehicles reducing stress and aiding safe transport, reducing congestion, being reliable and performing as well as conventional vehicles and providing mobility freedom and comfort. Overall, 42% and 60% of the respondents perceive that these benefits would likely result from autonomous vehicles; between 27% and 39% disagree while those who are ambivalent to each of the items range between 15% and 34% (**see Table 3**).

As autonomous mobility would imply all users becoming passengers, the second category of potential benefits reflect the respondents' perceptions of whether or not there will be travel time-use advantages with autonomous vehicles. While only 31% agreed that AVs would give them extra time to play their favourite games while travelling, more than half agreed that they could use the time spent not driving to: enjoy the scenery outside (67%); communicate with friends and colleagues (55%); communicate with family (54%) and work (51%).

5.2.2 Individuals' perception of control, ease of use of driverless vehicles, and the external social environment

More than half (54%) of the respondent indicated that it would be easy for them to travel in autonomous cars, while as high as 73% indicated that they believe they have full control on their decision whether to use autonomous vehicles or not (i.e. *perceived behavioural control*). In terms of the potential influence of the external social environment (*i.e. subjective norm*), the survey results revealed that while a relatively higher percentage of the respondents (60%) agreed that autonomous vehicles would become the norm (implying that themselves and others will probably have to use driverless cars to meet their travel needs), a relatively lower proportion (42%) indicated that seeing their friends and colleagues travel in autonomous vehicles would necessarily make them do the same. Moreover, the majority of the respondents either disagreed or were ambivalent regarding the possibility that reputational benefits (i.e. *image*) within their community and among friends and colleagues will influence their decision to use autonomous vehicles.

5.2.3 Attitude toward technology and automation, and public fears and anxieties regarding driverless vehicles

Results of the survey show that overall, general attitude towards technology is positive, with the majority of the respondents indicating that technological advancement is generally a positive thing (85%) and that they are excited about the possibilities offered by new technologies and innovation (83%). On the specific issue of automation as a consequence of technological advances, one-third of the respondents expressed scepticism about its promises for a better future. In addition, one-third of the respondents—fewer than what would probably be expected—agreed that they fear automation will replace humans and take away jobs.

Despite the overall positive attitude towards technology and automation in the population, a significant proportion of the respondents expressed fears and concerns around autonomous vehicles. Public fears and anxiety captured by the survey reflect individuals' perception that it could be dangerous having autonomous vehicles interact with vulnerable road users, including cyclists (70%), pedestrians (66%), as well as motorists (66%). In our survey, there was a similar incidence of perceived dangers resulting from unforeseen failure of equipment or systems in the vehicle and deliberate hacking of the vehicle's computer systems for sinister motives.

5.2.4 Attitude towards the environment, sharing and motorized travel options

The final sets of latent concepts elicited from the survey were attitudes towards the environment, sharing/collaborative consumption and motorized forms of travel (i.e. car ownership/use and public transit). The results reveal a general positive attitude towards the environment in the sample, with between 79% and 90% agreeing to all the items measuring their attitude towards the environment. In addition, the majority of the respondents (69-78%) expected collaborative consumption/sharing practices such as shared-mobility to yield positive benefits, although fewer of them (45%) agreed that doing so would actually be fun **(see Table 3).**

Regarding car-ownership and use, the majority favoured the associated utilitarian benefits including comfort (87%) and travel speed (53%). However far fewer agreed that car use is necessarily safer (39%) and contributes less to air pollution (9%), noise pollution (9%) and congestion (10%). On the contrary, the majority of the respondents (i.e. 73-82%) favoured the environmental and travel speed benefits of using public transit, although these figures decrease among those who agree that public transit is a cheaper (61%), comfortable (42%), reliable (44%) travel option **(see Table 3)**.

Table 3: Latent variables, indicator items and descriptive summary of study participants' responses

Items	Scale (%)[6]					Mean (SD)
	1	2	3	4	5	
Attitude towards AVs (α = 0.895; Spearman-Brown reliability co-efficient =0.8030)						
Driverless cars are a good idea	11	16	16	30	27	3.458(1.319)
Driverless cars are an exciting prospect	8	11	8	35	38	3.829(1.265)
Perceived Benefits of AVs- Instrumental/hedonic utility[7] [8] (α = 0.928)						
*Driverless cars will reduce crashes	21	11	11	20	38	3.435(1.565)
*Driverless cars will save lives	19	9	14	21	37	3.485(1.519)
*Driverless cars will reduce traffic congestion	26	13	15	15	32	3.144(1.599)
*Driverless cars will lower vehicle emissions	21	11	18	20	31	3.294(1.507)
*Driverless cars will perform as well as conventional vehicles	15	11	22	19	33	3.435(1.428)
Driverless cars would reduce the stress of driving	11	19	12	30	28	3.463(1.347)
Driverless cars would be reliable	13	19	26	24	18	3.162(1.286)
Traveling in a driverless car would be comfortable	10	14	17	34	26	3.511(1.286)
Driverless cars would bring freedom in traveling around	12	15	19	30	24	3.390(1.313)
Perceived Benefits of AVs- travel time use[9] (α = 0.913)						
Traveling in a driverless car would enable me to look out the window and enjoy the scenes outside	10	11	13	35	32	3.680(1.283)
Traveling in a driverless car would enable me to play my favourite games	17	21	26	22	13	2.921(1.279)
Traveling in a driverless car would enable me to communicate with my friends and colleagues	11	14	20	33	22	3.386(1.283)
Traveling in a driverless car would enable me to communicate with my family	12	15	19	33	21	3.364(1.287)
Traveling in a driverless car would enable me to get some work done	13	19	17	29	22	3.274(1.344)
Fears and Anxiety about AV technology-interaction with other road users[10] [11](α = 0.913)						
Driverless cars interacting with conventional vehicles	26	40	15	14	5	2.303(1.136)
Driverless cars interacting with pedestrians	29	37	12	17	4	2.307(1.184)
Driverless cars interacting with cyclists	32	38	11	14	5	2.217(1.178)
Fears and Anxiety about AV technology-automated system-related[12] [13] (α = 0.756)						
Likelihood of equipment or system failure	27	44	12	15	3	2.249(1.106)
Legal liability for owners and users	4	16	17	44	20	2.387(1.106)
Hacking of the vehicle's computer systems	30	40	15	12	2	2.165(1.061)
Image (α= 0.966; Spearman-Brown reliability co-efficient = 0.966)						
Traveling in a driverless car, I would gain respect and recognition in my community	27	23	34	9	6	2.443(1.165)
Traveling in a driverless car, I would gain respect and recognition among my friends and colleagues	27	23	35	9	6	2.440(1.143)
Subjective Norm (α = 0.711; Spearman-Brown reliability co-efficient = 0.711)						
I will travel in a driverless car if my friends and colleagues do the same	15	20	23	24	18	3.079(1.322)
Driverless vehicles will be the norm on our roads in the future	7	15	18	32	28	3.572(1.241)
Attitude towards technology (α = 0.920; Spearman-Brown reliability co-efficient =0.920)						
I am excited about the possibilities offered by new technologies	3	3	11	37	46	4.199(0.953)
I think advancement in technology is generally a positive thing	3	3	9	42	43	4.187(0.938)
Attitude towards automation (α = 0.703; Spearman-Brown reliability co-efficient =0.704)						
I am sceptical about automation and its promises for a better future	20	27	19	24	9	2.754(1.279)
I fear automation will completely replace humans and take over our jobs	25	23	18	20	13	2.719(1.357)
Perceived Ease of Use						

[6] All items are presented on a five point Likert scale derived from the original 7-point scale presented to the respondents in the survey, and labelled as: 1 = strongly disagree; 2= disagree; 3 = neutral; 4 = agree; 5= strongly agree, unless otherwise indicated in the relevant footnotes

[7] * Item scale label: 1= very unlikely; 2 = unlikely; 3 = neutral; 4 = Likely; 5 = Very likely
[8] Sub-scale items adapted from Bansaal et al., (2016)
[9] Sub-scale items adapted from Bansaal et al., 2016
[10] Item scale label: 1 = very worried; 2 = worried; 3= neither; 4 = not worried; 5 = not worried at all
[11] Sub-scale items adapted from Bansaal et al., 2016
[12] Item scale label: 1 = very worried; 2 = worried; 3= neither; 4 = not worried; 5 = not worried at all
[13] Sub-scale items adapted from Bansaal et al., 2016

I believe it will be easy for me to travel in a driverless car	13	19	14	33	21	3.303(1.346)
Perceived behavioural control						
It would be up to me to travel in a driverless car or not	5	9	12	39	34	3.870(1.144)
Attitude towards the environment (α = 0.939)						
We need to control the rate at which raw materials are used to ensure that they last as long as possible	5	2	7	30	57	4.320(1.014)
It makes me sad to see natural environment destroyed	4	2	6	24	64	4.401(1.009)
In my daily life, I try to find ways to conserve energy	3	5	13	36	43	4.096(1.031)
I would like to reduce the consumption of energy and other resources while travelling	3	2	9	33	53	4.311(0.942)
I would like to see and support more sustainable business models in the transport sector	3	1	9	29	57	4.364(0.926)
Overall, I believe protecting the environment is an important issue	3	1	6	19	71	4.541(0.882)
Attitude towards sharing (α = 0.859)						
I think collaborative consumption/sharing is a positive thing	2	3	17	45	33	3.843(1.022)
I can save money by participating in collaborative consumption/sharing	3	3	19	44	32	3.378(1.074)
I think participating in collaborative consumption/sharing will be fun	6	12	38	28	17	3.996(0.918)
Collaborative consumption/sharing is a sustainable mode of consumption	4	6	22	40	29	4.033(0.897)
Attitude towards car ownership and use (α = 0.735)						
It's comfortable traveling in your own car	3	3	8	39	48	4.247(0.943)
It's a lot more faster traveling in your own car	7	17	23	26	27	3.483(1.247)
It's a lot more safe having your own car	7	20	34	23	16	3.211(1.152)
Using a private car contributes less to congestion	53	24	13	5	5	1.853(1.133)
Using a private car contributes less to air pollution	59	22	11	4	5	1.740(1.094)
Using a private car contributes less to noise pollution	55	22	13	4	4	1.801(1.108)
Attitude towards public transit (α = 0.797)						
Using public transport means contributing less to air pollution	3	5	10	41	41	4.103(1.002)
Using public transport means contributing less to noise pollution	4	8	15	37	36	3.928(1.092)
Using public transport means contributing less to congestion	3	5	11	36	45	4.136(1.021)
I think public transport is cheaper	7	14	18	42	19	3.525(1.149)
It is comfortable traveling on public transport	12	27	20	36	6	2.970(1.164)
I find public transport reliable	13	26	17	37	7	3.002(1.197)
It is faster using public transport	3	3	8	39	48	2.855(1.220)

Notes: α = Cronbach's Alpha reliability coefficient. Overall scale reliability of response items (α) = 0.927. For sub-scales with two items, Spearman-Brown reliability co-efficient is also reported.

5.3 Modelling the determinants of autonomous vehicles interests and use intentions

The first conceptual model presented in section 2.1 (CM-1, Fig1a) and resulting survey responses outlined in the previous section are used in a Structural Equation Model (SEM) to examine the determinants of autonomous vehicle adoption interests and use intentions. The outcome variable in the model is *adoption intention,* which is a latent variable derived from the two response items summarised in **Fig 3**. The reason why we combined the two items is that an individual's intention to adopt a new technology (such as a self-driving vehicle), we assume, implicitly suggests that they are interested in the technology. The reverse is also true. Thus, combining the two items (i.e. statement of interest and use intention) into a single outcome variable in the SEM, allows us to take into account this fundamental correlation between interest and intentions.

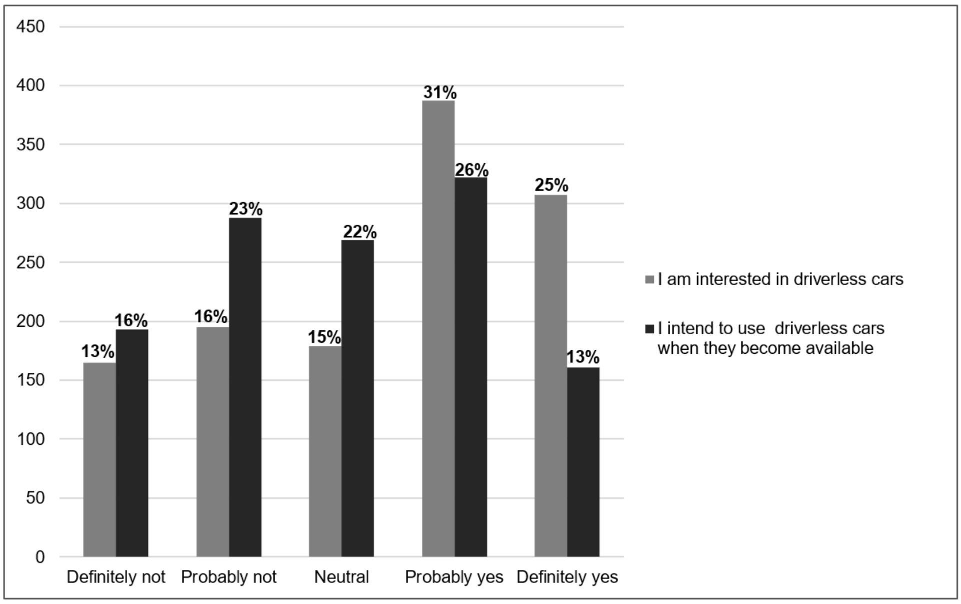

Fig 3: Respondents' interest in and adoption intentions regarding AVs (N= 1233) (Spearman Brown reliability statistic =0.890)

The SEM analyses were performed using AMOS 21 software in SPSS. The simplified path diagram of the SEM is presented in **Fig 4,** while the detailed path diagram and a summary of the correlation and covariance estimates and direct effects among variables are presented **in appendix Fig A2** and **appendix Table A1, respectively.** Below, results of the associations between latent variables are presented first, followed by those of direct predictive effects.

In the SEM, overall perception of benefits of self-driving vehicles (i.e. *perceived-benefits-composite*) is a composite latent variable derived from three first level latent variables, representing perceived attitude, utilitarian and hedonic benefits (*perceived-benefits-1*) and time use benefits (*perceived-benefits-2*) of autonomous vehicles. The results show that overall perception of the benefits of autonomous vehicles correlate positively with general attitudes towards technology, but negatively with attitude towards automation as a consequence of technological advances. Attitude toward technology and fear and anxiety are positively correlated, implying a paradoxical situation in which pro-technology attitudes exist alongside high levels of safety and security risks regarding autonomous vehicles.

Moreover, the results show that perception of the benefits of autonomous vehicles decreases among females while fears and anxiety around the technology increases with being female. The belief that autonomous vehicles will become the norm correlates positively with overall perceived benefits of the technology, as well as the belief that usage could result in reputational benefits. However, the finding suggests that controlling for other factors, being female decreases the reputational (image) and external social environment effects (subjective norm) that may be associated with using autonomous vehicles. Controlling for other variables in the model, familiarity with advance driver assisted technologies correlates negatively with being female and belonging to relatively younger age groups, but positively with higher levels of education and higher earnings. **Appendix Table A1** shows additional correlation and covariance effects between variables in the model.

The SEM results showing direct explanatory effect of independent variables on interests and adoption intentions of autonomous vehicles are outlined as follows **(see appendix Table A1).** Pro-technology attitude and higher levels of education have positive effects on individuals' perception that it would be easy for them to use autonomous vehicles. Controlling for other factors, perceived ease of use of autonomous vehicles, in turn, positively predicts perceptions of the instrumental benefits (perceived-benefits-1) and travel time-use benefits (perceived-benefits-2) of autonomous vehicles, affective attitude towards autonomous vehicles, and interests in and intention to use driverless vehicles. Moreover, the results show that individuals who are familiar with advanced driver assisted technologies are more likely to want to use autonomous vehicles, controlling for other factors. Attitude towards automation and perceived behavioural control decreases willingness to use driverless cars. This implies that the more people believe that they have control over their decision to use an autonomous car the less likely they are to actually use it. Quite paradoxically, however, fears and anxiety with regard to autonomous vehicles positively predict readiness to use this new form of transport. This implies that despite having concerns about the safety and security risks of self-driving cars, overall interests in and willingness to use autonomous vehicles remain high, controlling for other factors in the model. Finally, being relatively younger and highly educated have positive effects on overall perception of the benefits of autonomous vehicles as well as readiness to use the technology.

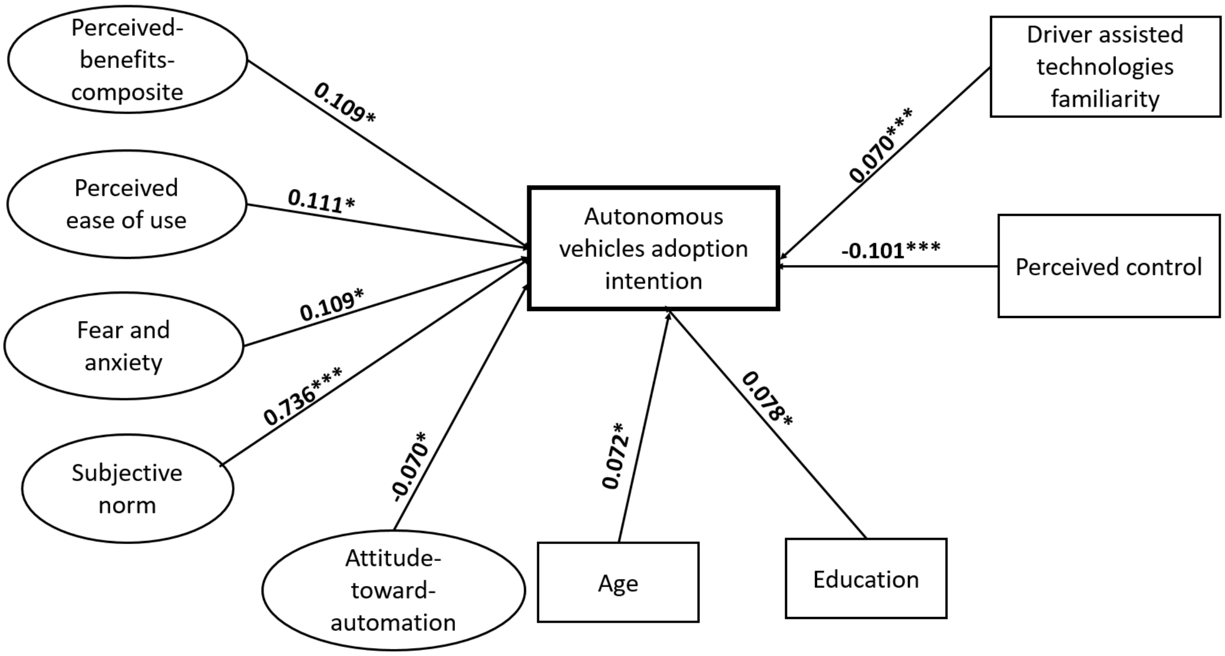

Fig 4: Simplified path diagram of SEM of autonomous vehicles interest and adoption intentions.

Notes: Model identification indices: $\chi2$ = 1864.272, df = 640, Normed-$\chi2$ =2.913, p < 0.01; RMSEA = 0.039; NFI = 0.933; CFI = 0.955; IFI = 0.955; TLI = 0.948. Full path diagram and table summary of estimates are presented in appendix Fig A2 and Table A1. Results of convergent and discriminant validity tests are presented in appendix Table A5, under the column labelled SEM-1

5.4 Modelling autonomous vehicles modal preferences—ownership, public transit and sharing

As explained initially in the introduction and methodology sections of this paper, individuals' responses to statements of interest and intention can only help answer one important aspect of the user adoption question, giving us no idea of what specific options of AVs they are willing to use. Thus, whereas the analysis in the previous section examined the determinants of interests in and readiness to use autonomous vehicles in the total sample (N=1233), the analysis presented in this section focuses on understanding the determinants of preferences for specific use alternatives of autonomous vehicles (i.e. sharing, ownership and public transit), by employing conceptual models CM-2, CM-3 and

CM-4. Therefore, the analysis uses data on a sub-sample of individuals who indicated willingness to use at least one option of driverless vehicles (n = 919) as explained in the survey design **(see section 4.2).**

Fig 5a presents a summary of the results of individuals' preferences for the different use options of driverless vehicles. These initial choices form the basis to re-cluster the sample according to individual options for use as outcome variables in SEM models of the determinants of autonomous vehicles ownership, sharing and public transport**.** For example, where the focus is on ownership as dependent variable in the SEM, all individuals who indicated preference to own a driverless vehicle are assigned *'Yes' (1)* and the rest of the group who did not are assigned *'No' (0).* The same approach is used to derive a sample of those who prefer to share and use autonomous public transport respectively as summarised in **Fig 5b**. The resulting SEMs of preferences for ownership, public transport and sharing of autonomous vehicles are presented later in the sections that follow. Before that, we first show the divergence in individuals' responses to the statement of use intentions regarding driverless vehicles and their stated preferences for specific options that were elicited in **Parts I** and **II** of the survey, respectively.

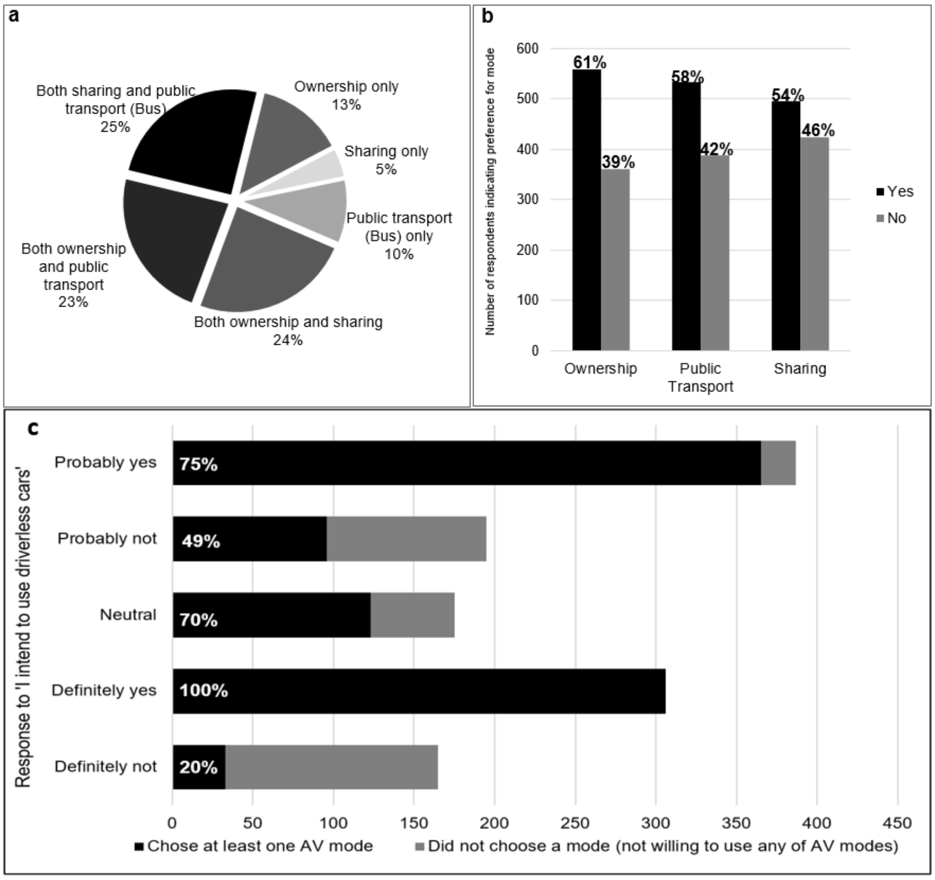

Fig 5: Autonomous vehicles modal preferences among individuals willing to use the technology

Fig 5c shows the differences in responses elicited regarding the intention to use autonomous vehicles, using the Likert-scale and those obtained when the respondents were presented with specific alternatives of autonomous vehicles to choose from, in reference to their most recent work or school and University journeys. The results show that, responses to the two questions differed among all the study participants, except for those who indicated 'definitely yes' to the statement of adoption intention: All of them indicated preference for at least one mode of autonomous vehicles. Among those who indicated 'definitely not', 'neutral', 'probably not' and 'probably yes' to the intention statement, 20%, 70%, 49% and 75%, respectively, opted for at least one of the driverless vehicle use options when presented with real modal options. We reflect on the possible reasons for the observed differences and their implications, later in the discussion section **(see section 6.2).**

5.4.1 Structural equation models of the determinants of preferences for ownership, public transport and sharing of autonomous vehicles

In this section, three interrelated SEMs are specified based on the conceptual models of modal preferences presented earlier in **section 3.2.** The SEM of preferences for ownership of autonomous vehicles utilises the conceptual model presented in **Fig1 d** (i.e. CM-4). Since the focus is on ownership, the SEM includes three additional variables namely attitude towards the environment and car ownership/use (**see Table 2**) and the importance individuals place on privacy when using motorized forms of transport. In the survey, this variable was elicited by asking the respondents to indicate what they thought about traveling with strangers in the same vehicle. Thus, privacy was used in this context to mean the state of being free from the attention of others who are not members of your household while traveling. Regarding privacy, 47% of the respondents agreed that this was important to them, 30% disagreed and 23% were ambivalent. To account for the correlations among mode related attitudes, two mode-related latent interaction variables are included in the model. These are interactions between attitude towards car ownership and sharing, and attitude towards public transit and car ownership.

The SEM of preferences for autonomous buses is based on the conceptual model presented in **Fig1 c** (i.e. CM-3). This model includes an additional latent variable that captures attitude towards public transit (**Fig 7)**, as well as interaction terms between attitude toward public transit and sharing, and attitude towards public transit use and car ownership.

The last SEM, which focuses on the determinants of sharing driverless vehicles, is based on the conceptual model presented in **Fig 1b** (i.e. CM-2). An additional latent variable which captures attitude towards sharing/collaborative consumption is included in the model**,** as well as two interaction variables namely, interaction between sharing and car ownership, and sharing and public transport.

The modelling results for the three SEMs are outlined in the following sections. The main correlation effects among the models' variables are outline first, followed by their direct effect on the outcome variables of interest (i.e. specific autonomous vehicles use options)

Correlations effects among variables across the three SEMs

In SEM of autonomous vehicles ownership **(appendix Fig A3 and Table A2)**, there are two types of car-ownership attitudes—attitudes that reflect the instrumental utilitarian benefits of the car (labelled Car-ownership-attitude-1) and attitudes that reflect the environmental implications of car-use (labelled Car-ownership-attitude-2). The results show that pro-environmental attitudes correlate negatively with environmental-related car-ownership/use attitudes such as effects on congestion, air and noise pollution (i.e. car-ownership-attitude-2). Higher education is associated with decreased favouring of car-ownership and use (Car-ownership-attitude-1), but pro-car ownership/use attitudes are associated with increased attachment of importance to privacy in traveling. There is also a positive association between attitude towards ownership and sharing, and attitude toward sharing and public transit as interaction variables.

In the SEM of preferences for autonomous buses **(appendix Fig A4 and Table A3)**, the results show that pro-public transit attitude correlates positively with positive attitudes towards the environment and technology. Furthermore, being young is associated with reduced likelihood to prioritize privacy, but controlling for all other factors, individuals who prioritize privacy, tend to hold less favourable attitude towards public transit. Indeed, with public transport, individuals have to travel with other strangers as opposed to the private car where people tend to travel alone or share a ride with other household members. Thus, the 'publicness' of autonomous buses as opposed to the 'personal' of ownership of autonomous vehicles could explain this finding. The two interaction variables—attitude towards sharing and public transport, and attitude towards public transport and ownership—are also positively correlated.

Finally in terms of correlation effects, the results of SEM of preference for shared autonomous vehicles **(appendix Fig A5 and Table A4)** shows that that pro-sharing attitudes correlate positively favourable attitudes towards the environment and technology. Relatively younger people are more likely to favour sharing. Although favourable attitudes towards sharing remains high in the sample population **(see Table 2)**, there is a small but statistically significant association between being female and favouring sharing-based consumption models. Finally, the modal attitude-related interaction variables—interaction between attitude towards sharing and ownership, and that of attitude toward public transit and sharing—covary positively with each other.

Direct explanatory effects across the three SEMs

This section outlines results of the direct effects of the explanatory variables on outcome variables of interest across the three SEMs. Simplified path diagrams of the SEMs are depicted in **Figs 6**, showing only the factors that have statistically significant effects on the outcome variables of interest. The detailed path diagrams and table summary of correlations, covariance and regression estimates of the three models are presented in **appendix 2**.

The modelling results show that perceived ease of use of autonomous vehicles is associated with increased likelihood to want to own an autonomous vehicle **(Fig 6a)**, but reduced likelihood to use this technology in the form of public transit **(Fig 6c)**. This suggests that people do not believe that it would be easy for them to use autonomous buses. Familiarity with driver assisted technologies has positive predictive effect on individuals' preference to own autonomous vehicles. Unlike preferences for ownership of autonomous vehicles, familiarity with driver-assisted technologies negatively predicts preference for using autonomous buses. This finding is possibly explained by the earlier finding that individuals who own cars and frequently drive tend to be familiar with driver assisted technologies. Perceived ease of use and familiarity with driver assisted technologies do not have statistically significant effects on preferences for shared autonomous vehicles.

Moreover, individuals who favour car-use because of the instrumental benefits it affords such as safety, comfort and travel speed, are more likely to want to own driverless vehicles **(Fig 6a)**. However, pro-environmental attitudes negatively predict ownership of autonomous vehicles, implying that individuals who believe that reducing anthropogenic stresses on the environment is necessary, are less likely to want to own a self-driving vehicle, controlling for other factors. Regarding use of shared autonomous vehicles and autonomous buses, the results show that pro-sharing attitudes and favourable attitude towards public transit are associated with increased likelihood by individuals to want to use the former and the latter alternatives, respectively **(Fig 6b)**. Attitude towards the environment is also associated with increased likelihood to use shared autonomous vehicles. This suggests that positive environmental values influence the survey respondents' willingness to use shared autonomous vehicles when they become available. All the mode-related attitudes interaction variables did not have statistically significant effect across the three models, except in the SEM of preference for shared autonomous vehicles. In this model, the results show that the interaction variable comprising attitude towards sharing and public transit was associated with increased likelihood among individuals to want to use shared autonomous vehicles when they become available. Controlling for other variables, however, the need for privacy while travelling negatively predicts preference for shared autonomous vehicles **(Fig 6b)**.

Furthermore, individuals who believe that they have control over their use of autonomous vehicles are less likely to favour autonomous buses **(Fig 6c)**. Image, which reflects perceived reputational benefits of using autonomous vehicles, is associated with decreased likelihood of using autonomous buses. However, believing that autonomous vehicles will be the norm and that seeing significant others use them can influence individuals to do the same (i.e. subjective norm), positively predicts preference for autonomous buses **(Fig 6c)**.

Finally, regarding socio-demographic factors, the findings show that being female is negatively associated with preference for autonomous buses **(Fig 6c)**, although no statistically significant effect exists among gender and preferences for ownership and sharing of autonomous vehicles. The effect of education was significant in the SEM of preferences for shared autonomous vehicles **(Fig 6b)**, but not in those of public transit and ownership. The results also show that higher levels of educational attainment (tertiary qualification) is associated with increased likelihood to choose shared autonomous vehicles.

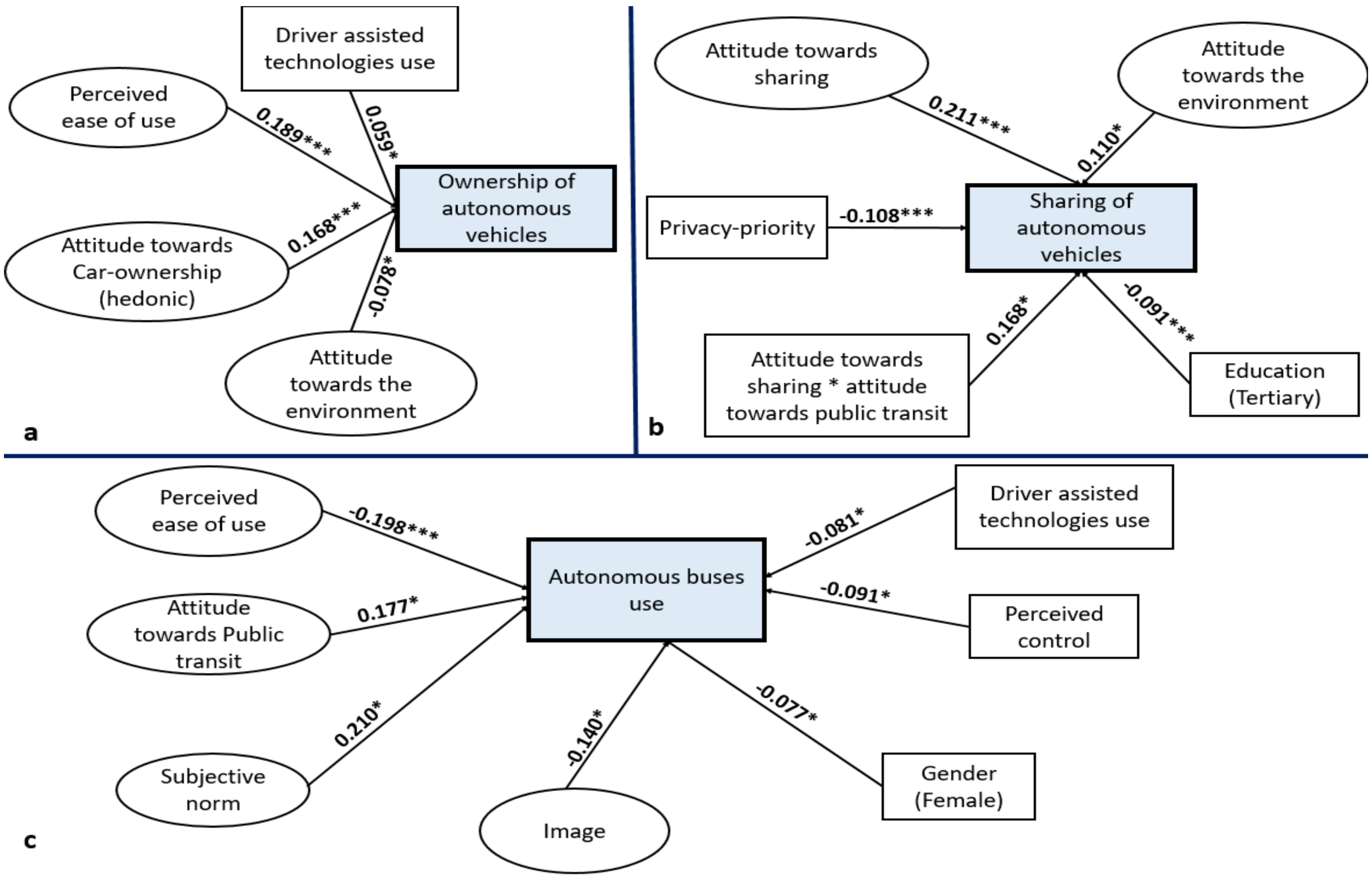

Fig 6: Simplified path diagrams of SEMs showing only the variables that have statistically significant direct effect on preference for (a) ownership of autonomous vehicles (b) sharing of autonomous vehicles and (c) autonomous public transit (bus).

Notes: Full path diagrams, summary of model estimates and model identification indices are presented in appendix Fig A3-A5 and Tables A1-A4. Results of convergent and discriminant validity tests are presented in appendix Table A5, under the column labelled SEM-2-4

5.5 Exploring willingness to pay for preferred autonomous vehicle use options by engine fuel source

Besides the modal preferences, the survey explored preferences for engine source fuel among the respondents **(Fig 7)** and how much individuals are willing to pay to use their preferred alternative **(Fig 8)**. The results show that the majority of the respondents (75%) would like to have their preferred autonomous vehicle mode being electric. Another 22% prefer hybrid autonomous vehicles while fewer of the respondents indicated preference for fossil-fuel powered engine in their preferred autonomous vehicle option **(Fig 7a**). A breakdown of the results according to individuals choosing sharing, public transport and ownership of autonomous vehicles is presented in **Fig 7b**. Overall, most of the would-be users across the three options indicated preference for relatively cleaner engine fuel sources (i.e. electric and hybrid), although the proportion of potential users who would prefer fossil-fuelled engines is slightly higher among those who chose ownership (i.e. 5%) compared to those who chose public transit (2%) and sharing (2%).

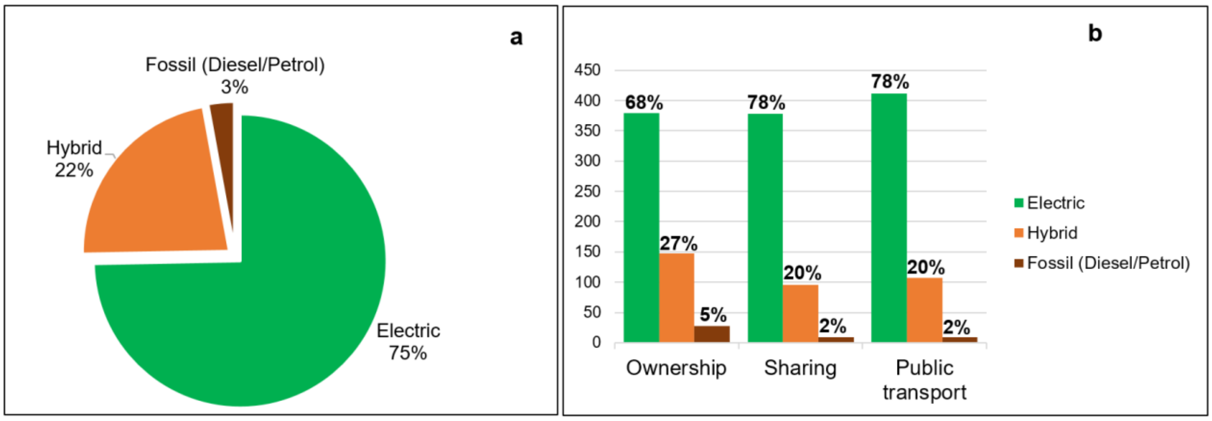

Fig 7: Autonomous vehicles engine fuel source preference among would-be users and across different use options

A descriptive summary of individuals' willingness to pay for their preferred autonomous vehicles use options by engine fuel sources is presented in **Fig 8**. Among those who indicated preference for ownership of autonomous vehicles, most of them (79%) indicated that they would be willing to pay between €20,000-30,000 (49%) and €31,000-40,000 for the vehicle presented to them in the survey **(see Appendix 1, Fig A1)**. As shown in **Fig 8a**, the remaining 21% are willing to pay higher to own an autonomous vehicle. A breakdown of the willingness to pay by engine fuel source of the vehicle shows that about half of the would-be owners are willing to pay between €20,000-30,000 to own an electric (50%) and hybrid (49%) autonomous vehicle respectively. Relatively fewer proportion of those who indicated preference for fossil-fuelled autonomous vehicles (i.e. 33%) are willing to pay the price range of €20,000-30,000. However, the results show a relatively higher proportion of those who indicated preference for fossil-fuelled autonomous cars (i.e. 41%) are willing to pay the price range of €31,000-40,000 vehicles to own one compared to 30% of those who indicated preference for electric and hybrid autonomous vehicles respectively **(Fig 8b)**.

Regarding the option of shared-autonomous vehicles, the majority of the respondents (i.e. 81%) indicated that they would be willing to pay €15 or less to use an autonomous car-sharing service for an hour's journey. Within this sample, 39% were willing pay less than €10/hr to use an autonomous car-sharing service. Major car-sharing services offering conventional fleet of cars, such as GoCar in Dublin, charge about €10/hr of use. This finding suggests that this 39% of potential autonomous car-sharing users expect to pay rates lower than what is charged by conventional car-sharing companies in their city. The next block of pricing (i.e. €10-15/hr) was found acceptable by 42% of the respondents, while the remaining 19% where willing to pay more than €15/hr to use shared autonomous cars (**Fig 8c**). A detailed breakdown of willingness to pay to use electric, hybrid and fossil-fuelled shared autonomous vehicles is presented in **Fig 8d.**

Finally, the fares that individuals who prefer to use autonomous public transport services are willing to pay are presented in **Fig 8e.** In Dublin**,** commuters pay a flat fare for public transport, which is charged based on the number of bus stops (also known as stages) covered by the journey. At the time of the survey, this flat fare was €2.05/13 stops or stages. This amount was used as the baseline fare in the survey. About 40% of the respondents indicated that they would be willing to pay less than the baseline flat fare amount, currently charged for a bus ride, to use autonomous buses. This possibly suggests that a large number of the respondents consider this baseline fare expensive and would be willing to pay less to use autonomous buses when they become available. About 45% of the respondents found a flat fare of €2.60-3.30/13 stops or stag acceptable, suggesting that this proportion of respondents were willing to pay a fare that is about 27-62% more than the baseline rate currently paid by conventional public transport users. A breakdown of willingness to pay for autonomous buses according to engine fuel source is presented in **Fig 8f.**

Fig 8: Individual's willingness to pay to use their preferred mode of autonomous vehicles based on engine fuel source: (a) Private ownership (b) Sharing (c) Public transport (bus)

6 Discussion of findings and implications for policy and practice

Technological advances are making new forms of transport such as autonomous vehicles possible, but there are enormous uncertainties around how these will shape urban mobility and ultimately contribute to sustainable transport imperatives. In order to address this gap and better understand how individuals are likely to use driverless vehicles to meet their travel needs and the potential sustainability impacts, this paper has examined empirically user adoption and preferences regarding autonomous vehicles. In doing so, the paper has revealed useful insights about the factors that can drive adoption of and preferences for different use options of autonomous vehicles. Below, the key findings and their implications are discussed, with a particular focus on how autonomous vehicles might shape travel behaviors through mode choice (i.e. sharing, ownership and public transport) and ultimately affect motorization levels, travel-related energy use, the environment and society.

6.1 Autonomous vehicles interest and adoption intentions elicited with Likert-scale statements

The analysis first examined the determinants of adoption intention regarding autonomous vehicles. Adoption intention combined two items elicited using the Likert-scale approach to reflect individuals' interest in and intention to use autonomous vehicles. In doing so, we captured the underlying correlations that exist between interest and use intentions regarding autonomous vehicles to represent a single outcome variable of interest in the SEM. The results for this analysis show that pro-technology attitudes, familiarity with existing advance driver assisted technologies, and perceptions that driverless vehicles will be useful and easy to use, increase intention to use the technology. In the context of this study, what these findings suggest is that people who expect autonomous vehicles to provide travel time-use advantages in addition to instrumental and hedonic benefits, such as safety, comfort, travel speed and performance, are more likely to want to use them. Specifically, the results show that both perceived benefits and perceived ease of use—concepts integrated into our model from Davis' original TAM model— have the largest predictive effect on adoption intention, controlling for other factors. The above findings corroborate those of other research deploying the TAM model, which have shown that these two variables tend to be the strongest predictors of the adoption of new technologies (see e.g. Venkatesh and Davis, 2000; Venkatesh et al., 2003; Panagiotopoulos and Dimitrakopoulos, 2018). For example, Panagiotopoulos and Dimitrakopoulos (2018) found that adoption intentions regarding autonomous vehicles are influenced by perceived usefulness/benefits and ease of use, with the former exerting the largest effect on intention.

Moreover, in the SEM of autonomous vehicles adoption intention, perceived behavioral control was included from the Ajzen's original TPB. Doing so enabled us to gain further insights into the drivers of use adoption intentions, beyond individuals' perceptions of the benefits and ease of use of autonomous vehicles. Previous studies on transport mode choice suggest that perceived-behavioral control is one of the key predictors of behavioral intentions (Sun et al., 2015; Scott et al., 2007; Galea and Bray, 2006; Bamberg et al., 2003). In our study, including this variable in the analysis allowed us to capture the extent to which individuals believe that they have control over their use intention and, ultimately, their decision to use autonomous vehicles when they become available. As the results show, perceived behavioral control had a negative effect on adoption intentions, controlling for other factors. Jing et al (2019) reports similar findings in their study whereby perceived behavioral control was found to reduce intention to adopt autonomous vehicles. From our work, we interpret this finding as suggesting that there is a strong conviction in the sample population (especially among those who are not interested in and do not want to use autonomous vehicles), that individuals have full control over whether or not they will use this new technology.

The possible effects of the external social environment on adoption intention were captured via two concepts, namely subjective norm and image, which we integrated into our analysis from the original TPB and TAM, respectively. These two concepts are complementary in that subjective norm from TPB allowed us to capture the perceived influence of significant others (i.e. friends and colleagues) while image from TAM helped us to capture the perceived reputational/status benefits that individuals associate with using autonomous vehicles. Previous studies have shown that an individual's perception of the influence of others' can have significant influence on their own actions or behaviours (Krueger and Rashidi 2018; Bamberg et al., 2003). In the context of autonomous vehicles, our findings show that subjective norm correlated positively with fear and anxiety. Based on the indicator items used to measure subjective norm (**see Table 2**), we interpret this finding as suggesting that whether an individual has fears or anxiety regarding autonomous vehicles, could be related to whether they believe the technology will become the norm and will possibly be used by others such as their friends and colleagues. In other words, the observed correlation suggests that the majority of the sample have fears and anxieties regarding risk of automated driving, but at the same time, they believe that driverless vehicles will be the norm in the near future when many people will likely use the technology. Consistent with the findings of previous studies (see e.g. Jing et al., 2019; Talebian and Mishras, 2018), we found that subjective norm has a positive predictive effect on intention to adopt autonomous vehicles. Moreover, whereas subjective norm exerted a positive effect on adoption intention, image had the opposite effect, controlling for other variables. This finding suggests that while individuals recognise the effect that autonomous vehicles becoming the norm could have on their own use intentions, most of them do not perceive that reputational benefits will influence positively their adoption intentions.

A rather paradoxical finding from the analysis is that while the respondents agreed there are potential public safety and security risks around autonomous vehicles for which they are concerned or worried, these concerns do not appear to decrease overall intention to use the technology. As the findings of our study partly show, nearly half of all the respondents agree that automating driving would likely reduce crashes and save lives. Indeed, similar contradictions can be seen even in the increasing use of conventional motorized transport, despite an estimated 1.2 million deaths occurring annually from road traffic accidents (see WHO, 2015). In fact, the expected safety and lifesaving benefits of autonomous vehicles are frequently invoked to justify the need for this new transport technology, but whether these promises will actually materialize remains one of the imponderables in the transition to autonomous mobility.

Finally, the effect of socio-demographic factors on adoption intention were examined in the SEM. Consistent with the finding of previous studies (see e.g. Liu et al., 2019; Woldeamanuel and Nguyen, 2018; Abraham et al., 2017), this paper has shown that relatively younger adults with higher levels of education, who have pro-technology attitudes are more willing to use autonomous vehicles. These socio-demographic factors have already been found to be instrumental in the adoption and use of new forms of technology-mediated transport such as car-sharing, ride-hailing and bike-sharing (see e.g. Acheampong and Siiba, 2019; Prieto et al., 2017; Efthymiou and Waddell, 2013), and will likely continue to drive the diffusion and use of autonomous vehicles.

6.2 From Likert scale-based use intentions to preferences for specific use options of autonomous vehicles— differences in responses

Perhaps, one of the most interesting contributions of the current paper stems from the research design, whereby we sought to examine whether there would be any differences in individuals' responses to Likert scale-based statement of adoption intent on the one hand, and their stated preferences for specific alternatives of autonomous vehicles on the other hand. We found that indeed, such differences in the responses to the two questions could be observed in the sample population. Specifically, we found that all individuals who indicated that they definitely intend to use autonomous vehicles also indicated their preferences for at least one of the specific use options of driverless vehicles presented to them in the survey. However, differences could be observed, whereby some of the respondents who had initially indicated that they were not interested or were unsure and ambivalent in response to the Likert scale-based statement of intention, indicated preferences for at least one of the use alternatives of autonomous vehicles when presented with real modal options. We believe that the specificity of the experiment involving real modal choices constrained to the individuals' most recent trips, as opposed to the Likert scale-based elicitation of intentions, accounts for the observed differences in individuals' responses.

Thus, the aforementioned findings have implications for the way surveys are designed to elicit preferences regarding autonomous vehicles and indeed for other forms of transportation. As argued in the introduction section, previous studies tend to be either focused on statements of adoption intentions or stated preferences for specific options. On its own, the latter approach could have a limitation in obscuring important differences in how individuals respond to the adoption question. However, as the current paper has shown, including statements of intention and providing real modal options could help better understand and compare the differences in responses that the two framings of the adoption question elicit.

6.3 Modal preferences regarding autonomous vehicles

In order to provide an empirical basis to explore possible sustainability implications of autonomous vehicles beyond the drivers of adoption intentions outlined above, this paper has also systematically modelled preferences for specific use option and engine fuel sources in the sub-group of the sample who indicated willingness to use autonomous vehicles. Results of the SEM analyses and their implications are discussed as follows:

The findings suggest variations in the influence of socio-demographic factors (i.e. education, gender, income and age) on adoption intentions and preferences for specific use options. As previously explained under **section 6.1**, regarding adoption intention, education and income both had positive predictive effects, controlling for other factors in the SEM. In the SEMs of the determinants of preferences for shared-autonomous vehicles, education has a positive effect, suggesting that highly educated individuals are more willing to share. The effect of age however is negative, suggesting that relatively older individuals do not favor the concept of shared-autonomous-mobility. Being female was also found to be associated with decreased preference for autonomous public transit. While our data does not allow us to fully explain why this is so, we believe that this might be related to our initial finding that, overall, more females than males expressed fear and anxiety regarding autonomous vehicles in general. Previous research (see e.g. Deb et al., 2017; Payre, et al., 2014) has also suggested that men are more likely to demonstrate favorable attitude towards fully autonomous vehicles compared to women who often show concern about safety as reported in this study. Regarding preferences for ownership of autonomous vehicles, none of the socio-demographic factors had a statistically significant effect in our analysis.

Moreover, the results show that for single mode options, shared-autonomous vehicles remain the least popular one, although the proportion of would-be users willing to accept sharing in combination with other alternatives such as ownership and public transport is significantly higher. Overall, preference for ownership of autonomous vehicles either as a single option or in combination with sharing or public transport is also high. Unlike the general adoption intentions regarding autonomous vehicles where perceived benefits is a major determining factor, with preferences for specific use options (i.e. sharing, ownership and public transport), the findings suggest that it is rather attitudes towards these use options that matter the most, even after accounting for the interaction effects among those attitudes. Those who favor car-ownership/use are more likely to want to own autonomous vehicles. Similarly, those with positive attitudes towards public transport and sharing as an alternative consumption paradigm, are more willing to use autonomous vehicle sharing and public transport alternatives, respectively.

The findings also suggest that pro-environmental attitudes increase willingness to use public transport and shared autonomous vehicles, but decrease preferences for ownership. Across the different use options presented in the survey, there are indications that preferences for clean engine fuel sources such as electricity and hybrid energy sources remain very high among would-be users of autonomous vehicles. Indeed, most of the respondents have pro-environmental values, which could explain the high preference for cleaner engine fuel sources.

The aforementioned findings suggest that preferences for autonomous vehicles are very much embedded in attitudes and choices regarding existing forms of motorized transport. Thus, a plausible scenario is that even with autonomous vehicles, people will most likely stay, at least in the short run, with what they are familiar with in terms of travel mode choices. Should this happen, it is possible that current overall modal split and most importantly, the large share of private car-based transport, might not change in the era of autonomous vehicles. These findings also raise enormous challenges for making urban transport sustainable. For example, autonomous vehicles are expected to transform motorized transport by enabling the implementation of flexible on-demand car-sharing services (see e.g. Milakis et al, 2017; Chan, 2017; Schoettle and Sivak, 2015). The common assumption is that these capabilities of driverless vehicles will necessarily usher cities into a future where sustainable shared mobility is the norm. However, as this study has shown, car-sharing alone is not the most preferred option of travel mode. Indeed, resonating with global trends (see e.g. Shaheen and Cohen, 2017; De Lorimier and El-Geneidy 2013; Ohta et al., 2013), only a small percentage of the sample population currently uses car-sharing. It is therefore not surprising that with autonomous vehicles, the majority of the sample are also unwilling to use the option of sharing alone. This implies that car-sharing could only become supplementary, with people owning and using cars to meet a significant amount of their travel needs and only using shared-autonomous vehicles to make rather fewer journeys trips. Consequently, the possibility of reducing car ownership, motorization levels, congestion, emissions and travel-related negative impacts on society through shared-mobility, might not materialize in the era of autonomous vehicles.

Aside car-sharing, the findings of this study also have implications for increasing public transit ridership in the era of autonomous vehicles. Indeed, one of the major challenges currently in transport policy is how to get more people across different socioeconomic groups to use public transport. The findings of this study suggest that those currently using public transit will likely continue to do so, but the biggest challenge would be getting car users to switch given the embedded attitudes towards car-use and overall limited interest in car-sharing. Increasing public transport use will likely become even more challenging for urban transport authorities in light of the COVID-19 pandemic. Indeed, one of the major sources of uncertainty for public transit planning is whether the pandemic will deter people from using public transport and instead encourage more car-based transport, especially among those who do not cycle or walk to participate in urban activities such as work, shopping and leisure. Thus, the future of sustainable urban transport in the context of autonomous vehicles will have to grapple with the potential negative attitudes that could emerge and affect public transit and car-sharing demand, as a result of the COVID-19 pandemic. Moreover, as the findings regarding willingness to pay shows, regarding autonomous buses, a good proportion of the individuals are willing to pay less than what they are currently paying for conventional transport to use autonomous buses. This raises an important issue around the pricing and affordability of public transport which could be addressed in planning future transport in the context of autonomous buses to enable more people to use public transport.

Furthermore, perception of ease of use of autonomous vehicles appears to decrease with autonomous buses as the choice alternative. This probably suggests that people imagine and associate automated driving with cars, but not very much with large capacity, double-decker buses for public transit as presented in our study. Ability to use a new technology partly determines trust with the technology. Thus, user-friendliness in the design and operation of autonomous public transport systems would be an important determining factor of mass transit ridership in the future of autonomous buses.

Finally, findings of this paper could also provide insights into the various pathways towards meeting sustainable transport imperatives in the era of autonomous vehicles. That overall attitudes towards the environment, public transport and sharing as an alternative to ownership, remain high in the population could be an asset in enabling sustainable transport futures. The challenge for policy will be to bridge the gap between these positive attitudes and real travel choices, especially among those who hold them but make the opposite choices, by using private car-based transport. To this end, the design and implementation of urban transport policies can leverage these positive attitudes as part of wider strategies in increasing the uptake of public transit and car-sharing in the era of autonomous vehicles and in the context of the uncertainties generated by the COVID-19 pandemic. Interventions aimed at communicating the benefits of public transport and sharing and offering people incentives to do so, could help nudge behaviours towards sustainable motorized mobility choices. Ultimately, urban planning and policy must address structural conditions such as unfettered sprawl and suburbanization that currently exist and could be entrenched with the advent of autonomous vehicles, as highlighted by Rode et al. (2017), to bring about sustainable mobility outcomes.

7 Limitations and recommendations for future research

A number of limitations are worth mentioning for the purpose of contextualising the findings of the current paper and for further research. Firstly, the survey attracted a large number of young adults, especially 18-24 year-olds. A primary reason is that the survey was mostly administered online. Despite this, opinions about autonomous vehicles were found to be broadly similar across the different age groups in our sample. Attracting more respondents from different age groups would certainly help improve the generalizability of the research findings. We see the use of personal interviews as one way of reaching more people who are relatively much older.

Secondly, we have deployed four comprehensive conceptual models to examine use intentions and preferences for different use options of autonomous vehicles. Yet, the survey design did not capture all possible and relevant attributes of autonomous vehicles such as access time and travel time of particular autonomous transport services, vehicle brand and design. We found this to be one of the trade-offs to be made between adopting a detailed behavioural approach such as the one presented in this study or adopting a discrete choice experimental design which attempts to capture these attributes and their levels. Even so, it is possible, using our design to capture this information by adding extra questions. In doing so, however, the right balance will have to be sought between including additional questions to achieve comprehensiveness and realism on the one hand, and the possibility, on the other hand, of causing respondent fatigue if the resulting survey becomes too long. Thirdly, our findings are from a single case study (i.e. Dublin, Ireland), and it would be useful to empirically test the conceptual frameworks and overall research design in different socio-cultural and geographical contexts.

Finally, the current research has examined autonomous vehicles use intentions and preferences at a time when the technology has not yet become a diffused mode of transport. Intentions and preferences, as well as their underlying attitudes, perceptions and values are not static, but rather subject to changes over time under different conditions. It was not possible to capture this temporal dimension in the current study using a cross-sectional survey design. As the technology diffuses and gradually becomes part of the everyday, we see a longitudinal design that builds on the empirically tested models presented in this paper, as one way of accounting for the temporal dimension in future studies.

8 Conclusion: towards sustainable mobility in future cities

Envisioning urban transport and mobility futures in the context of new and emerging technologies, such as autonomous vehicles is fraught with many uncertainties. In this paper, we have attempted to explore the potential implications of autonomous vehicles for future transport, based on an empirical study of the perspectives and likely choices of the potential user, as one of the main forces that will shape the diffusion and use of this technology. Our findings reveal attitudes and stated preferences that are deeply rooted in individuals current travel choices and attitudes. Thus, in one plausible scenario, the current trend of high levels of car-based transport and the associated negative impacts could continue in a future where autonomous vehicles are available. However, our findings also suggest that alternative futures where autonomous car-sharing and public transit dominate are also plausible and could be enabled by tapping into the existing individuals' awareness of the socio-environmental consequences of their travel behaviours, to cultivate more sustainable urban transport attitudes and choices.

From a policy perspective, this means that transport policies must go hand in hand with education policies. Given that the people who care about the environment and are aware of the environmental sustainability challenges that our cities and the whole planet face, are the same people who are most willing to integrate sustainability solutions into their daily life and mobility, governments should proactively develop policies seeking to increase the environmental awareness of the population. The road to environmental awareness leads to the road towards sustainable urban mobility. However, as this study has shown, metaphorically speaking a single road towards the future of urban mobility does not exist. People have different opinions, attitudes and values which will trigger different choices. Some will prefer to own autonomous cars, others to share them. Some will go for autonomous buses, others for a combination of diverse options. Governments should hear all these different voices and feelings and create appropriate political platforms for people to share their opinion and participate in the planning process that shapes the design and infrastructure of urban transport. This is ultimately a matter of 'politicizing' the autonomous car (and, more in general, artificial intelligence technology) 'so that its deployment in cities is discussed and agreed as inclusively and as democratically as possible' (Yigitcanlar and Cugurullo, 2020: 14). Failure to engage politically would form a narrow road to the city of the future, so narrow that some people will inevitably be excluded. That is not the road that leads to urban sustainability.

Appendix 1: Image included in the questionnaire

Fig A1: Image of an unbranded fully autonomous vehicle presented to respondents in the survey questionnaire

Appendix 2: Full path diagram and table summaries of estimates of structural equation models

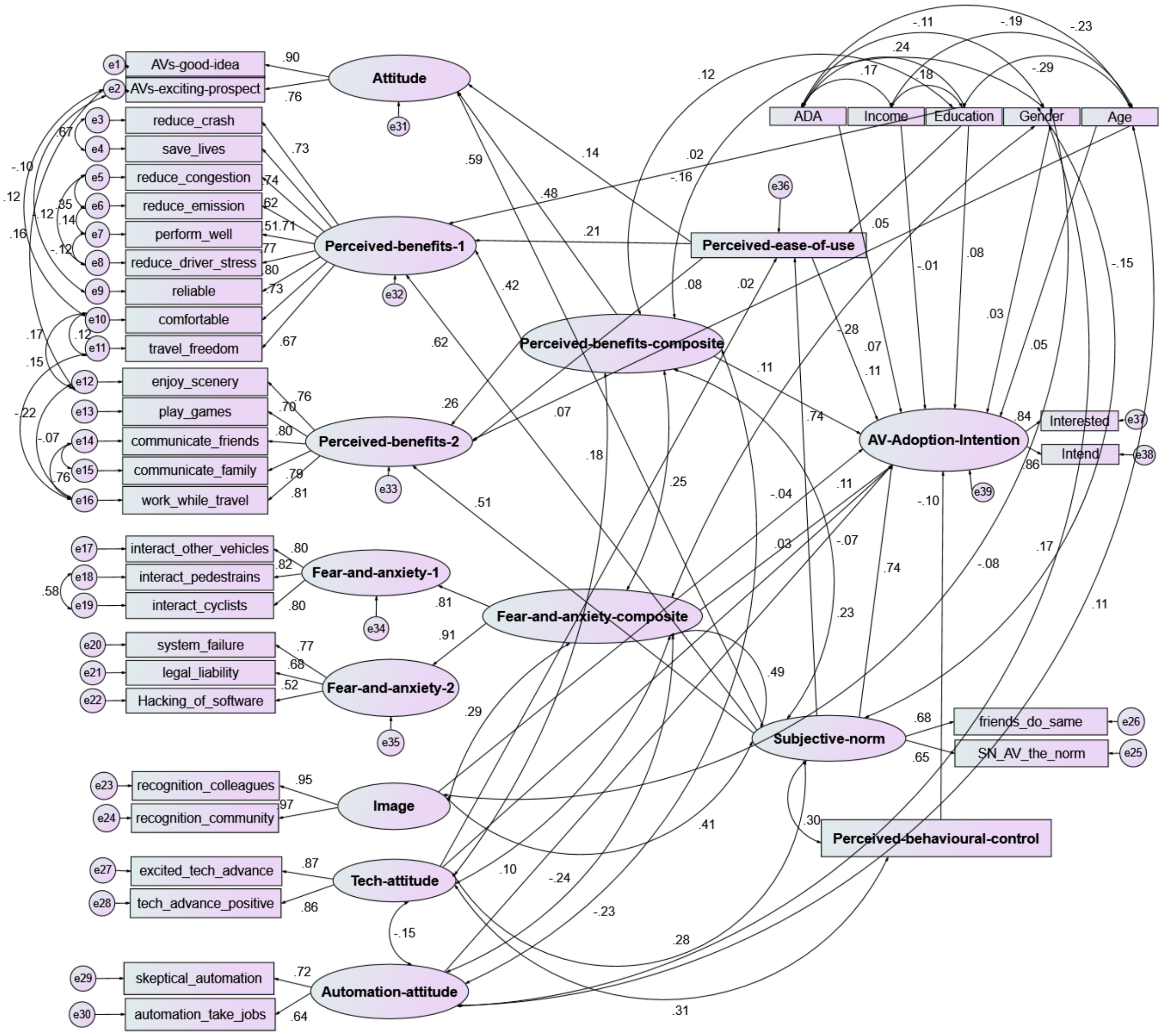

Fig A2: Path diagram of SEM of autonomous vehicles interest and adoption intentions.

Notes: Model identification indices: χ^2 = 1864.272, df = 640, Normed-χ^2 =2.913, $p < 0.01$; RMSEA = 0.039; NFI = 0.933; CFI = 0.955; IFI = 0.955; TLI = 0.948. Results of convergent and discriminant validity tests are presented in appendix **Table A5**, under the column labelled SEM-1

Table A1: Correlations, covariance and regression weights of relationships among variables in SEM of autonomou vehicles adoption intention

A. ***Direct Effects***			ß	b	S.E.	C.R.	P
AV-adoption-intention	<--	Perceived-benefits-composite	0.426	0.109	0.210	2.028	0.043
AV-adoption-intention	<--	Perceived-ease-of-use	0.091	0.111	0.043	2.129	0.033
AV-adoption-intention	<--	Perceived-behavioural-control	-0.100	-0.101	0.026	-3.831	***
AV-adoption-intention	<--	Attitude-toward-automation	-0.079	-0.070	0.036	-2.178	0.029
AV-adoption-intention	<--	Attitude-toward-technology	0.021	0.029	0.020	1.043	0.297
AV-adoption-intention	<--	Fear and anxiety	0.231	0.109	0.075	3.096	0.002
AV-adoption-intention	<--	Subjective norm	0.955	0.736	0.115	8.300	***
AV-adoption-intention	<--	Image	-0.033	-0.045	0.021	-1.570	0.116
AV-adoption-intention	<--	Education	0.050	0.078	0.015	3.229	0.001
AV-adoption-intention	<--	Gender	0.043	0.029	0.033	1.283	0.200
AV-adoption-intention	<--	Income	-0.008	-0.009	0.018	-0.452	0.651
AV-adoption-intention	<--	Driver-assisted-technology	0.104	0.070	0.031	3.355	***
AV-adoption-intention	<--	Age	0.075	0.052	0.031	2.396	0.017
Perceived-benefits (instrumental)	<--	Perceived-ease-of-use	0.132	0.206	0.030	4.399	***

Perceived-benefits (time use)	<--	Perceived-ease-of-use	0.067	0.084	0.039	1.706	0.088
AV-attitude	<--	Perceived-ease-of-use	0.094	0.142	0.034	2.729	0.006
Perceived-ease-of-use	<--	Subjective norm	1.171	0.736	0.063	18.609	***
Perceived-ease-of-use	<--	Education	0.043	0.055	0.017	2.471	0.013
Perceived-ease-of-use	<--	Attitude-toward-technology	0.014	0.016	0.026	0.552	0.581
Perceived-benefits (instrumental)	<--	Subjective norm	0.636	0.623	0.062	10.222	***
AV-attitude	<--	Subjective norm	0.629	0.595	0.069	9.144	***
Perceived-benefits (time use)	<--	Subjective norm	0.644	0.511	0.078	8.257	***
Perceived-benefits (instrumental)	<--	Education	0.012	0.024	0.009	1.361	0.174
Perceived-benefits (time use)	<--	Age	0.100	0.072	0.033	3.043	0.002
B. Correlations and covariance			**Cov**	**Corr**	**S.E.**	**C.R.**	**P**
Perceived-benefits-composite	<-->	Attitude-toward-automation	-0.027	-0.230	0.007	-3.680	***
Attitude-toward-technology	<-->	Fear and anxiety	0.035	0.101	0.011	3.068	0.002
Perceived-benefits-composite	<-->	Fear and anxiety	0.016	0.248	0.004	3.630	***
Attitude-toward-automation	<-->	Fear and anxiety	-0.052	-0.237	0.009	-5.511	***
Attitude-toward-technology	<-->	Attitude-toward-automation	-0.099	-0.155	0.023	-4.223	***
Subjective norm	<-->	Image	0.232	0.415	0.019	12.430	***
Subjective norm	<-->	Fear and anxiety	0.093	0.486	0.010	9.613	***
Image	<-->	Fear and anxiety	0.099	0.290	0.013	7.837	***
Perceived-benefits-composite	<-->	Attitude-toward-technology	0.034	0.181	0.010	3.239	0.001
Attitude-toward-technology	<-->	Subjective norm	0.158	0.282	0.020	7.804	***
Perceived-benefits-composite	<-->	Subjective norm	0.024	0.235	0.009	2.776	0.006
Perceived-behavioural-control	<-->	Subjective norm	0.125	0.305	0.013	9.596	***
Perceived-behavioural-control	<-->	Attitude-toward-technology	0.227	0.310	0.022	10.453	***
Driver-assisted-technology	<-->	Gender	-0.028	-0.114	0.006	-4.352	***
Driver-assisted-technology	<-->	Age	-0.057	-0.229	0.007	-7.929	***
Driver-assisted-technology	<-->	Education	0.133	0.238	0.016	8.198	***
Age	<-->	Attitude-toward-automation	0.036	0.110	0.011	3.323	***
Age	<-->	Education	-0.167	-0.289	0.017	-9.815	***
Gender	<-->	Perceived-benefits-composite	-0.015	-0.162	0.004	-3.339	***
Gender	<-->	Fear and anxiety	-0.048	-0.282	0.006	-7.502	***
Gender	<-->	Attitude-toward-automation	0.053	0.167	0.011	4.629	***
Gender	<-->	Subjective norm	-0.042	-0.151	0.009	-4.773	***
Gender	<-->	Image	-0.040	-0.081	0.014	-2.827	0.005
Education	<-->	Perceived-benefits-composite	0.026	0.122	0.010	2.629	0.009
Income	<-->	Driver-assisted-technology	0.068	0.167	0.012	5.833	***
Income	<-->	Education	0.165	0.176	0.027	6.092	***
Income	<-->	Age	-0.078	-0.186	0.012	-6.435	***

Notes: ß = Unstandardized regression estimates, b = standardized regression estimates; cov =covariance, corr =correlation;
*** P-value < 0.01

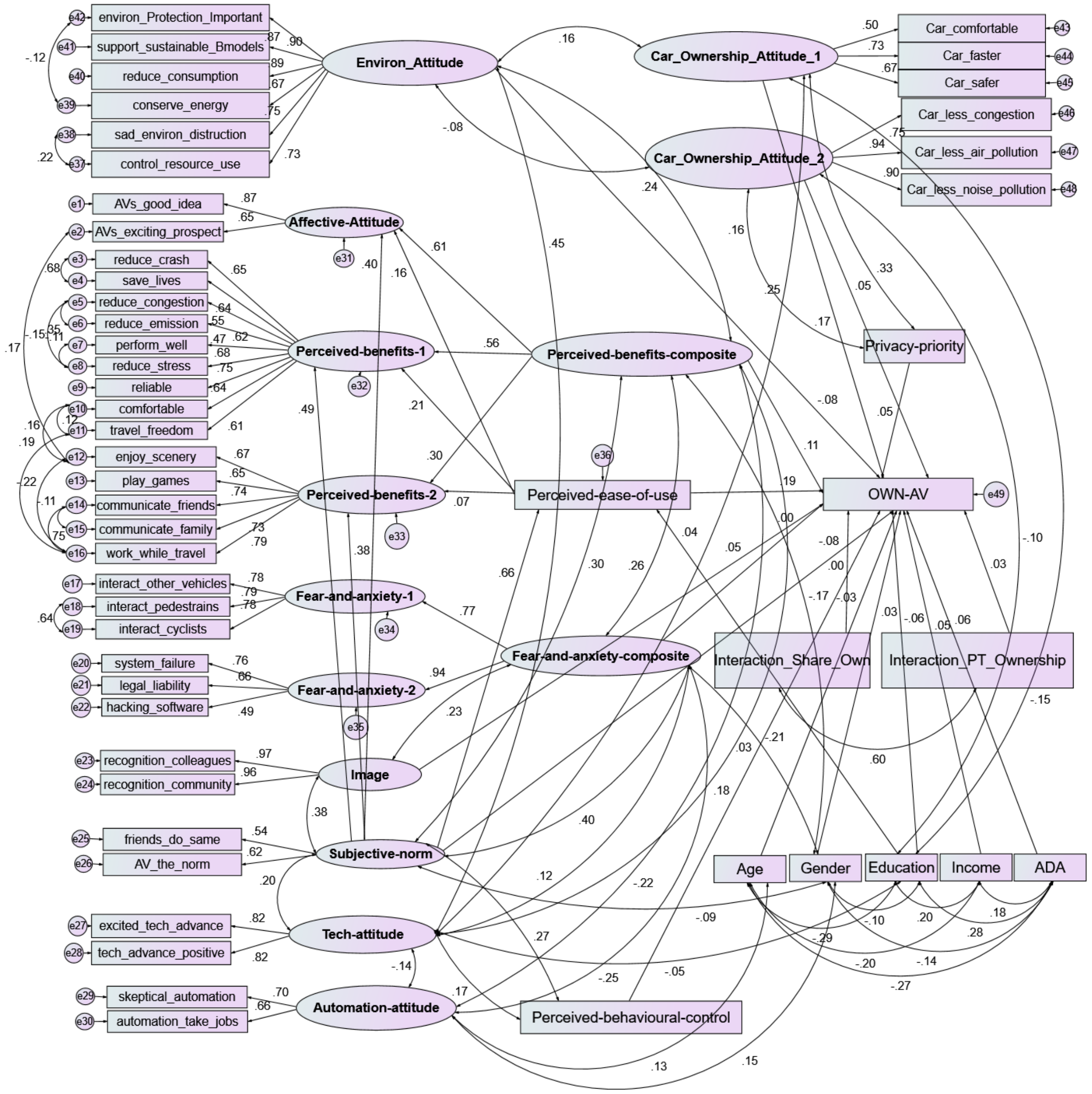

Fig A3: Path diagram of SEM of the determinants of preferences for autonomous vehicles ownership.

Notes: Model identification indices: χ^2 = 2715.338, df = 1256, Normed-χ^2 =2.161, $p < 0.01$; RMSEA = 0.036; NFI = 0.866; CFI = 0.935; IFI = 0.936; TLI = 0.929. Results of convergent and discriminant validity tests are presented in **appendix Table A5**, under the column labelled SEM-2

Table A2: Correlations, covariance and regression weights of relationships among variables in SEM of autonomous vehicles ownership

A. Direct Effects			**ß**	**b**	**S.E.**	**C.R.**	**P**
AV-ownership	<--	Perceived-benefits-composite	0.263	0.106	0.160	1.649	0.099
AV-ownership	<--	Perceived-ease-of-us	0.116	0.189	0.033	3.507	***
AV-ownership	<--	Fear and anxiety	0.002	0.002	0.062	0.039	0.969
AV-ownership	<--	Image	0.025	0.051	0.020	1.217	0.224
AV-ownership	<--	Privacy-priority	0.026	0.046	0.020	1.313	0.189
AV-ownership	<--	Income group	0.029	0.053	0.018	1.613	0.107
AV-ownership	<--	Driver-assisted-technology-use	0.058	0.059	0.034	1.728	0.048
AV-ownership	<--	Age-group	-0.032	-0.032	0.034	-0.923	0.356
AV-ownership	<--	Gender	0.029	0.031	0.031	0.913	0.361
AV-ownership	<--	Subjective norm	-0.093	-0.084	0.104	-0.893	0.372
AV-ownership	<--	Education	-0.026	-0.060	0.015	-1.681	0.093
AV-ownership	<--	Car-ownership-attitude-2	0.054	0.054	0.034	1.595	0.111
AV-ownership	<--	Attitude-toward-environment	-0.102	-0.078	0.049	-2.084	0.037
AV-ownership	<--	Car-ownership-attitude-1	0.319	0.168	0.084	3.789	***
AV-ownership	<--	Perceived-behavioural-control	0.020	0.028	0.027	0.748	0.455
AV-ownership	<--	Attitude towards sharing * attitude towards car ownership	0.001	0.003	0.014	0.076	0.939
AV-ownership	<--	Attitude towards public transit * attitude towards car ownership	0.011	0.031	0.014	0.769	0.442
Perceived-ease-of-us	<--	Education	0.030	0.043	0.019	1.584	0.113
Perceived-ease-of-us	<--	Subjective norm	1.188	0.656	0.095	12.479	***
Av-attitude	<--	Perceived-ease-of-us	0.078	0.163	0.029	2.679	0.007
Av-attitude	<--	Subjective norm	0.349	0.404	0.070	4.985	***
Perceived-benefits (time use)	<--	Subjective norm	0.561	0.377	0.114	4.907	***
Perceived-benefits (instrumental/hedonic)	<--	Perceived-benefits-composite	1.329	0.557	0.224	5.935	***
Av-attitude	<--	Perceived-benefits-composite	1.169	0.606	0.202	5.781	***
Perceived-benefits (time use)	<--	Perceived-ease-of-us	0.054	0.066	0.047	1.156	0.248
Perceived-benefits (instrumental/hedonic)	<--	Subjective norm	0.528	0.494	0.083	6.353	***
Perceived-benefits (instrumental/hedonic)	<--	Perceived-ease-of-us	0.124	0.210	0.034	3.688	***
B. Correlations and covariance			**<--**	**Corr**	**S.E.**	**C.R.**	**P**
Attitude-toward-technology	<-->	Fear and anxiety	0.016	0.123	0.005	3.168	0.002
Attitude-toward-technology	<-->	Perceived-benefits-composite	0.013	0.181	0.004	3.160	0.002
Attitude-toward-technology	<-->	Attitude-toward-environment	0.062	0.451	0.006	10.143	***
Perceived-benefits-composite	<-->	Attitude-toward-environment	0.017	0.237	0.004	4.081	***
Fear and anxiety	<-->	Perceived-benefits-composite	0.018	0.264	0.005	3.546	***
Car-ownership-attitude-2	<-->	Attitude-toward-environment	-0.015	-0.082	0.006	-2.568	0.010
Attitude-toward-automation	<-->	Perceived-benefits-composite	-0.027	-0.224	0.008	-3.366	***
Subjective norm	<-->	Image	0.167	0.382	0.019	8.895	***
Subjective norm	<-->	Fear and anxiety	0.063	0.404	0.009	6.808	***
Attitude-toward-technology	<-->	Car-ownership-attitude-1	0.024	0.254	0.004	5.548	***
Attitude-toward-technology	<-->	Subjective norm	0.033	0.203	0.007	4.933	***
Image	<-->	Fear and anxiety	0.081	0.227	0.015	5.491	***
Subjective norm	<-->	Perceived-benefits-composite	0.026	0.302	0.009	2.927	0.003
Attitude-toward-technology	<-->	Attitude-toward-automation	-0.031	-0.138	0.009	-3.273	0.001
Attitude-toward-automation	<-->	Fear and anxiety	-0.055	-0.252	0.012	-4.720	***
Attitude-toward-environment	<-->	Car-ownership-attitude-1	0.015	0.160	0.004	3.962	***
Education	<-->	Car-ownership-attitude-2	-0.054	-0.098	0.017	-3.141	0.002
Education	<-->	Car-ownership-attitude-1	-0.043	-0.149	0.011	-4.091	***
Education	<-->	Attitude-toward-technology	-0.022	-0.053	0.013	-1.745	0.081
Privacy-priority	<-->	Car-ownership-attitude-1	0.071	0.325	0.010	7.201	***
Income group	<-->	Age-group	-0.085	-0.198	0.014	-5.930	***
Income group	<-->	Driver-assisted-technology-use	0.076	0.176	0.014	5.290	***
Driver-assisted-technology-use	<-->	Education	0.157	0.279	0.019	8.280	***
Driver-assisted-technology-use	<-->	Gender	-0.036	-0.138	0.008	-4.466	***
Income group	<-->	Education	0.202	0.202	0.033	6.112	***
Age-group	<-->	Education	-0.158	-0.285	0.019	-8.506	***

Gender	<-->	Education	-0.063	-0.104	0.018	-3.447	***
Driver-assisted-technology-use	<-->	Age-group	-0.065	-0.270	0.008	-8.023	***
Gender	<-->	Fear and anxiety	-0.039	-0.209	0.008	-5.113	***
Perceived-behavioural-control	<-->	Subjective norm	0.079	0.269	0.012	6.607	***
Gender	<-->	Perceived-benefits-composite	-0.017	-0.167	0.005	-3.265	0.001
Gender	<-->	Attitude-toward-automation	0.050	0.154	0.014	3.649	***
Gender	<-->	Subjective norm	-0.022	-0.093	0.009	-2.488	0.013
Perceived-behavioural-control	<-->	Attitude-toward-technology	0.042	0.170	0.008	5.011	***
Age-group	<-->	Attitude-toward-automation	0.039	0.129	0.012	3.323	***
Privacy-priority	<-->	Car-ownership-attitude-2	0.067	0.161	0.014	4.833	***
Attitude towards sharing * attitude towards car ownership	<-->	Attitude towards public transit * attitude towards car ownership	1.134	0.602	0.073	15.633	***

Notes: ß = Unstandardized regression estimates, b = standardized regression estimates; cov =covariance, corr =correlation;
*** P-value < 0.01

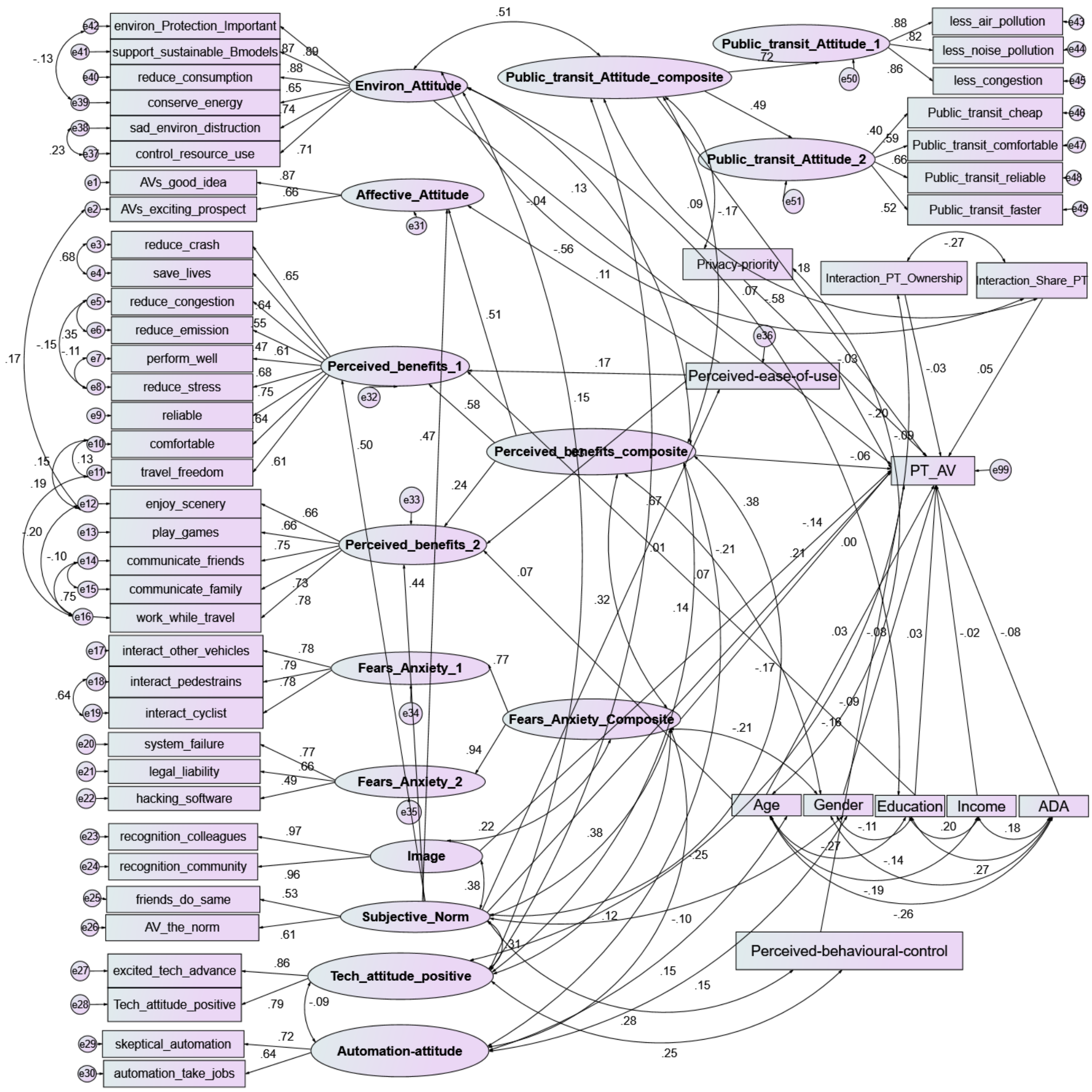

Fig A4: Path diagram of SEM of preferences for autonomous buses (public transit)

Notes: Model identification indices: χ^2 = 2971.499, df = 1305, Normed-χ^2 =2.162, p < 0.01; RMSEA = 0.037; NFI = 0.876; CFI = 0.926; IFI = 0.926; TLI = 0.919. Results of convergent and discriminant validity tests are presented in appendix **Table A5**, under the column labelled SEM-3

Table A3: Correlations, covariance and regression weights of relationships among variables in SEM of preferences for autonomous buses (public transport)

*A. **Direct Effects***			ß	b	S.E.	C.R.	P
AV-public-transit-use	<--	Fear and anxiety	-0.004	-0.003	0.063	-0.068	0.946
AV-public-transit-use	<--	Image	-0.069	-0.140	0.022	-3.142	0.002
AV-public-transit-use	<--	Privacy-priority	-0.020	-0.035	0.020	-0.985	0.325
AV-public-transit-use	<--	Perceived-ease-of-us	-0.123	-0.198	0.035	-3.556	***
AV-public-transit-use	<--	Education	0.012	0.026	0.015	0.759	0.448
AV-public-transit-use	<--	Income group	-0.011	-0.019	0.019	-0.568	0.570
AV-public-transit-use	<--	Driver-assisted-technology-use	-0.081	-0.081	0.034	-2.354	0.019
AV-public-transit-use	<--	Gender	-0.072	-0.077	0.032	-2.219	0.026
AV-public-transit-use	<--	Age-group	0.033	0.032	0.035	0.931	0.352
AV-public-transit-use	<--	Subjective norm	0.241	0.210	0.119	2.032	0.042
AV-public-transit-use	<--	Public-transit-attitude	0.243	0.177	0.108	2.242	0.025
AV-public-transit-use	<--	Perceived-benefits-composite	-0.180	-0.057	0.237	-0.760	0.447

AV-public-transit-use	<--	Perceived-behavioural-control	-0.067	-0.091	0.029	-2.332	0.020
AV-public-transit-use	<--	Attitude-toward-environment	-0.057	-0.041	0.067	-0.850	0.395
AV-public-transit-use	<--	Attitude towards public transit * Attitude towards car ownership	-0.009	-0.026	0.013	-0.740	0.459
AV-public-transit-use	<--	Attitude towards sharing * Attitude towards public transit	0.010	0.046	0.012	0.798	0.425
Perceived-ease-of-us	<--	Subjective norm	1.229	0.665	0.098	12.570	***
Av-attitude	<--	Perceived-benefits-composite	1.253	0.510	0.284	4.420	***
Av-attitude	<--	Perceived-ease-of-us	0.054	0.113	0.030	1.794	0.073
Perceived-benefits (instrumental/hedonic)	<--	Perceived-ease-of-us	0.097	0.166	0.036	2.737	0.006
Perceived-benefits (time use)	<--	Perceived-ease-of-us	0.021	0.026	0.047	0.448	0.654
Perceived-benefits (instrumental/hedonic)	<--	Education	0.029	0.071	0.009	3.346	***
Av-attitude	<--	Subjective norm	0.419	0.473	0.074	5.627	***
Perceived-benefits (time use)	<--	Subjective norm	0.672	0.445	0.123	5.448	***
Perceived-benefits (instrumental/hedonic)	<--	Subjective norm	0.540	0.499	0.087	6.201	***
Perceived-benefits (time use)	<--	Age-group	0.094	0.070	0.041	2.289	0.022
B. Correlations and covariance			**Cov**	**Corr**	**S.E.**	**C.R.**	**P**
Subjective norm	<-->	Image	0.162	0.377	0.018	8.845	***
Attitude-toward-technology	<-->	Fear and anxiety	0.015	0.120	0.005	2.928	0.003
Attitude-toward-automation	<-->	Fear and anxiety	-0.057	-0.252	0.012	-4.791	***
Attitude-toward-automation	<-->	Perceived-benefits-composite	-0.021	-0.212	0.007	-2.881	0.004
Attitude-toward-technology	<-->	Perceived-benefits-composite	0.008	0.136	0.003	2.239	0.025
Fear and anxiety	<-->	Perceived-benefits-composite	0.018	0.323	0.005	3.357	***
Attitude-toward-technology	<-->	Attitude-toward-automation	-0.019	-0.085	0.010	-1.994	0.046
Attitude-toward-technology	<-->	Attitude-toward-environment	0.019	0.152	0.004	4.788	***
Subjective norm	<-->	Fear and anxiety	0.059	0.383	0.009	6.592	***
Perceived-benefits-composite	<-->	Attitude-toward-environment	0.007	0.133	0.003	2.792	0.005
Image	<-->	Fear and anxiety	0.079	0.223	0.015	5.433	***
Subjective norm	<-->	Perceived-benefits-composite	0.025	0.380	0.008	3.105	0.002
Attitude-toward-technology	<-->	Subjective norm	0.047	0.306	0.007	6.401	***
Public-transit-attitude	<-->	Attitude-toward-environment	0.066	0.510	0.007	9.322	***
Age-group	<-->	Education	-0.149	-0.270	0.018	-8.060	***
Age-group	<-->	Attitude-toward-automation	0.045	0.147	0.012	3.784	***
Education	<-->	Attitude-toward-environment	0.030	0.074	0.010	2.864	0.004
Income group	<-->	Age-group	-0.083	-0.195	0.014	-5.852	***
Gender	<-->	Fear and anxiety	-0.040	-0.212	0.008	-5.159	***
Gender	<-->	Education	-0.065	-0.109	0.018	-3.538	***
Income group	<-->	Education	0.196	0.196	0.033	5.887	***
Income group	<-->	Driver-assisted-technology-use	0.076	0.175	0.014	5.282	***
Driver-assisted-technology-use	<-->	Education	0.149	0.267	0.019	7.879	***
Gender	<-->	Driver-assisted-technology-use	-0.037	-0.141	0.008	-4.545	***
Driver-assisted-technology-use	<-->	Age-group	-0.063	-0.263	0.008	-7.855	***
Perceived-behavioural-control	<-->	Subjective norm	0.081	0.278	0.012	6.752	***
Gender		Attitude-toward-automation	0.052	0.154	0.014	3.689	***
Perceived-behavioural-control		Attitude-toward-technology	0.060	0.246	0.009	6.406	***
Gender		Subjective norm	-0.022	-0.095	0.008	-2.582	0.010
Gender		Perceived-benefits-composite	-0.014	-0.171	0.005	-2.909	0.004
Privacy-priority		Public-transit-attitude	-0.054	-0.173	0.013	-4.157	***
Privacy-priority		Age-group	-0.039	-0.094	0.013	-3.100	0.002
Attitude towards public transit * Attitude towards car ownership		Attitude towards sharing * Attitude towards public transit	-0.916	-0.274	0.093	-9.859	***
Attitude towards sharing * Attitude towards public transit		Attitude-toward-environment	-0.471	-0.557	0.035	-13.475	***
Attitude towards sharing * Attitude towards public transit		Public-transit-attitude	-0.493	-0.578	0.043	-11.419	***
Attitude towards public transit * Attitude towards car ownership		Attitude-toward-technology	-0.082	-0.163	0.017	-4.744	***

Notes: ß = Unstandardized regression estimates, b = standardized regression estimates; cov =covariance, corr =correlation; *** P-value < 0.01

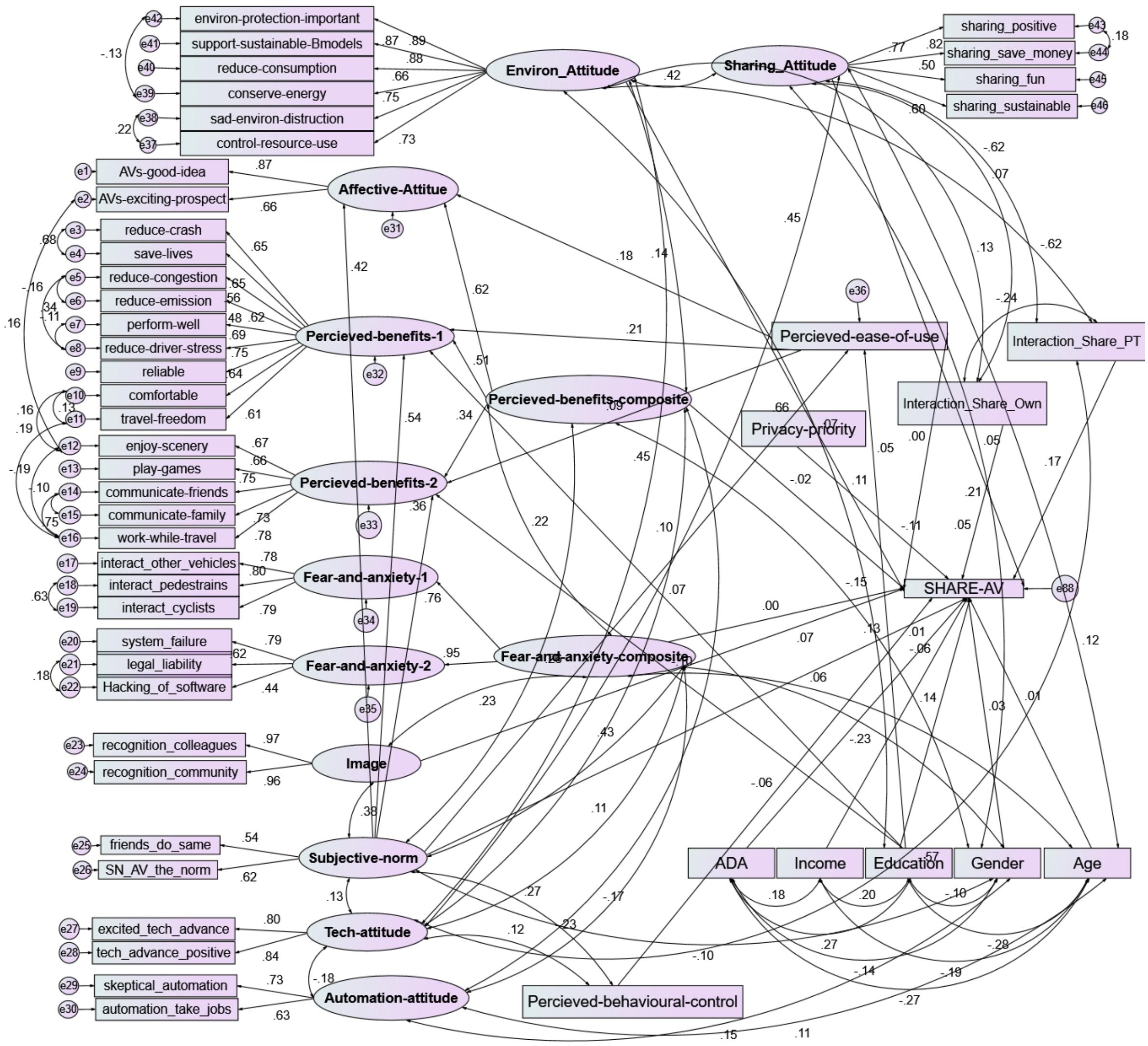

Fig A5: Path diagram of SEM of preferences for shared autonomous vehicles

Notes: Model identification indices: χ^2 = 2507.366, df = 1149, Normed-χ^2 =2.182, p < 0.01; RMSEA = 0.036; NFI = 0.891; CFI = 0.938; IFI = 0.938; TLI = 0.931. Results of convergent and discriminant validity tests are presented in appendix **Table A5**, under the column labelled SEM-4

Table A4: Correlations, covariance and regression weights of relationships among variables in SEM of preferences for autonomous vehicle sharing

A. ***Direct Effects***			**ß**	**b**	**S.E.**	**C.R.**	**P**
AV-share	<--	Education	0.062	0.140	0.015	4.083	***
AV-share	<--	Collaborative-consumption/sharing-attitude	0.254	0.211	0.062	4.118	***
AV-share	<--	Attitude-toward-environment	0.149	0.110	0.062	2.415	0.016
AV-share	<--	Privacy-priority	-0.063	-0.108	0.018	-3.427	***
AV-share	<--	Gender	0.028	0.029	0.032	0.864	0.388
AV-share	<--	Age-group	0.010	0.010	0.036	0.286	0.775
AV-share	<--	Income group	-0.035	-0.061	0.018	-1.870	0.062
AV-share	<--	Driver-assisted-technology-use	0.013	0.013	0.034	0.383	0.702
AV-share	<--	Fear and anxiety	0.007	0.005	0.071	0.105	0.916
AV-share	<--	Image	0.034	0.068	0.020	1.680	0.093
AV-share	<--	Perceived-benefits-composite	-0.051	-0.023	0.132	-0.389	0.697
AV-share	<--	Perceived-ease-of-us	-0.003	-0.005	0.034	-0.088	0.930
AV-share	<--	Subjective norm	0.143	0.128	0.104	1.381	0.167
AV-share	<--	Perceived-behavioural-control	-0.042	-0.057	0.027	-1.562	0.118

AV-share	<--	Attitude towards sharing * attitude towards car ownership	0.018	0.050	0.012	1.534	0.125
AV-share	<--	Attitude towards sharing * Attitude towards public transit	0.034	0.168	0.011	3.146	0.002
Perceived-ease-of-us	<--	Subjective norm	1.177	0.657	0.094	12.568	***
Perceived-ease-of-us	<--	Education	0.034	0.048	0.020	1.728	0.084
Perceived-benefits (instrumental/hedonic)	<--	Subjective norm	0.573	0.542	0.084	6.792	***
Av-attitude		Subjective norm	0.362	0.418	0.072	5.062	***
Perceived-benefits (time use)		Subjective norm	0.525	0.357	0.113	4.650	***
Perceived-benefits (instrumental/hedonic)		Perceived-ease-of-us	0.123	0.208	0.033	3.666	***
Perceived-benefits (time use)		Perceived-ease-of-us	0.076	0.093	0.047	1.624	0.104
Av-attitude		Perceived-ease-of-us	0.087	0.179	0.030	2.937	0.003
Perceived-benefits (instrumental/hedonic)		Education	0.029	0.071	0.009	3.205	0.001
Perceived-benefits (time use)		Education	-0.058	-0.100	0.018	-3.207	0.001
B. Correlations and covariance			**Cov**	**Corr**	**S.E.**	**C.R.**	**P**
Subjective norm	<-->	Fear and anxiety	0.062	0.430	0.009	6.797	***
Attitude-toward-technology	<-->	Fear and anxiety	0.013	0.111	0.004	3.072	0.002
Attitude-toward-automation	<-->	Fear and anxiety	-0.047	-0.227	0.011	-4.370	***
Attitude-toward-automation	<-->	Perceived-benefits-composite	-0.024	-0.168	0.009	-2.753	0.006
Attitude-toward-technology	<-->	Perceived-benefits-composite	0.008	0.100	0.004	2.204	0.028
Perceived-benefits-composite	<-->	Attitude-toward-environment	0.012	0.142	0.003	3.426	***
Collaborative-consumption/sharing-attitude	<-->	Attitude-toward-environment	0.064	0.419	0.007	9.727	***
Collaborative-consumption/sharing-attitude	<-->	Attitude-toward-technology	0.070	0.453	0.007	10.113	***
Attitude-toward-technology	<-->	Attitude-toward-environment	0.062	0.452	0.006	10.445	***
Attitude-toward-technology	<-->	Attitude-toward-automation	-0.044	-0.183	0.010	-4.594	***
Image	<-->	Fear and anxiety	0.076	0.234	0.014	5.506	***
Fear and anxiety	<-->	Perceived-benefits-composite	0.016	0.217	0.005	3.051	0.002
Subjective norm	<-->	Image	0.167	0.376	0.019	8.798	***
Attitude-toward-technology	<-->	Subjective norm	0.021	0.125	0.006	3.430	***
Subjective norm	<-->	Perceived-benefits-composite	0.026	0.264	0.010	2.513	0.012
Education	<-->	Attitude-toward-environment	0.027	0.066	0.010	2.619	0.009
Age-group	<-->	Collaborative-consumption/sharing-attitude	0.024	0.120	0.006	4.209	***
Age-group	<-->	Education	-0.156	-0.283	0.018	-8.420	***
Gender	<-->	Education	-0.062	-0.104	0.018	-3.407	***
Gender	<-->	Driver-assisted-technology-use	-0.036	-0.139	0.008	-4.488	***
Income group	<-->	Education	0.196	0.196	0.033	5.889	***
Driver-assisted-technology-use	<-->	Education	0.150	0.268	0.019	7.902	***
Driver-assisted-technology-use	<-->	Income group	0.077	0.176	0.014	5.302	***
Age-group	<-->	Driver-assisted-technology-use	-0.064	-0.267	0.008	-8.007	***
Age-group	<-->	Income group	-0.083	-0.194	0.014	-5.849	***
Gender	<-->	Fear and anxiety	-0.039	-0.227	0.007	-5.351	***
Perceived-behavioural-control	<-->	Attitude-toward-technology	0.031	0.124	0.008	4.027	***
Perceived-behavioural-control	<-->	Subjective norm	0.079	0.265	0.012	6.619	***
Age-group	<-->	Fear and anxiety	0.010	0.064	0.005	1.934	0.053
Age-group	<-->	Attitude-toward-automation	0.034	0.108	0.012	2.855	0.004
Gender	<-->	Collaborative-consumption/sharing-attitude	0.012	0.054	0.006	1.844	0.065
Gender	<-->	Subjective norm	-0.024	-0.104	0.009	-2.770	0.006
Gender	<-->	Perceived-benefits-composite	-0.018	-0.151	0.006	-3.016	0.003
Gender	<-->	Attitude-toward-automation	0.050	0.147	0.014	3.577	***
Attitude towards sharing * Attitude towards public transit		Attitude towards sharing * attitude towards car ownership	-0.795	-0.240	0.097	-8.218	***
Attitude towards sharing * Attitude towards public transit		Attitude-toward-environment	-0.557	-0.624	0.039	-14.218	***
Attitude towards sharing * attitude towards car ownership		Attitude-toward-environment	0.064	0.128	0.016	4.035	***

Attitude towards sharing * Attitude towards public transit	Attitude-toward-technology	-0.516	-0.568	0.038	-13.687	***
Attitude towards sharing * Attitude towards public transit	Collaborative-consumption/sharing-attitude	-0.621	-0.622	0.044	-14.179	***
Attitude towards sharing * attitude towards car ownership	Collaborative-consumption/sharing-attitude	0.040	0.072	0.019	2.090	0.037

Notes: ß = Unstandardized regression estimates, b = standardized regression estimates; cov =covariance, corr =correlation;
*** P-value < 0.01

Table A5: AVE and MSV values of measurement models showing evidence of convergent and discriminant validity

SEM-1						SEM-2					
AVE		MSV				AVE					MSV
Attitude	0.696	Perceived benefit-composite	<-->	Attitude-toward-automation	0.053	Attitude	0.590	Attitude-toward-technology	<-->	Fear-and-anxiety-composite	0.015
Perceived benefits-1 (instrumental)	0.492	Attitude-toward-technology	<-->	Fear-and-anxiety-composite	0.010	Perceived benefits-1 (instrumental)	0.395	Attitude-toward-technology	<-->	Perceived benefit-composite	0.032
Perceived benefits-2 (time-use)	0.598	Perceived benefit-composite	<-->	Fear-and-anxiety-composite	0.062	Perceived benefits-2 (time-use)	0.513	Attitude-toward-technology	<-->	Attitude-toward-environment	0.203
Perceived benefit (composite)	0.159	Attitude-toward-automation	<-->	Fear-and-anxiety-composite	0.056	Perceived benefit (composite)	0.256	Perceived benefit-composite	<-->	Attitude-toward-environment	0.056
Fear and anxiety-1	0.653	Attitude-toward-technology	<-->	Attitude-toward-automation	0.024	Fear and anxiety-1	0.618	Fear-and-anxiety-composite	<-->	Perceived benefit-composite	0.072
Fear and anxiety-2	0.440	Subjective norm	<-->	Image	0.172	Fear and anxiety-2	0.418	Car-ownership-attitude-2	<-->	Attitude-toward-environment	0.007
Fear-and-anxiety-composite	0.745	Subjective norm	<-->	Fear-and-anxiety-composite	0.236	Fear-and-anxiety-composite	0.740	Attitude-toward-automation	<-->	Perceived benefit-composite	0.051
Subjective norm	0.444	Image	<-->	Fear-and-anxiety-composite	0.084	Subjective norm	0.335	Subjective norm	<-->	Image	0.146
Image	0.919	Perceived benefit-composite	<-->	Attitude-toward-technology	0.033	Image	0.925	Subjective norm	<-->	Fear-and-anxiety-composite	0.162
Attitude-toward-technology	0.749	Attitude-toward-technology		Subjective norm	0.080	Attitude-toward-technology	0.672	Attitude-toward-technology	<-->	Car-ownership-attitude-1	0.065
Attitude-toward-automation	0.464	Perceived benefit-composite		Subjective norm	0.055	Attitude-toward-automation	0.459	Attitude-toward-technology	<-->	Subjective norm	0.042
						Car-ownership-attitude-1	0.410	Image	<-->	Fear-and-anxiety-composite	0.052

						Car-ownership-attitude-2	0.756	Subjective norm	<-->	Perceived benefit-composite	0.093
						Attitude-toward-environment	0.650	Attitude-toward-technology		Attitude-toward-automation	0.019
								Attitude-toward-automation		Fear-and-anxiety-composite	0.064
								Attitude-toward-environment		Car-ownership-attitude-1	0.026
SEM-3						**SEM-4**					
	AVE				**MSV**		**AVE**				**MSV**
Attitude	0.588	Subjective norm	<-->	Image	0.144	Attitude	0.592	Subjective norm	<-->	Fear-and-anxiety-composite	0.192
Perceived benefits-1 (instrumental)	0.391	Attitude-toward-technology	<-->	Fear-and-anxiety-composite	0.015	Perceived benefits-1 (instrumental)	0.396	Attitude-toward-technology	<-->	Fear-and-anxiety-composite	0.014
Perceived benefits-2 (time-use)	0.514	Attitude-toward-automation	<-->	Fear-and-anxiety-composite	0.060	Perceived benefits-2 (time-use)	0.518	Attitude-toward-automation	<-->	Fear-and-anxiety-composite	0.052
Perceived benefit-composite	0.262	Attitude-toward-automation	<-->	Perceived benefit-composite	0.038	Perceived benefit (composite)	0.264	Attitude-toward-automation	<-->	Perceived benefit-composite	0.028
Fear and anxiety-1	0.619	Attitude-toward-technology	<-->	Perceived benefit-composite	0.040	Fear and anxiety-1	0.622 0.401	Attitude-toward-technology	<-->	Perceived benefit-composite	0.028
Fear and anxiety-2	0.418	Fear-and-anxiety-composite	<-->	Perceived benefit-composite	0.062	Fear and anxiety-2		Perceived benefit-composite	<-->	Attitude-toward-environment	0.038
Fear-and-anxiety-composite	0.739	Attitude-toward-technology	<-->	Attitude-toward-automation	0.017	Fear-and-anxiety-composite	0.746	Collaborative-consumption/sharing-attitude	<-->	Attitude-toward-environment	0.181
Subjective norm	0.336	Attitude-toward-technology	<-->	Attitude-toward-environment	0.205	Subjective norm	0.339	Collaborative-consumption/sharing-attitude	<-->	Attitude-toward-technology	0.190

Image	0.925	Subjective norm	<-->	Fear-and-anxiety-composite	0.170	Image	0.925	Attitude-toward-technology	<-->	Attitude-toward-environment	0.208
Attitude-toward-technology	0.672	Public-transit-attitude-composite		Perceived benefit-composite	0.041	Attitude-toward-technology	0.670	Attitude-toward-technology		Attitude-toward-automation	0.025
Attitude-toward-automation	0.463	Perceived benefit-composite		Attitude-toward-environment	0.057	Attitude-toward-automation	0.461	Image		Fear-and-anxiety-composite	0.055
Public-transit-attitude-1	0.731	Image		Fear-and-anxiety-composite	0.051	Collaborative-consumption/sharing-attitude	0.449	Fear-and-anxiety-composite		Perceived benefit-composite	0.039
Public-transit-attitude-2	0.305	Subjective norm		Perceived benefit-composite	0.087	Attitude-toward-environment	0.648	Subjective norm		Image	0.140
Public-transit-attitude-composite	0.366	Attitude-toward-technology		Subjective norm	0.036			Attitude-toward-technology		Subjective norm	0.023

Notes: Average Variance Explained (AVE) is the amount of variance that a latent variable explains in its indicator variables relative to the overall variance of its indicators. AVE values across the four models is either above or very close to the minimum acceptable value of 0.5. Maximum Shared Variance (MSV) tests discriminant validity. It is calculated by squaring the correlations of any two related latent variables. Discriminant validity is achieved where MSV < AVE of any set of correlated latent variables. Across the four models, MSV values are less than the AVE values of any two latent variables that are confirmed to be related. Together, the results demonstrate sufficient convergent and discriminant validity in the four SEMs.

Appendix 3: Additional validity information based on in-sample, out-sample validation of the structural equation models

In addition to discriminant and convergence validity tests reported in Table A5, split-sample validations tests were conducted to assess the performance of the structural equation models on different samples of the data. SEM is a large sample statistical modelling technique (Kline, 2016), implying that in performing the hold-out validation, the total sample needed to be divided such that the resulting sub-samples have large enough observations. In view of this, the total sample was split into 60% and 40% in-sample and out-samples, respectively. Each of the models was run with the 60% and 40% sub-samples. Model-to-data fit for each SEM was ascertained, based on the model identification indices namely: Root Mean Square Error of Approximation (RMSEA); Chi-square statistic (χ^2) and Normed Chi-square (χ^2/df); Normed Fit Index (NFI); Comparative Fit Index (CFI); Tucker–Lewis Index (TLI); Incremental fit index (IFI). RMSEA value of 0.01, 0.05, and 0.08 indicate excellent, good, and mediocre fit, respectively, while NFI, CFI, TLI and IFI values ≥0.90 indicate acceptable model fit (see Kline, 2016).

A summary of the model results are reported in appendix Tables A6, A7, A8 and A9 for SEMs of autonomous vehicles adoption intentions and preferences for ownership, public transport and sharing of autonomous vehicles, respectively. Overall, the identification indices across the four models are within the acceptable thresholds, suggesting that there is a good fit between the models and the data for the 60% and 40% sub-samples. In other words, the models are reasonably consistent with the data for the randomly selected sub-samples as is also the case with the full datasets. The NFI values for the SEM of ownership and sharing, using the 40% sub-sample, are slightly below the 0.90 threshold. These identification statistics are sensitive to sample size and model complexity (Kline, 2016), implying they should approach the ≥ 0.90 threshold with larger sample sizes, as reported across all the models that are specified using the total sample.

Table A6: Validation results of SEM of AV adoption intention by 60-40% sample split

60% sample			**ß**	**b**	**S.E.**	**C.R.**	**P**
Perceived-ease-of-use	<--	Subjective norm	1.225	0.737	0.085	14.436	***
Perceived-ease-of-use	<--	Education	0.052	0.067	0.022	2.339	0.019
Perceived-ease-of-use	<--	Attitude-toward-technology	0.010	0.012	0.032	0.317	0.751
Perceived-benefits (instrumental)	<--	Perceived-ease-of-use	0.156	0.243	0.036	4.292	***
Perceived-benefits (time use)	<--	Perceived-ease-of-use	0.086	0.109	0.051	1.704	0.088
AV-attitude	<--	Perceived-ease-of-use	0.117	0.173	0.047	2.510	0.012
AV-adoption-intention	<--	Education	0.043	0.067	0.020	2.163	0.031
AV-adoption-intention	<--	Gender	0.016	0.011	0.041	0.386	0.699
AV-adoption-intention	<--	Income	0.013	0.015	0.024	0.565	0.572
AV-adoption-intention	<--	Driver-assisted-technology	0.141	0.095	0.040	3.498	***
AV-adoption-intention	<--	Age	0.085	0.060	0.039	2.156	0.031
Perceived-benefits (time use)	<--	Subjective norm	0.623	0.472	0.104	5.970	***
AV-adoption-intention	<--	Perceived-behavioural-control	-0.084	-0.082	0.034	-2.426	0.015
AV-adoption-intention	<--	Image	-0.018	-0.024	0.025	-0.701	0.483
AV-adoption-intention	<--	Perceived-benefits-composite	0.648	0.186	0.197	3.280	0.001
AV-adoption-intention	<--	Perceived-ease-of-use	0.154	0.188	0.051	2.995	0.003
Perceived-benefits (instrumental)	<--	Subjective norm	0.651	0.613	0.080	8.102	***
AV-attitude	<--	Subjective norm	0.563	0.501	0.094	5.999	***
AV-adoption-intention	<--	Subjective norm	0.823	0.603	0.148	5.574	***
AV-attitude	<--	Perceived-benefits-composite	1.733	0.604	0.311	5.577	***
AV-adoption-intention	<--	Fear and anxiety	0.293	0.132	0.113	2.597	0.009
AV-adoption-intention	<--	Attitude-toward-automation	-0.052	-0.051	0.039	-1.342	0.179
AV-adoption-intention	<--	Attitude-toward-technology	0.007	0.009	0.024	0.271	0.786
Perceived-benefits (instrumental)	<--	Education	0.029	0.060	0.011	2.786	0.005
Perceived-benefits (time use)	<--	Age	0.098	0.072	0.042	2.347	0.019

40% sample			ß	b	S.E.	C.R.	P
Perceived-ease-of-use	<--	Subjective norm	1.381	0.815	0.107	12.853	***
Perceived-ease-of-use	<--	Education	0.038	0.050	0.025	1.513	0.130
Perceived-ease-of-use	<--	Attitude-toward-technology	-0.093	-0.105	0.037	-2.538	0.011
Perceived-benefits (instrumental)	<--	Perceived-ease-of-use	0.070	0.110	0.052	1.350	0.177
Perceived-benefits (time use)	<--	Perceived-ease-of-use	0.045	0.057	0.059	0.766	0.444
AV-attitude	<--	Perceived-ease-of-use	0.006	0.009	0.050	0.121	0.903
AV-adoption-intention	<--	Education	0.048	0.074	0.024	2.025	0.043
AV-adoption-intention	<--	Gender	0.067	0.044	0.050	1.328	0.184
AV-adoption-intention	<--	Income	-0.020	-0.022	0.026	-0.759	0.448
AV-adoption-intention	<--	Driver-assisted-technology	0.065	0.043	0.046	1.401	0.161
AV-adoption-intention	<--	Age	0.052	0.036	0.046	1.115	0.265
Perceived-benefits (time use)	<--	Subjective norm	0.794	0.593	0.115	6.915	***
AV-adoption-intention	<--	Perceived-behavioural-control	-0.115	-0.108	0.039	-2.935	0.003
AV-adoption-intention	<--	Image	-0.075	-0.101	0.033	-2.271	0.023
AV-adoption-intention	<--	Perceived-benefits-composite	-0.593	-0.094	0.319	-1.861	0.063
AV-adoption-intention	<--	Perceived-ease-of-use	-0.038	-0.046	0.075	-0.508	0.611
Perceived-benefits (instrumental)	<--	Subjective norm	0.759	0.707	0.109	6.953	***
AV-attitude	<--	Subjective norm	0.986	0.841	0.107	9.222	***
AV-adoption-intention	<--	Subjective norm	1.535	1.082	0.203	7.561	***
AV-attitude	<--	Perceived-benefits-composite	0.675	0.129	0.175	3.869	***
AV-adoption-intention	<--	Fear and anxiety	0.129	0.060	0.130	0.991	0.322
AV-adoption-intention	<--	Attitude-toward-automation	-0.046	-0.045	0.041	-1.124	0.261
AV-adoption-intention	<--	Attitude-toward-technology	-0.067	-0.090	0.041	-1.638	0.101
Perceived-benefits (instrumental)	<--	Education	0.025	0.052	0.031	0.825	0.410
Perceived-benefits (time use)	<--	Age	0.109	0.080	0.051	2.141	0.032

Notes: ß = Unstandardized regression estimates, b = standardized regression estimates; *** P-value < 0.01
Model identification indices 60% sample: χ^2 = 1449.058, df = 640, Normed-χ^2 = 2.264, p < 0.01; RMSEA = 0.041; NFI =0.915; CFI = 0.950; IFI = 0.951; TLI = 0.942;
Model identification indices 40% sample: χ^2 = 1160.808, df =, Normed-χ^2 = 1.814, p < 0.01; RMSEA = 0.041; NFI = 0. 904; CFI = 0.954; IFI = .954; TLI = 0.947

Table A7: Validation results of SEM of autonomous vehicles ownership by 60-40% sample split

60% sample			ß	b	S.E.	C.R.	P
AV-ownership	<--	Perceived-benefits-composite	0.341	0.152	0.210	1.624	0.104
AV-ownership	<--	Perceived-ease-of-us	0.145	0.236	0.047	3.109	0.002
AV-ownership	<--	Fear and anxiety	-0.001	-0.001	0.073	-0.016	0.988
AV-ownership	<--	Image	0.021	0.044	0.026	0.829	0.407
AV-ownership	<--	Privacy-priority	0.003	0.004	0.025	0.103	0.918
AV-ownership	<--	Income group	0.023	0.041	0.023	0.991	0.322
AV-ownership	<--	Driver-assisted-technology-use	0.043	0.044	0.043	1.016	0.310
AV-ownership	<--	Age-group	-0.058	-0.057	0.043	-1.338	0.181
AV-ownership	<--	Gender	-0.003	-0.003	0.040	-0.070	0.944
AV-ownership	<--	Subjective norm	-0.151	-0.132	0.150	-1.013	0.311
AV-ownership	<--	Education	-0.015	-0.035	0.019	-0.778	0.437
AV-ownership	<--	Car-ownership-attitude-2	0.107	0.097	0.046	2.335	0.020
AV-ownership	<--	Attitude-toward-environment	-0.167	-0.117	0.074	-2.254	0.024
AV-ownership	<--	Car-ownership-attitude-1	0.411	0.191	0.121	3.403	***
AV-ownership	<--	Perceived-behavioural-control	0.023	0.032	0.034	0.671	0.502
AV-ownership	<--	Attitude towards sharing * attitude towards car ownership	0.012	0.021	0.024	0.496	0.620
AV-ownership	<--	Attitude towards public transit * Attitude towards car ownership	0.014	0.035	0.017	0.836	0.403
Perceived-ease-of-us	<--	Education	0.034	0.049	0.023	1.490	0.136
Perceived-ease-of-us		Subjective norm	1.317	0.705	0.125	10.508	***
Av-attitude		Perceived-ease-of-us	0.047	0.096	0.042	1.109	0.267
Av-attitude		Subjective norm	0.476	0.518	0.102	4.657	***
Perceived-benefits (time use)		Subjective norm	0.711	0.453	0.165	4.300	***
Perceived-benefits (instrumental/hedonic)		Perceived-benefits-composite	1.180	0.520	0.229	5.152	***
Perceived-benefits (time use)		Perceived-ease-of-us	-0.017	-0.020	0.068	-0.249	0.804

Perceived-benefits (instrumental/hedonic)	<--	Subjective norm	0.653	0.563	0.121	5.376	***
Perceived-benefits (instrumental/hedonic)	<--	Perceived-ease-of-us	0.109	0.176	0.049	2.218	0.027

40% sample			**ß**	**b**	**S.E.**	**C.R.**	**P**
AV-ownership	<--	Perceived-benefits-composite	0.360	0.090	0.425	0.847	0.397
AV-ownership	<--	Perceived-ease-of-us	0.100	0.163	0.045	2.235	0.025
AV-ownership	<--	Fear and anxiety	-0.025	-0.017	0.116	-0.219	0.826
AV-ownership	<--	Image	0.043	0.088	0.036	1.191	0.234
AV-ownership	<--	Privacy-priority	0.079	0.139	0.034	2.316	0.021
AV-ownership	<--	Income group	0.038	0.071	0.029	1.308	0.191
AV-ownership	<--	Driver-assisted-technology-use	0.081	0.082	0.055	1.469	0.142
AV-ownership	<--	Age-group	0.009	0.009	0.055	0.162	0.872
AV-ownership	<--	Gender	0.080	0.088	0.051	1.569	0.117
AV-ownership	<--	Subjective norm	-0.120	-0.117	0.146	-0.819	0.413
AV-ownership	<--	Education	-0.052	-0.122	0.025	-2.089	0.037
AV-ownership	<--	Car-ownership-attitude-2	-0.031	-0.035	0.051	-0.611	0.541
AV-ownership	<--	Attitude-toward-environment	-0.041	-0.036	0.071	-0.585	0.559
AV-ownership	<--	Car-ownership-attitude-1	0.178	0.126	0.108	1.647	0.099
AV-ownership	<--	Perceived-behavioural-control	0.017	0.023	0.045	0.372	0.710
AV-ownership	<--	Attitude towards sharing * attitude towards car ownership	0.006	0.026	0.021	0.303	0.762
AV-ownership	<--	Attitude towards public transit * Attitude towards car ownership	-0.005	-0.016	0.025	-0.194	0.846
Perceived-ease-of-us	<--	Education	0.016	0.023	0.034	0.473	0.636
Perceived-ease-of-us	<--	Subjective norm	0.928	0.554	0.140	6.636	***
Av-attitude	<--	Perceived-ease-of-us	0.109	0.240	0.038	2.876	0.004
Av-attitude	<--	Subjective norm	0.194	0.254	0.088	2.199	0.028
Perceived-benefits (time use)	<--	Subjective norm	0.377	0.286	0.146	2.587	0.010
Perceived-benefits (instrumental/hedonic)	<--	Perceived-benefits-composite	2.526	0.721	1.079	2.341	0.019
Perceived-benefits (time use)	<--	Perceived-ease-of-us	0.157	0.200	0.060	2.605	0.009
Perceived-benefits (instrumental/hedonic)	<--	Subjective norm	0.303	0.337	0.104	2.924	0.003
Perceived-benefits (instrumental/hedonic)	<--	Perceived-ease-of-us	0.125	0.233	0.044	2.829	0.005

Notes: ß = Unstandardized regression estimates, b = standardized regression estimates; *** P-value < 0.01
Model identification indices 60% sample: χ^2 = 2306.935, df = 1256, Normed-χ^2 = 1.836, p < 0.01; RMSEA = 0.038; NFI =0.853; CFI = 0.927; IFI = 0.927; TLI = 0.919.
Model identification indices 40% sample: χ^2 = 1937.619, df = 1256, Normed-χ^2 = 1.542, p < 0.01; RMSEA = .040; NFI = 0.803; CFI = 0.920; IFI = 0.921; TLI = 0 .912

Table A8: Validation results of SEM of autonomous vehicles (buses) public transit preferences by 60-40% sample split

60% sample			**ß**	**b**	**S.E.**	**C.R.**	**P**
AV-public-transit-use	<--	Fear and anxiety	-0.033	-0.024	0.069	-0.477	0.633
AV-public-transit-use	<--	Image	-0.074	-0.149	0.024	-3.087	0.002
AV-public-transit-use	<--	Privacy-priority	-0.025	-0.043	0.021	-1.158	0.247
AV-public-transit-use	<--	Perceived-ease-of-us	-0.116	-0.189	0.038	-3.067	0.002
AV-public-transit-use	<--	Education	0.006	0.014	0.017	0.361	0.718
AV-public-transit-use	<--	Income group	-0.005	-0.009	0.021	-0.254	0.800
AV-public-transit-use	<--	Driver-assisted-technology-use	-0.065	-0.065	0.038	-1.703	0.088
AV-public-transit-use	<--	Gender	-0.073	-0.078	0.036	-2.022	0.043
AV-public-transit-use	<--	Age-group	0.020	0.020	0.040	0.513	0.608
AV-public-transit-use	<--	Subjective norm	0.241	0.211	0.123	1.966	0.049
AV-public-transit-use	<--	Public-transit-attitude	0.119	0.087	0.100	1.189	0.235
AV-public-transit-use	<--	Perceived-benefits-composite	-0.107	-0.040	0.190	-0.561	0.574
AV-public-transit-use	<--	Perceived-behavioural-control	-0.051	-0.070	0.030	-1.704	0.088
AV-public-transit-use	<--	Attitude-toward-environment	0.041	0.028	0.077	0.532	0.595

AV-public-transit-use	<--	Attitude towards public transit * Attitude towards car ownership	-0.018	-0.049	0.015	-1.191	0.234
AV-public-transit-use	<--	Attitude towards sharing * Attitude towards public transit	0.007	0.035	0.013	0.580	0.562
Perceived-ease-of-us	<--	Subjective norm	1.225	0.660	0.107	11.487	***
Av-attitude	<--	Perceived-ease-of-us	0.089	0.188	0.031	2.915	0.004
Perceived-benefits (instrumental/hedonic)	<--	Perceived-ease-of-us	0.124	0.213	0.036	3.462	***
Perceived-benefits (time use)	<--	Perceived-ease-of-us	0.050	0.062	0.051	0.980	0.327
Perceived-benefits (instrumental/hedonic)	<--	Education	0.030	0.071	0.010	3.056	0.002
Av-attitude	<--	Subjective norm	0.376	0.427	0.076	4.943	***
Perceived-benefits (time use)	<--	Subjective norm	0.608	0.405	0.128	4.765	***
Perceived-benefits (instrumental/hedonic)	<--	Subjective norm	0.562	0.518	0.092	6.111	***
Perceived-benefits (time use)	<--	Age-group	0.096	0.070	0.046	2.071	0.038
	<--						
40% sample			**ß**	**b**	**S.E.**	**C.R.**	**P**
AV-public-transit-use	<--	Fear and anxiety	-0.145	-0.095	0.122	-1.183	0.237
AV-public-transit-use	<--	Image	-0.041	-0.084	0.035	-1.166	0.244
AV-public-transit-use	<--	Privacy-priority	-0.024	-0.041	0.037	-0.645	0.519
AV-public-transit-use	<--	Perceived-ease-of-us	-0.086	-0.139	0.045	-1.898	0.058
AV-public-transit-use	<--	Education	0.005	0.011	0.024	0.202	0.840
AV-public-transit-use	<--	Income group	-0.023	-0.043	0.029	-0.796	0.426
AV-public-transit-use	<--	Driver-assisted-technology-use	-0.073	-0.074	0.055	-1.340	0.180
AV-public-transit-use	<--	Gender	-0.093	-0.101	0.051	-1.819	0.069
AV-public-transit-use	<--	Age-group	0.052	0.053	0.055	0.955	0.340
AV-public-transit-use	<--	Subjective norm	0.188	0.180	0.143	1.314	0.189
AV-public-transit-use	<--	Public-transit-attitude	0.406	0.356	0.179	2.265	0.024
AV-public-transit-use	<--	Perceived-benefits-composite	-0.307	-0.058	0.534	-0.575	0.566
AV-public-transit-use	<--	Perceived-behavioural-control	-0.044	-0.059	0.045	-0.984	0.325
AV-public-transit-use	<--	Attitude-toward-environment	-0.248	-0.207	0.103	-2.423	0.015
AV-public-transit-use	<--	Attitude towards public transit * Attitude towards car ownership	0.005	0.016	0.017	0.274	0.784
AV-public-transit-use	<--	Attitude towards sharing * Attitude towards public transit	-0.002	-0.013	0.019	-0.111	0.912
Perceived-ease-of-us	<--	Subjective norm	0.957	0.565	0.138	6.941	***
Av-attitude	<--	Perceived-ease-of-us	0.104	0.226	0.038	2.739	0.006
Perceived-benefits (instrumental/hedonic)	<--	Perceived-ease-of-us	0.117	0.220	0.044	2.666	0.008
Perceived-benefits (time use)	<--	Perceived-ease-of-us	0.162	0.205	0.060	2.695	0.007
Perceived-benefits (instrumental/hedonic)		Education	0.020	0.053	0.014	1.425	0.154
Av-attitude		Subjective norm	0.262	0.337	0.089	2.942	0.003
Perceived-benefits (time use)		Subjective norm	0.422	0.316	0.144	2.933	0.003
Perceived-benefits (instrumental/hedonic)		Subjective norm	0.301	0.332	0.104	2.880	0.004
Perceived-benefits (time use)		Age-group	0.133	0.105	0.066	2.016	0.044

Notes: ß = Unstandardized regression estimates, b = standardized regression estimates; *** P-value < 0.01

Model identification indices 60% sample: χ^2 = 2734.632, df = 1305, Normed-χ^2 = 2.095, p < 0.01; RMSEA = 0.038; NFI = 0.865; CFI = 0.924; IFI = 0.925; TLI = 0.917.

Model identification indices 40% sample: χ^2 = 2165.198, df = 1305, Normed-χ^2 = 1.659, p < 0.01; RMSEA = 0.045; NFI = 0.780; CFI = 0.898; IFI = 0.899; TLI =0.888

Table A9: Validation results of SEM of autonomous vehicles sharing by 60-40% sample split

60% sample			**ß**	**b**	**S.E.**	**C.R.**	**P**
AV-share	<--	Education	0.051	0.114	0.019	2.620	0.009
AV-share	<--	Collaborative-consumption/sharing-attitude	0.305	0.223	0.090	3.393	***
AV-share	<--	Attitude-toward-environment	0.194	0.131	0.084	2.316	0.021
AV-share	<--	Privacy-priority	-0.061	-0.105	0.023	-2.680	0.007
AV-share	<--	Gender	0.073	0.077	0.041	1.773	0.076
AV-share	<--	Age-group	0.004	0.004	0.046	0.085	0.932
AV-share	<--	Income group	-0.016	-0.027	0.024	-0.661	0.509
AV-share	<--	Driver-assisted-technology-use	-0.026	-0.026	0.043	-0.595	0.552
AV-share	<--	Fear and anxiety	0.026	0.017	0.087	0.300	0.764
AV-share	<--	Image	0.043	0.087	0.025	1.708	0.088
AV-share	<--	Perceived-benefits-composite	-0.145	-0.072	0.174	-0.834	0.404
AV-share	<--	Perceived-ease-of-us	-0.030	-0.049	0.049	-0.628	0.530
AV-share	<--	Subjective norm	0.216	0.188	0.150	1.447	0.148
AV-share	<--	Perceived-behavioural-control	-0.036	-0.050	0.034	-1.055	0.291
AV-share	<--	Attitude towards sharing * attitude towards car ownership	-0.030	-0.051	0.024	-1.248	0.212
AV-share	<--	Attitude towards sharing * Attitude towards public transit	0.038	0.154	0.016	2.453	0.014
Perceived-ease-of-us	<--	Subjective norm	1.301	0.708	0.122	10.653	***
Perceived-ease-of-us	<--	Education	0.036	0.050	0.024	1.510	0.131
Perceived-benefits (instrumental/hedonic)	<--	Subjective norm	0.712	0.626	0.125	5.711	***
Av-attitude	<--	Subjective norm	0.508	0.555	0.105	4.834	***
Perceived-benefits (time use)	<--	Subjective norm	0.672	0.434	0.165	4.076	***
Perceived-benefits (instrumental/hedonic)	<--	Perceived-ease-of-us	0.098	0.159	0.050	1.964	0.049
Perceived-benefits (time use)	<--	Perceived-ease-of-us	0.012	0.014	0.069	0.175	0.861
Av-attitude	<--	Perceived-ease-of-us	0.050	0.100	0.044	1.135	0.257
Perceived-benefits (instrumental/hedonic)	<--	Education	0.031	0.071	0.012	2.676	0.007
Perceived-benefits (time use)		Education	-0.067	-0.113	0.023	-2.928	0.003
40% sample			**ß**	**b**	**S.E.**	**C.R.**	**P**
AV-share	<--	Education	0.081	0.186	0.024	3.379	***
AV-share	<--	Collaborative-consumption/sharing-attitude	0.226	0.216	0.087	2.607	0.009
AV-share	<--	Attitude-toward-environment	0.106	0.090	0.094	1.129	0.259
AV-share	<--	Privacy-priority	-0.061	-0.104	0.030	-2.026	0.043
AV-share	<--	Gender	-0.049	-0.053	0.051	-0.959	0.338
AV-share	<--	Age-group	-0.004	-0.004	0.056	-0.073	0.942
AV-share	<--	Income group	-0.051	-0.093	0.029	-1.746	0.081
AV-share	<--	Driver-assisted-technology-use	0.071	0.071	0.055	1.299	0.194
AV-share	<--	Fear and anxiety	0.028	0.017	0.123	0.224	0.823
AV-share	<--	Image	0.006	0.011	0.037	0.153	0.878
AV-share	<--	Perceived-benefits-composite	-0.152	-0.032	0.470	-0.323	0.747
AV-share	<--	Perceived-ease-of-us	0.007	0.010	0.046	0.143	0.886
AV-share	<--	Subjective norm	0.135	0.127	0.154	0.876	0.381
AV-share	<--	Perceived-behavioural-control	-0.062	-0.083	0.045	-1.378	0.168
AV-share	<--	Attitude towards sharing * attitude towards car ownership	0.033	0.132	0.014	2.395	0.017
AV-share	<--	Attitude towards sharing * Attitude towards public transit	0.028	0.169	0.015	1.822	0.068
Perceived-ease-of-us	<--	Subjective norm	0.951	0.560	0.143	6.630	***
Perceived-ease-of-us	<--	Education	0.022	0.031	0.034	0.633	0.527
Perceived-benefits (instrumental/hedonic)	<--	Subjective norm	0.312	0.343	0.105	2.957	0.003
Av-attitude	<--	Subjective norm	0.223	0.286	0.092	2.416	0.016
Perceived-benefits (time use)	<--	Subjective norm	0.431	0.324	0.153	2.818	0.005
Perceived-benefits (instrumental/hedonic)	<--	Perceived-ease-of-us	0.119	0.221	0.045	2.645	0.008

Perceived-benefits (time use)	<--	Perceived-ease-of-us	0.146	0.187	0.061	2.402	0.016
Av-attitude	<--	Perceived-ease-of-us	0.107	0.233	0.039	2.769	0.006
Perceived-benefits (instrumental/hedonic)	<--	Education	0.018	0.049	0.014	1.256	0.209
Perceived-benefits (time use)		Education	-0.038	-0.070	0.029	-1.298	0.194

Notes: ß = Unstandardized regression estimates, b = standardized regression estimates; *** P-value < 0.01
Model identification indices 60% sample: χ^2 = 2085.047, df = 1149, Normed-χ^2 = 1.184, p < 0.01; RMSEA = 0.037; NFI = 0.862; CFI =0.933; IFI =0.933; TLI = 0.925.
Model identification indices 40% sample: χ^2 = 1777.782, df = 1149, Normed-χ^2 = 1.547, p < 0.01; RMSEA = .041; NFI = 0.809; CFI = 0.922; IFI = 0.923; TLI = 0.913

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