On the impact of vehicle automation on the Value of Travel Time while performing work and leisure activities in a car: theoretical insights and results from a stated preference survey

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Dr.ir. Gonçalo Homem de Almeida Correia (**corresponding author**)
Delft University of Technology
Faculty of Civil Engineering and Geosciences
Department of Transport & Planning
P.O. Box 5048
2600 GA Delft, The Netherlands
Phone: +31 (15) 27 81384
E-mail: G.Correia@tudelft.nl

University of Coimbra
Department of Civil Engineering
CITTA Research Center for Territory, Transports and the Environment
Coimbra, Portugal

Ir. Erwin de Looff
Delft University of Technology
Faculty of Civil Engineering and Geosciences
Department of Transport & Planning
P.O. Box 5048
2600 GA Delft, The Netherlands
Phone: +31 (0)6 43818478
E-mail: ejdelooff@gmail.com

Dr.ir. Sander van Cranenburgh
Delft University of Technology
Faculty of Technology, Policy and Management
Transport and Logistics group
2628 BX Delft, The Netherlands
Phone: +31 (15) 27 81957
E-mail: S.vanCranenburgh@tudelft.nl

Dr.ir. Maaike Snelder
TNO and Delft University of Technology
Van Mourik Broekmanweg 6,
P.O. Box 49
2600 AA Delft, The Netherlands
Tel: +31 88 8668522;
Email: maaike.snelder@tno.nl

Prof.dr.ir. Bart van Arem
Delft University of Technology
Faculty of Civil Engineering and Geosciences
Department of Transport & Planning
P.O. Box 5048
2600 GA Delft, The Netherlands
Phone: +31 (15) 27 86342
E-mail: b.vanarem@tudelft.nl

ABSTRACT

Many experts believe the transport system is about to change dramatically. This change is due to so-called fully-automated vehicles (AVs). However, at present, there are numerous important knowledge gaps that need to be solved for the successful integration of AVs in our transport systems, in particular regarding the impacts of AVs on travel demand. For instance, full automation will enable passengers to perform other, non-driving, related tasks while traveling to their destination. This may substantially change the way in which passengers experience traveling by car, and, in turn, may lead to considerable changes in the so-called Value of Travel Time (VOTT). Many experts anticipate the VOTT to decrease substantially due to AVs. However, the extent to which VOTT will change is currently far from clear. This study aims to develop new insights on the potential impacts of fully automated vehicles on the VOTT for commute trips. To do so, we first look at the existing microeconomics theory on the perceived VOTT and analyze the expected changes accrued from the effect of working and having leisure in an AV. We conclude that the VOTT of a work vehicle should be lower than what is experienced today in a conventional vehicle but the leisure one could stay the same. Then we conduct a stated choice experiment, specifically designed and administered for measuring the VOTT, and analyze these data using discrete choice models (DCMs). In total, we collected data from about 500 respondents. In the experiment, respondents were presented choice tasks consisting of three alternatives: an AV with office interior, an AV with leisure interior, and a conventional car. The same experiment was also given to another sample of respondents but this time describing a chauffeur-driven vehicle. Overall we find the average VOTT for an AV with an office interior (5.50€/h) to be lower than the VOTT for the conventional car (7.47€/h), however the AV with leisure interior is not found to decrease the value of time (8.17€/h) which confirms the theoretical results. The VOTT for the chauffeur experiment is systematically lower than for the AV experiment which we attribute to some distrust that people have regarding the AVs.

Keywords: Value of travel time (VOTT); Automated Vehicles (AVs); Driverless Vehicles; Stated Choice (SC); Discrete Choice Models (DCMs); microeconomics theory.

1 INTRODUCTION

Automated vehicles (AVs) are expected to populate the transport system in the foreseeable future (Nieuwenhuijsen et al., 2018). Many believe AVs will improve the efficiency of the transport system. For instance, platooning enables an optimization of traffic flow management, and increases the aerodynamic movement of the vehicles, resulting in fuel efficiency (Beiker, 2014; Haboucha et al., 2017). Furthermore, AVs have the potential to reduce the number of fatalities, increase road capacity, and provide more accessibility to young, elderly and disabled people (Anderson et al., 2014; Fagnant and Kockelman, 2015; Harper et al., 2016). Another important potential benefit of AVs for travelers, which is the focus of this study, stems from the possibility to perform a work or leisure activity (Jain and Lyons, 2008; König and Neumayr, 2017). This may dramatically change the travel experience on the side of the traveler (Jamson et al., 2013).

In the context of these high expectations on AVs, there is a significant and growing body of research on automated driving. For example, the effect of AVs on traffic safety and traffic flow efficiency have been studied by Van Arem et al. (2006) whereas Bansal et al. (2016) studied the willingness to pay (WTP) to upgrade a conventional car to an AV. The road network capacity on intersections using AVs has been studied by Le Vine et al. (2015) and Lioris et al. (2017). Other studies relating different penetration rates of (semi-)automated vehicles and road capacity have been done by Bose & Ioannou (2003), Li & Ioannou (2004), Van Arem et al. (2006), Hoogendoorn et al. (2014) and Letter & Elefteriadou (2017). Correia and van Arem (2016) have looked at urban mobility changes that may happen as a result of the possibility of private vehicles moving driverless. In one of their scenarios, the authors assume a hypothetical reduction of the value of travel time (VOTT) of 50% (caused by the enhanced experience inside these vehicles), and find that more demand is satisfied by the same number of family cars, therefore, the VOTT has a direct mobility effect. Traveling is an activity which in general individuals would rather avoid, they would prefer to be at home, at work, or somewhere else than riding a bus or driving a car. "Therefore individuals are willing to pay some amount for a travel-time reduction, which has a behavioral dimension" (Jara-Diaz, 2007) and must be quantified as this is connected to the global welfare of society.

Despite these recent research efforts, it is fair to say that current understanding regarding how travelers will experience AVs is still limited. Although many researchers expect that the VOTT will decrease as a result of automated driving, to the best of our knowledge only few studies have started to investigate the impacts of AVs on the VOTT. Milakis et al. (2017) surveyed several experts who have concluded the reductions of travel time to be in the interval of 15% to 30%, however, this was not based on specific behavioral studies. Childress et al. (2015) assume, like others do in other studies, that there is a reduction of VOTT which they associate with the difference between high-quality rail and the private car. Contrary to general expectations, Yap et al. (2016) found that people are willing to pay more (rather than less) to reduce their travel time in an AV as compared to a normal car when this is used as a last mile connection. This result raises important questions when compared to mainstream theory: the VOTT should decrease due to opportunities to improve productivity while driving (Fagnant and Kockelman, 2015; Krueger et al., 2016; Scheltes and Correia, 2017; van den Berg and Verhoef, 2016).

The main objective of this study is to investigate the VOTT of AV travelers. Our study complements earlier research in this context as we focus on the situation in which travelers have a privately owned AV to their disposal for their commuter trip. We study the VOTT from a theoretical perspective by looking at the microeconomics theory that explains the perceived VOTT and modifying it by assuming that work and leisure activities would be possible inside a car. Furthermore, we conduct a stated preference choice experiment where we intend to estimate empirically the changes on the VOTT resulting from vehicle automation. To reduce the cognitive burden on the side of the respondents in the data collection, we focus on cars and AVs only (ignoring other modes of transport). We consider only fully-automated vehicles (level 5 (SAE International, 2014)), since this type of AVs would presumably allow people to perform work or leisure activities while driving in any place. We analyze our data using state-of-the-art discrete choice models (DCMs) but also some more advanced models including hybrid choice modeling (Ben-Akiva et al., 1999). The novelty of AV technology may render it difficult for respondents to fully understand the presented choice tasks. Therefore, and to corroborate our results, we have run two experiments. In the first experiment, respondents are presented with AV alternatives, while in the second experiment respondents are presented with a private driver alternative (chauffeur). The latter is presumably somewhat easier to grasp for respondents than AV alternatives.

The remaining of this paper is structured as follows: In the next section, we define the VOTT that is the subject of this paper analyzing its possible changes due to automated driving from a microeconomics perspective. This is followed by the SC method used to measure empirically the VOTT changes. The survey and sample used in the case-study of the Netherlands are explained next. The paper continues with the results of the experiment which are followed by the main conclusions and also the implications of the results particularly for Cost-Benefit Analysis (CBA). The paper ends with recommendations for future research accrued from the limitations and scope of this research.

2 VOTT IN MICROECONOMICS THEORY

2.1 The subjective VOTT

The definition of what is the VOTT is important for this research. Although not being the purpose of this paper to go deep into the theory of what VOTT means, it is, however, important to establish which type of VOTT we are addressing in this work. The definition and corresponding quantification of the VOTT has been evolving and for a review on this theory, we recommend the paper by Jara-Diaz (2007) to understand the evolution in the field at least up to that point in time.

The VOTT does not correspond only to the activity of traveling itself but it is also related with the activities that can be performed as an alternative during the day mainly divided in work and leisure. A pure view of time as a resource for production has led to the original idea of associating the VOTT to the salary rate (Becker, 1965), thus ignoring that time also has to be assigned to other activities and that travel time has in itself a (dis)utility associated to it. Theory evolved to consider these components and explain how they interact together through microeconomics theory with contributions from (Evans, 1972; Oort, 1969; Small, 1982).

Discrete choice models to explain transport mode choice are an important part of travel demand modeling. According to Random Utility theory a decision maker chooses the alternative that maximizes his/her utility. After having estimated the utility function, one can infer the WTP to reduce one unit of travel time, which is essentially the rate of substitution between time and cost for a constant utility.

Typically, the deterministic part of the utility function of a particular mode of transport (ignoring now the index of the decision maker) has the following form:

$$V_i = \beta_0 + \beta_{time} t_i + \beta_{cost} c_i + (\dots) \tag{1}$$

Where the βs are coefficients to be estimated and t_i and c_i are the travel time and cost of the transport mode i respectively. From equation 1 the WTP is obtained by dividing the coefficient of the travel time (β_{time}) by the coefficient of the travel cost (β_{cost}). This can be expressed as a ratio between the marginal systematic utility of time and the marginal systematic utility of cost: $\frac{\partial V_i}{\partial t_i} / \frac{\partial V_i}{\partial c_i}$, which is known as the subjective VOTT.

2.2 Deriving the subjective VOTT

Using Jara-Diaz (2007) microeconomics model of utility (U) maximization yielded from consumption (denoted as G, expressed in monetary units), leisure (denoted as L, expressed in time units), work (denoted as W, expressed in time units) and travel time used in transport mode i (t_i) we have the following utility function for an individual choosing among his/her different daily activities (it is assumed that the life situation of this person is in a long-term equilibrium):

$$Max\ U(G, L, W, t_i) \tag{2}$$

Which is subject to,

$$G + c_i = wW, \tag{3}$$
$$L + W + t_i = \tau, \tag{4}$$
$$L \geq \alpha G, \tag{5}$$

Where w is the salary, τ is the total available time, α is consumption time per unit of G, and $i \in M$, with M being the set of transport modes.

In Jara-Diaz (2007) model an average individual is assumed. He/she has as his/her source of income his/her salary w which yields a total of wW monetary units and a consumption G plus the travel costs c_i both in monetary units which naturally leads to constraint (3). Time is limited to τ and is only consumed in leisure (L), work (W) and travel time on mode i (t_i) therefore constraint (4) is added. Assuming that consumption occurs during leisure, the leisure time (L) has to be greater than the time to consume G (αG) as expressed by constraint (5).

As shown in (Jara-Diaz, 2007) replacing the equality constraints in equations (2)-(5) we get a new conditional maximization problem:

$$\underset{W}{\text{Max}}\, U[(wW - c_i), (\tau - W - t_i), W, t_i] \tag{6}$$

subject to,

$$\tau - W - t_i - \alpha(wW - c_i) \geq 0 \tag{7}$$

From this model we get what is called the subjective value of travel time (SVTT) which in this paper we refer to as VOTT (Jara-Diaz, 2007):

$$VOTT = \frac{\frac{\partial V_i}{\partial t_i}}{\frac{\partial V_i}{\partial c_i}} = w + \frac{\frac{\partial U}{\partial W}}{\frac{\partial U}{\partial G} - \theta\alpha} - \frac{\frac{\partial U}{\partial t_i}}{\frac{\partial U}{\partial G} - \theta\alpha} \tag{8}$$

In the equation the term $\frac{\frac{\partial U}{\partial W}}{\frac{\partial U}{\partial G}-\theta\alpha}$ is the value of work in direct utility expressed in monetary units, the term $\frac{\frac{\partial U}{\partial t_i}}{\frac{\partial U}{\partial G}-\theta\alpha}$ is the utility of traveling by itself expressed in monetary units (or value of traveling as a commodity) with θ being the multiplier of constraint (5) and w, as explained before, is the salary. Another important notion is that $w + \frac{\frac{\partial U}{\partial W}}{\frac{\partial U}{\partial G}-\theta\alpha}$ is what is called the value of leisure (Jara-Diaz and Guevara, 2003) which, as it can be seen, equals the salary plus the utility of the time at work itself transformed into monetary units.

These results mean that the subjective value of travel time is the sum of the leisure value of time and the value of travel time. As Jara-Diaz (2007) states: "if people enjoy working and dislike traveling then their $VOTT$ will be considerably higher than the salary".

2.3 The VOTT while working in a vehicle

In the presence of AVs the Jara-Diaz model needs to be extended. In a situation where the travel time is used for work the model above can be converted into:

$$Max\ U(G, L, W, t_i) \tag{9}$$

Which is subject to,

$$G + c_i = wW + \boldsymbol{wt_i}, \tag{10}$$
$$L + W + t_i = \tau, \tag{11}$$
$$L \geq \alpha G, \tag{12}$$

Where now the travel time is converted into income through component wt_i in equation (10).

Solving the model as before (see Appendix A) we have the new perceived value of travel time:

$$VOTT = \frac{\frac{\partial V_i}{\partial t_i}}{\frac{\partial V_i}{\partial c_i}} = \frac{\frac{\partial U}{\partial W}}{\frac{\partial U}{\partial G} - \theta\alpha} - \frac{\frac{\partial U}{\partial t_i}}{\frac{\partial U}{\partial G} - \theta\alpha} \tag{13}$$

In this case, the model shows that the VOTT should only be the difference between the direct utility of spending time at work (no salary included) and the direct utility of experiencing traveling. The salary does not play a role because time spent traveling is time in which the traveler is receiving a salary.

Furthermore, this suggests that if the value of work time is equal to the value of travel time (as a commodity), then the VOTT (i.e. the perceived value of travel time) would be zero. This would mean that a person could go on forever traveling, albeit naturally being limited by the duration of the day. In other words, if you love traveling and you love to work or if you hate traveling but you also hate to work, then you could be stuck in the car forever, it does not matter.

The equality of both terms makes sense in a scenario where working conditions in a car are exactly the same as working at an office so that perception of time in the car is the perception of time at work. If the feeling of working inside the car is positive while working is negative, it could happen that the VOTT would be negative which would mean that a person would be asking for money to stop traveling if that makes any sense.

Conversely, if the experience of working in the car is negative and actually working at the office is somehow acceptable then the VOTT will be positive but lower than the existing situation because the salary is no longer part of the VOTT expression.

2.4 The VOTT while having leisure in a vehicle

Model (1) - (5) can be changed in an alternative way where the time spent in transport mode i is considered to be leisure time as well, then we have the following model:

$$Max\ U(G, L, W, t_i) \tag{14}$$

Which is subject to,

$$G + c_i = wW \tag{15}$$

$$L + W + t_i = \tau, \tag{16}$$

$$L + \boldsymbol{t_i} \geq \alpha G, \tag{17}$$

Time t_i is summed to the leisure time as an extra component and together they have to be greater than the time needed for consuming G.

Solving the model as before (Appendix B) gives rise to another perceived value of travel time:

$$VOTT = \frac{\frac{\partial V_i}{\partial t_i}}{\frac{\partial V_i}{\partial c_i}} = \frac{\frac{\partial U}{\partial L}}{\frac{\partial U}{\partial G} - \theta\alpha} - \frac{\frac{\partial U}{\partial t_i}}{\frac{\partial U}{\partial G} - \theta\alpha} \tag{18}$$

But knowing that the value of leisure time $\frac{\frac{\partial U}{\partial L}}{\frac{\partial U}{\partial G} - \theta\alpha}$ equals $w + \frac{\frac{\partial U}{\partial W}}{\frac{\partial U}{\partial G} - \theta\alpha}$ (P.J. Mackie et al., 2001) then it follows that:

$$VOTT = w + \frac{\frac{\partial U}{\partial W}}{\frac{\partial U}{\partial G} - \theta\alpha} - \frac{\frac{\partial U}{\partial t_i}}{\frac{\partial U}{\partial G} - \theta\alpha} \tag{19}$$

Which is the same perceived value of travel time as the one for the base case without AVs. It seems that consumption G yielded from the salary is constraining the leisure time formed by the normal leisure (L) and the travel time in mode i which is also counting as leisure in this scenario. A person will not be able to consume while traveling if the income is not enough.

These are theoretical findings that give us a framework on how to analyze the empirical results produced through the survey experiment that will be explained next.

3 SURVEY FOR ESTIMATING THE VOTT

3.1 Stated choice experiment

The WTP of individuals can be derived using various approaches (Breidert et al., 2006). Since fully-automated vehicles are non-existing, we opt for a stated choice (SC) choice experiment in combination with DCMs. DCM are currently the most popular approach to infer WTP, see e.g. Arentze & Molin (2013), Hess et al. (2005) and Kouwenhoven et al. (2014). Besides that, DCMs are also applied in a number of related studies on automated driving (e.g. Haboucha et al., 2017; Krueger et al., 2016; Yap et al., 2016).

Nevertheless, it is important to recognize that SC experiments have limitations. In particular, results may be unreliable for a number of reasons. So-called hypothetical bias may occur when respondents are not able to grasp the experiment due to cognitive burdens, or respondents may give strategic answers in the hope to influence the policy outcomes, therefore, affecting the VOTT estimates. This was, for example, recognized in a recent workshop by Stathopoulos et al. (2017) where the need for formulating models of innovation adoption was one of the major conclusions. For example, Cherchi finds that normative behavior can shape answers from certain groups of people in SC experiments regarding the adoption of new technologies like electric vehicles (Cherchi, 2017). To try to minimize these limitations, an as clear as possible explanation was given as to what an AV is. Two pictures were shown to exemplify what these two types of office interiors could look like. Furthermore, we have designed two experiments, one in which AV alternatives were presented and a second in which private chauffeur alternatives were presented. We conducted the second experiment as a way to provide additional support for our results. Moreover, in this paper, we have the perspective of focusing more on relative results among the alternatives and experiments rather than so much focusing on the absolute values, although we do aim at validating the VOTT with conventional cars as experienced by the Dutch population currently.

3.1.1 Alternatives and attributes

Three alternatives are described of which two are AVs and the other is a conventional car. In the second experiment, the two AV alternatives are classified as “chauffeur driven”. Because the experiment does not change by the fact that it is an AV or a chauffeur driven car we will explain the alternatives and attributes only referring to the AVs in the following paragraphs.

In the first AV option, the passenger is said to be able to work in the AV, since its interior is designed as a work environment (designated by AV-office). We note that this is, of course, dependent on the type of profession that the respondent has, and clearly a factory worker, for example, will not be able to perform his/her profession inside a car but we expect this factor not to be so important in the Netherlands (the case study country) where the majority of the workforce is working in services, education and public administration (CBS Statline, 2016). In the second AV option, the AV has a leisure interior, which allows performing non-working activities while traveling (designated by AV-leisure). This distinction is done to gain insights on the different trip experience that a passenger may have while working or having leisure time. The third alternative is about a trip driving a conventional car.

Table 1 gives an overview of the attributes and attribute levels of the SC experiment. For all modes, travel time ranges from 15 to 45 minutes, with equal 15-minute intervals, and travel cost ranges from €4.50 to €7.50 with equal €1.50 intervals. These travel times and travel costs are pivoted around their average values in the Netherlands. Travel companions (if there are more passengers) and (AV-)activity are also included as these were expected to influence the AV experience. We could have pivoted the experiment around the reported travel times from each respondent and this would, for example, allow comparing different sensitivities of the different groups of travelers. However, we decided to keep the experiment simpler and just pivot around the average values in the Netherlands though being aware that for higher realism the experiment could have been improved by taking the usual commuter trip pattern from the traveler (Ortúzar and Willumsen, 2011). For more accurate VOTTs applicable to different regions of the Netherlands and traveler types, such pivoting would be recommended but with it there would be the need for extra survey development time and cost budget.

Table 1: Overview of attributes and attribute levels used in the SC experiment

Attribute	Attribute levels		
Travel time car	15 min	30 min	45 min
Travel time AV-office	15 min	30 min	45 min
Travel time AV-leisure	15 min	30 min	45 min
Travel costs car	€4.50	€6.00	€7.50
Travel costs AV-office	€4.50	€6.00	€7.50
Travel costs AV-leisure	€4.50	€6.00	€7.50
Walking time car	2 min	4 min	6 min
Travel companions car	Travel alone	Travel with family and/or friends	
Travel companions AV-office	Travel alone	Travel with family and/or friends	
Travel companions AV-leisure	Travel alone	Travel with family and/or friends	
(AV-)activity (Only for the AV-office interior)	Work extra time	Save time at office	

The walking time applies only to the conventional car alternative because it is assumed that AVs provide a door-to-door service. All alternatives include the travel companions attribute, in which it is possible to travel alone or with family/friends. Respondents were not given the option of riding with colleagues or even strangers like in so-called external carpooling (Correia and Viegas, 2011).

The (AV-)activity comprises the activity one performs in the vehicle. Four possibilities exist: driving, having leisure time, working extra time and working for saving time at the office. The conventional car always has the attribute value ‘driving’. The AV-leisure is always associated with ‘having leisure time’. The activity attribute for the AV will vary between ‘work extra time’ in which the person is considered to work additional time in the AV such that he or she earns extra salary or collects more spare days, and ‘save time at the office’ where the transportation time is used for work that is discounted from the work schedule, therefore, adding time at home (see Figure 1).

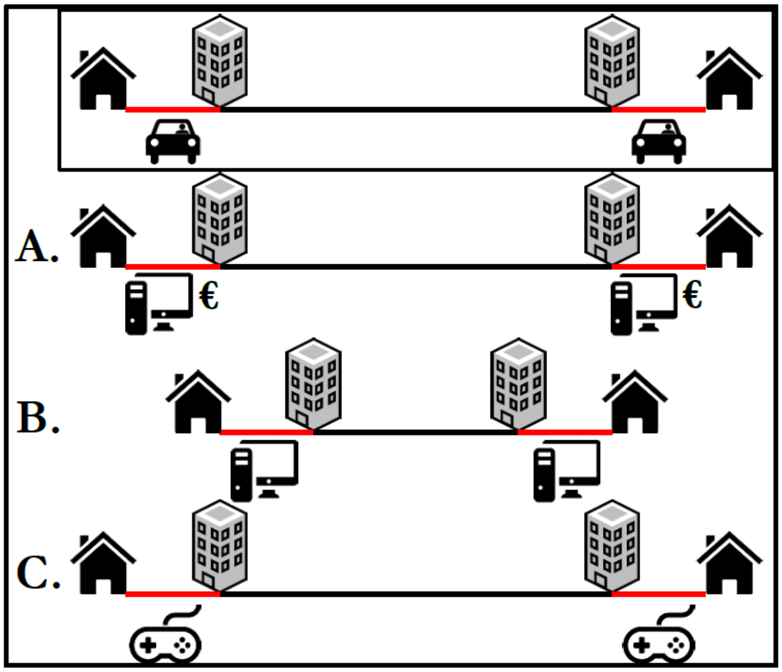

Figure 1: Identified AV activities from top to bottom: current situation, A. work extra time, B. save working time at the office, C. have leisure time.

3.1.2 Choice sets

An efficient experimental design is used. Efficient experimental designs aim to minimize the standard errors of the estimated parameters given a set of prior values. The lower the standard error of a parameter, the higher the reliability of the estimate. We choose a so-called D-optimal design as D-efficient designs are among the most commonly used efficient designs (Rose et al., 2008; Rose and Bliemer, 2009). To construct the design, we used non-zero priors. To set the priors we used the estimated coeficients from the study by (Yap et al., 2016). However, no literature has been found to come up with priors regarding the attributes ‘travel companions’ and ‘activity’. Therefore, we set these priors to zero while generating the design.

Finally, 12 different choice sets were generated, where each respondent had to answer all choice sets. For each choice set, it was mentioned clearly that each trip was being done from home to work (commuting morning peak). An example of a choice set is provided in Figure 2. Note that in the case of the chauffeur driven vehicle experiment the text changed in the label of the two AV alternatives but the remaining structure of the experiment stayed the same.

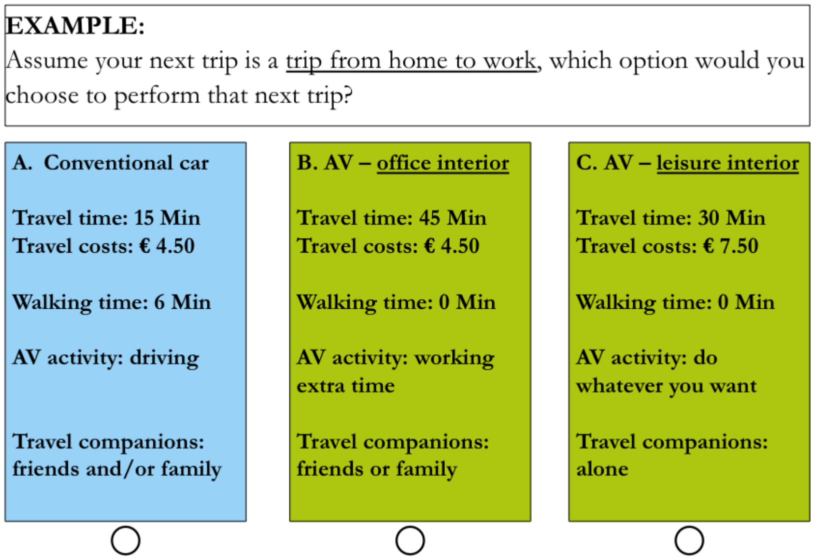

Figure 2: Example of a choice set as provided to respondents in the survey

3.2 Survey structure

Before the survey began an explanation was given about vehicle automation:

"In a fully-automated vehicle, also known as a self-driving car, it is not necessary to pay attention to the road; the AV drives itself to your destination. Because you do not have to pay attention to the road, it is possible to perform other activities while driving in an AV.

An AV would be comparable to your own car if you had a chauffeur to travel everywhere. There is no waiting time between the moment you 'call' the car and when you start riding it. Besides, it is assumed that while you ride in an AV, there are no unexpected trepidations to cause car sickness.

In an AV with office interior, you must imagine that you have the ability to do your work in a comfortable way. You can work on your laptop because you have power and Wi-Fi.

In an AV with leisure interior, you must imagine that the interior allows you to have leisure in a comfortable way. For example, you can take a nap, read a book, make a call, have quality time with family and friends, and watch a movie etcetera".

After the introduction, the survey consisted of three main parts. The first part included 12 choice sets, which started with an explanation of the alternatives and the attributes that reads like this:

"The first part of the survey consists of 12 choice sets in which you have to choose the your preferred option.

Each choice set has three alternatives: a conventional car, an automated vehicle (AV) with an office interior, and an AV with a leisure interior.

Two different working possibilities are defined for the office-vehicle:

- *Work extra time: this means that you can work more hours, since travel time is substituted as working time.*

- *Save time at the office: this means that you work the same amount of hours as determined in your labor contract, however, part of your working hours now take place in the car. In essence, you substitute travel time for additional time at home"*.

The office and leisure interiors were depicted using two pictures available on the internet (Figure 3).

Figure 3: Depiction of leisure interior (left) and office interior (right). Source: Google images

The second part of the survey consisted of 18 attitudinal statements on a 7-point Likert scale. Attitudes regarding automated driving could play an important role in the trading behavior. Yap et al. (2016) found that attitudinal factors towards automated driving influence the choice behavior regarding AVs.

The list below shows all 18 indicators that respondents had to rate from "strongly agree" to "strongly disagree". The statements are partly based and adapted from Carlson et al. (2011), Casley, Jardim & Quartulli (2013), Merritt, Heimbaugh, LaChapell & Lee (2012), Payre, Cestac & Delhomme (2014), and Yap et al. (2016):

1. I enjoy driving a car myself.
2. I would like to purchase an automated vehicle if it has better fuel efficiency than its conventional counterpart.
3. I trust that a computer can drive my car with no assistance from me.
4. I would be comfortable entrusting the safety of a close family member to an automated vehicle.
5. I think an individual requires a driving license before driving in an automated car.
6. I like it that I can be more productive on other tasks if I am riding in an AV.
7. I like it that I can delegate the driving to the automated driving system if I am due to certain circumstances not able to drive myself.

8. I like it that the automated car produces fewer pollutant emissions.
9. I like it that the car can park itself at cheaper parking spaces away from my destination.
10. I am afraid that the automated vehicle will malfunction.
11. I dislike the idea of automated driving.
12. I am afraid that the automated vehicle will not be fully aware of what is happening around him.
13. I do not like it that I do not have control of how the automated car drives.
14. I think that the automated driving system provides me more safety compared to manually driving.
15. I wish that automated vehicles were not around in the future.
16. I like it if I can recover control from the automated pilot if I do not like the way it is driving.
17. I like it that automated vehicles can adapt routes to avoid congestion.
18. I am afraid that I get motion sickness while riding in an automated vehicle.

At the end of the survey respondents were asked to answer questions about their socio-demographic characteristics. The variables that were collected are shown in Table 2.

Table 2: Socio-demographic variables and their categories

Question	*Socio-demographic variable*	*Categories*
How old are you?	**Age**	<20, 20-39, 40-64, 65-79, >80
Do you own a car?	**Car ownership**	Yes, No
Do you possess a driving license?	**Driving license**	Yes, No
What is your highest level of education?	**Educational level**	Low, Medium, High
What is your gender?	**Gender**	Male, Female
What is your current yearly net income?	**Net income class (€/year)**	< €10.000, €10.000 - €19.999, €20.000 - €29.999, €30.000 - €39.999, €40.000 - €49.999, > €50.000
What is your daily participation?	**Daily business**	Work full time, Work part-time, Study, Retired, None of the above
Is your work possible to be done in a comfortable car with internet and no trepidation?	**Able to work in an AV**	Yes, No
Are you willing to work in an AV?	**Willing to work in an AV**	Yes, No
What is your current door-to-door travel time?	**Current door-to-door travel time (min/one-way trip)**	<30 minutes, 30-60 minutes, >60 minutes
Would you, given the information, consider buying an AV for the same price as a normal car?	**Buying an AV**	Yes, No
Do you get a reimbursement for travel expenses you make for your work?	**Travel expenses reimbursement**	Yes, No
What is your most commonly used mode of transport?	**Most commonly used mode**	Car, bike, train, Bus Tram or Metro (BMT), carpooling

3.3 Sample statistics

The AV and chauffeur-driven car experiments are distributed using two separate Internet panels. The AV-survey is distributed through respondentendatabase.nl and the chauffeur-survey was distributed making use of globaltestmarket.com. Respondents were paid to complete the survey. Only respondents older than 18 years and in possession of a driving license were allowed to fill in the survey by the company which ran the survey. Notice that the question about the possession of a driving license in Table 1 was also included in order to control for the desired sample characteristics.

For the AV experiment, 279 respondents started the survey, of which 252 (90.3%) fully completed the questionnaire. Comparison between our sample and population statistics, in terms of socioeconomic variables such as gender, age, educational level, and current employment status reveals that we have obtained a fairly balanced sample of our target population. The age categories of “50 to 59” and “60 to 69” were oversampled, while the age category “70 years and older” was highly undersampled. The latter can be explained by the fact that older people are less frequent users of the Internet. The share of part-time workers and retirees (7.9% of the respondents were retired people) are undersampled, which can also be justified by their lower usage of the Internet. However, since these tend to see their commute behavior reduced in frequency we do not find this to be a limitation. Despite debatable, we in the end decided not to eliminate this part of the sample because of the small size of the group and because in the pilot with a few of these people it did not seem that they had lost sensitivity for their previous commuter trips.

In the case of the chauffeur-driven experiment, a total of 301 respondents started the survey from which 250 respondents completed the questionnaire (83.1%). Inspection of the data revealed that eight respondents provided unreliable ratings (they rated all the statements the same). These eight respondents were excluded from further analysis. In this sample especially the age category 70 years and older was underrepresented as in the AV survey. The full-time workers are highly oversampled (+23.8%) and the retirees are rather underrepresented with 6.6% of the answers (a difference of -17%). Ultimately, it is concluded that this sample is representative enough of the Dutch population, but there are some differences as noted.

3.4 Non-traders analysis

In this study, a distinction was done between traders and non-traders. A non-trader refers to a respondent that always chooses the same alternative for each choice task. Three possible reasons for this behavior are described in the literature: 1) a respondent has an extreme preference for one alternative; 2) a respondent gets bored or does not take the survey seriously or; 3) a respondent makes a political or strategic decision. However, it is very difficult to distinguish the three causes of non-trading behavior. The importance of excluding non-traders from the sample is that these respondents may have a major influence on the estimated marginal utility coefficients, which are used to derive the VOTT (Hess et al., 2010). All our analyses are conducted both with and without the non-traders. However, for reasons of brevity in the remaining part of this paper, we focus on the traders only.

In the AV survey, a total of 74 respondents (29.4%) of the 252 respondents showed non-trading behavior which yields a total of 178 remaining responses, 2136 choices. Most non-traders opted always for the conventional car (71.6%), and a minority chose always the AV-leisure (17.6%) or the AV-office (10.8%). Mostly older, retired, low educated respondents show non-trading behavior. We find that this non-trading correlates strongly with distrust (or non-understanding) toward AVs technology.

In the chauffeur-driven experiment 96 respondents (39.7%) filled in the same answer for every choice task. 46 males are non-traders, which is 39.7% of the male sample. 37 males opted always for the conventional car, which is 80.4% of the male non-traders group.

86.6% of the non-trading respondents opted always for the conventional car. Respectively 11.3% and 2.1% of the non-trader chose the chauffeur-driven office car and the chauffeur-driven leisure car. More than half of the retired respondents were non-traders and 64.3% of the respondents that had the employment status ‘other’ are non-traders as well. The share of working non-traders is higher in the chauffeur-case than in the AV-case.

It is striking that almost half of the respondents in the age 40-59 are identified as non-traders. 54.0% of the respondents in the age category ≥60 are non-traders. Relatively many respondents with a low education show non-trading behavior. Surprisingly, higher educated respondents show more non-trading behavior in the chauffeur-case than in the AV-case.

Regarding the chauffeur-case, we conclude that older respondents, retired respondents, ‘other’ employed respondents and lower educated respondents are more often non-traders. In this study, the non-traders have a strong preference for the conventional car. All in all, the sample excluding non-traders is representative for the Dutch population. 146 trading respondents remain in the sample, a total of 1752 choices, which is large enough for estimating the DCMs.

4 RESULTS

4.1 Model specification and estimation

A series of DCMs are estimated in order to find the best model describing the choice behavior in the SC experiment, including but not limited to Multinomial Logit (MNL) models, Nested Logit (NL) models, error-component mixed logit (ML) models, Panel ML models with random taste parameters, and hybrid discrete choice models. For all models, linear-additive utility specifications are used, see equation (20). The Utility is postulated to be derived from (up to) 4 parts: The first part captures the utility derived from the attributes, and β_x' is a vector containing the estimable taste parameters associated with the attributes of alternative j and x_{jn} is a vector containing the attribute levels of alternative j presented to decision-maker n. The second part captures the utility explained by socio-demographic characteristics of the decision-maker, where β_τ' is a vector containing estimable parameters associated with socio-demographic characteristics and τ_n is a vector containing the socio-demographic characteristics of the decision -maker n. The third part captures the utility explained by attitudes (only applicable to the hybrid discrete choice models). In the hybrid choice models attitudinal variables (φ_n) are incorporated to explain the choice behavior. Attitudes towards AVs are obtained from responses to a series of propositions (see section 3.2). The hybrid discrete choice models are jointly estimated, meaning that the parameters of the choice model and of the latent variable model are simultaneously identified. Finally, the fourth part ε_{jn} captures the unobserved utility associated with alternative j for decision-maker n and is assumed to be i.i.d. Extreme Value type I distributed (with scale of 1).

$$U_{nj} = \beta_x' x_{jn} + \beta_\tau' \tau_n + \beta_\varphi' \varphi_n + \varepsilon_{jn} \quad (20)$$

4.2 Automated vehicles experiment

Table 3 shows a collection of estimation results of the most insightful models we have estimated. Three types of models are estimated with and without socio-demographic variables, namely (1) MNL models, (2) Hybrid choice models (with MNL kernel), and (3) Panel ML models, with normally distributed random travel time taste parameters). The coefficient for the cost variables was kept the same for the different modes after running the models with and without the fixed parameter, from a behavior point of view this did not lead to changes on the conclusions regarding relative differences among the VOTTs. For a discussion on the implications of having different coefficients and also allowing for taste variations we refer the reader to (Ortúzar and Willumsen, 2011, p. 179). The name of each variable in the table ends with the utility function where the variable has been placed ("_car" for the conventional vehicle and "_AVO" and "_AVL" for the AV office and AV leisure respectively).

Based on Table 3 a number of inferences can be made. Firstly, the signs of all the estimated parameters are consistent with microeconomic theory. Secondly, the observation that ASC_{AVL} is significantly different from zero in most model specifications indicates that all else being equal, on average there is a preference for leisure AVs over conventional vehicles that is not explained by the variables in the model. Thirdly, looking at the results of the Panel ML model, we see that the corresponding standard deviations associated with the travel time parameters are all found to be significantly different from zero. This shows that unobserved taste heterogeneity for travel time is present. Fourthly, the best model fit is attained by the panel ML models. This reveals that for these data unobserved heterogeneity is better captured using random taste parameters than by means of latent attitudinal variables. Fifthly, regarding the type of activity to be performed in the office car, the negative value of $\beta_{\tau\ Activity\_AVO}$ indicates that substituting travel time for work time that can be used at home is preferred over working additional time to get more income. Being productive in an AV, people seem to prefer to spend less time in their workplace and transfer the saved time for doing other activities. So, it implies that AVs might change the activity patterns not only during the trip but also during the day as studied in a recent paper by Pudane et al. (2018).

Furthermore, the model results indicate that traveling alone for the commuter trip is generally preferred over traveling with family/friends (negative $\beta_{\tau\_travel\_company}$ parameters). Car-poolers prefer AVs when compared to the conventional vehicle. Respondents who are willing to work in an AV show a preference for AVs. Respondents who are willing to buy an AV have a preference for AVs as well. The possibility to perform the respondent's work in a car starts to be significant and decreasing the utility of the conventional car alternative, however in the latter models this variable disappears and does not seem to have any influence at all in the preferences, possibly due to other more significant variables taking its place. Moreover, as stated before, the majority of the workforce in the Netherlands works in services, education and public administration. A factor analysis conducted prior to the estimation of the choice models based on the propositions (see section 3.2) revealed that there are 3 latent attitudes towards AVs. See Appendix C for the results of the Exploratory Factor Analysis (EFA). However, within the hybrid choice model, only one attitudinal variable "*convenience of automated driving*" is found to significantly explain the choice behavior. Specifically, the negative sign of β_{φ} indicates that respondents who rated AVs as convenient, they are more likely to choose AVs alternatives.

Table 3: Estimation results for the coefficients in three DCM models for the AVs scenario with the sample excluding the non-traders

Parameter	Meaning of variable associated	MNL model	MNL model with socio-demographic	Hybrid choice model without Socio-demographic	Hybrid choice model with Socio-demographic	Panel ML model without Socio-demographic	Panel ML model with Socio-demographic
ASC_{AVL}		0.373 (1.64)*	0.78 (3.13)	0.416 (1.82)*	0.965 (3.77)	0.556 (2.15)	1.1 (3.62)
ASC_{AVO}	Alternative specific variables	-0.287 (-1.52)*	0.0729 (0.34)*	-0.25 (-1.31)	0.254 (1.16)*	-0.0823 (-0.39)*	0.412 (1.55)*
ASC_{CAR}		-	-	-	-	-	-
β_x							
β_{TT_CAR}		-0.0521 (-11.57)	-0.0555 (-11.82)	-0.0526 (-11.6)	-0.0559 (-11.84)	-0.0707 (-11.12)	-0.0674 (-11.53)
β_{TT_AVO}	Travel time of each alternative in minutes	-0.0391 (-7.37)	0.00537 (-7.65)	-0.0394 (-7.41)	-0.0413 (-7.68)	-0.0649 (-8.97)	-0.0614 (-8.87)
β_{TT_AVL}		-0.0582 (-10.35)	0.00575 (-10.76)	-0.0587 (-10.4)	-0.0621 (-10.79)	-0.0827 (-10.95)	-0.0809 (-11.04)
σ_{TT_CAR}		-	-	-	-	0.035 (8.43)	0.0243 (5.99)
σ_{TT_AVO}	Estimated standard deviations of the distribution of the travel time coefficients	-	-	-	-	0.038 (9.43)	0.0331 (8.61)
σ_{TT_AVL}		-	-	-	-	0.0385 (9.05)	0.0388 (8.98)
β_{TC}	Travel cost in euros	-0.402 (-16)	-0.417 (-16.29)	-0.404 (-16.04)	-0.418 (-16.32)	-0.509 (-16.97)	-0.505 (-17)
β_τ							
$\beta_{\tau\ Activity\_AVO}$	Extra work or saving time at work (1 and -1 respectively)	-0.115 (-1.97)	-0.129 (-2.2)	-0.117 (-2)	-0.131 (-2.22)	-0.145 (-2.21)	-0.158 (-2.42)
$\beta_{\tau\ Travel\_company\_AV}$	If there are travel companions or not in the AV (1 if yes and 0 if not)	-0.0902 (-2.58)	-0.0796 (-2.27)	-0.0888 (-2.54)	-0.0788 (-2.24)	-0.106 (-2.7)	-0.0987 (-2.54)
$\beta_{\tau\ Travel\_company\_car}$	If there are travel companions or not in the conventional car (1 if yes and 0 if not)	-0.204 (-3.3)	-0.21 (-3.3)	-0.205 (-3.3)	-0.21 (-3.3)	-0.211 (-2.97)	-0.223 (-3.17)
$\beta_{\tau\ Walking\_time\_car}$	Time to walk from the conventional car to the destination	-0.00747 (0.2)*	0.015 (0.4)*	0.00859 (0.81)*	0.016 (0.67)*	0.00154 (0.97)	0.00497 (0.91)*
$\beta_{\tau\ Age\_60plus\_car}$	If the person has more than 60 years old or not (1 if yes and 0 if not)	-	-	-	0.283 (2.56)	-	0.213 (1.15)*
$\beta_{\tau\ DO\_retired\_car}$	If the person is retired (1 if yes, 0 if not)	-	-	-	-0.583 (-3.79)	-	-0.612 (-2.43)
$\beta_{\tau\ DO\_WorkPart\_car}$	If the person does part time work (1 if yes, 0 if not)	-	-	-	0.288 (2.6)	-	0.318 (1.73)*
$\beta_{\tau\ Mode\_BMT\_car}$	If the person is using daily Bus Tram or Metro (1) or not (0)	-	0.895 (4.11)	-	0.891 (4.12)	-	0.95 (2.55)
$\beta_{\tau\ Mode\_carpool\_car}$	If the person is a carpooler (1) or not (0)	-	-1.5 (-5.36)	-	-1.49 (-5.32)	-	-1.61 (-3.39)
$\beta_{\tau\ Willing\_to\_work\_car}$	If the person is willing to work in an AV (-1 if yes, 1 if no)	-	0.219 (3.25)	-	0.293 (4.63)	-	0.292 (2.75)
$\beta_{\tau\ Able\_to\_work\_car}$	If the person is able to do his/her job in a car (-1 if yes, 1 if not)	-	0.11 (1.85)	-	-	-	-
$\beta_{\tau\ Buy\text{-}AV\_car}$	If the person is willing to buy an AV (-1 if yes, 1 if not)	-	0.422 (6.59)	-	0.456 (6.56)	-	0.556 (4.95)
β_φ							
$\beta_{\varphi\ Convenience\_AV\_car}$	Attitude toward convenience of an AV (the higher the more convenient)	-	-	-0.179 (-4.33)	0.00991 (0.83)*	-	-
	No. parameters	10	15	45**	52**	13	20
	No. of observations	2136	2136	2136	2136	2136	2136
	Null-Log-Likelihood	-2346.64	-2346.64	-2346.64	-2346.64	-2346.64	-2346.64
	Final-Log-likelihood	-2055.45	-1980.24	-2045.51	-1973.18	-1894.47	-1863.96
	Adjusted Rho-Square	0.12	0.156	0.128	0.159	0.193	0.206

* = not significant at a 95% confidence interval.

**=it also includes the remaining parameters of the joint estimation model

AVO = AV-office, AVL = AV-leisure.

4.3 Chauffeur experiment

In Table 4 the results of the models' estimation for the experiment with the chauffeur alternatives excluding the non-traders are shown. The name of each variable in Table 4 ends with the utility function where the variable has been placed ("_car" for the conventional vehicle and "_AVO" and "_AVL" for the Chauffeur office and Chauffeur leisure respectively).

All signs on the coefficients are as expected. The standard deviations in the travel time coefficients are all significant confirming that there is heterogeneity in the population. Most of the socio-demographic variables are not significant at a 95% level but just as in the AV-case, saving time at the office seems to be preferred over working extra time, and traveling alone is preferred over traveling with companions. Moreover, if the person is willing to work in an AV (car driven by a chauffeur) then there is a higher utility on riding the chauffeur driven vehicle. The variable related to the possibility of the respondent performing his/her job in a car continues not having any importance on the results.

For the hybrid models, the same latent attitude variable 'convenience' is found to be significant. The negative sign of β_{φ} indicates that respondents who rated highly the AVs as convenient, they tend to be more likely to choose AVs alternatives. However, the best models are the panel models with and without socio-demographic variables much like what happens with the AV experiment leading to a lower importance of the attitude variables when heterogeneity in the population is explicitly considered in the models.

4.4 Comparison between the chauffeur and the AV results

Having conducted both experiments gives us the opportunity to compare model outcomes. We see a number of nuanced, but insightful differences across the two models.

Firstly, we note that the Chauffeur experiment has, in general, a greater Rho-Square across all type of models that have been estimated. A possible explanation for this is that envisioning a car with a Chauffeur is cognitively less demanding than envisioning an AV – leading to on average higher choice consistency. Secondly, the ASCs in the chauffeur experiment are generally non-significant, which does not happen with the AV experiment. In the AV experiment we see a particular preference for leisure which does not seem to find an explanation in the variables that were used in the models. This may mean that there is a higher perceived possibility of having leisure in AVs when compared to being driven by a person. Thirdly, being a carpooler in the AV experiment leads to a higher utility when compared to the conventional car. This does not happen with the Chauffeur driven car, where carpooling is not a significant factor in choosing a car with a driver.

Noticing the reported differences we further conducted a Loglikelihood ratio test to the MNL models for the hypothesis of both datasets being the same. Our Null-Hypothesis is that the AV and chauffeur Data Generating Process (DGP) are the same. The test has the following characteristics:

Obs no. 3888
param = 10
LL = -3664.030

Alternative hypothesis: AV and chauffeur DGP are not the same

Subset1 (AV)
Obs no. 2136
param = 10
LL = -2055.448

Subset2 (CH)
Obs no. 1752
param = 10
LL = -1595.47

The test statistic is given by:

LRS = -2*(LL(B)-LL(A))
LRS = -2*(– 3664.030 - (-2055.448+ -1595.47))
LRS = -26.224

With a critical χ2 value, for 10 degrees of freedom, of 18.31, we can reject the hypothesis of the AV and chauffeur data being the same, which means that the observed differences between the two datasets are statistically significant.

Table 4: Estimation results for the coefficients in three DCM models for the chauffeur scenario with the sample excluding the non-traders

Parameter	Meaning of variable associated	MNL model	MNL model with socio-demographic	Hybrid choice model without Socio-demographic	Hybrid choice model with Socio-demographic	Panel ML model without Socio-demographic	Panel ML model with Socio-demographic
ASC_{AVL}		0.016 (0.95)*	-0.00184 (0.99)*	0.0401 (0.88)*	0.0569 (0.19)*	0.192 (0.64)*	0.155 (0.42)*
ASC_{AVO}	Alternative specific variables	-0.583 (-2.72)	-0.623 (-2.63)	-0.571 (-2.64)	-0.567 (-2.27)	-0.398 (-1.7)*	-0.487 (-1.5)*
ASC_{CAR}		-	-	-	-	-	-
β_x							
β_{TT_CAR}		-0.0602 (-11.82)	-0.0617 (-11.91)	0.0611 (-11.86)	-0.0619 (-11.92)	-0.0749 (-11.33)	-0.0753 (-11.36)
β_{TT_AVO}	Travel time of each alternative in minutes	-0.0365 (-5.8)	-0.0377 (-5.94)	-0.0372 (-5.88)	-0.0378 (-5.96)	-0.0569 (-7.12)	-0.0565 (-7.2)
β_{TT_AVL}		-0.0606 (-8.99)	-0.0625 (-9.18)	-0.0617 (-9.09)	-0.0628 (-9.2)	-0.0819 (-9.53)	-0.0836 (-9.7)
σ_{TT_CAR}		-	-	-	-	0.03 (6.91)	0.0295 (6.62)
σ_{TT_AVO}	Estimated standard deviations of the distribution of the travel time coefficients	-	-	-	-	0.0338 (7.9)	0.0302 (7)
σ_{TT_AVL}		-	-	-	-	0.0323 (6.93)	0.0325 (7.52)
β_{TC}	Travel cost in euros	-0.526 (-17.73)	0.535 (-17.84)	0.531 (-17.78)	-0.536 (-17.85)	-0.638 (-17.96)	-0.641 (-18.02)
β_τ							
$\beta_{\tau\ Activity\_AVO}$	Extra work or saving time at work (1 and -1 respectively)	-0.159 (-2.34)	-0.166 (-2.44)	-0.163 (-2.4)	-0.166 (-2.45)	-0.193 (-2.59)	-0.195 (-2.63)
$\beta_{\tau\ Travel\_company\_AV}$	If there are travel companions or not in the AV (1 if yes and 0 if not)	-0.187 (-4.43)	-0.181 (-4.29)	-0.184 (-4.35)	-0.181 (-4.27)	-0.216 (-4.63)	-0.206 (-4.44)
$\beta_{\tau\ Travel\_company\_car}$	If there are travel companions or not in the conventional car (1 if yes and 0 if not)	-0.321 (-4.55)	-0.325 (-4.55)	-0.323 (-4.55)	-0.325 (-4.55)	-0.344 (-4.42)	-0.346 (-4.42)
$\beta_{\tau\ Walking\_time\_car}$	Time to walk from the conventional car to the destination	0.0433 (0.31)*	0.0466 (1.07)	0.0454 (1.05)*	0.047 (1.08)*	0.0529 (1.11)*	0.0523 (1.09)*
$\beta_{\tau\ Age\_60plus\_car}$	If the person has more than 60 years old or not (1 if yes and 0 if not)	-	-	-	0.0175 (0.12)*	-	-0.0959 (-0.35)*
$\beta_{\tau\ DO\_retired\_car}$	If the person is retired (1 if yes, 0 if not)	-	-	-	-0.0275 (-0.16)*	-	-0.0456 (-0.14)*
$\beta_{\tau\ DO\_WorkPart\_car}$	If the person does part time work (1 if yes, 0 if not)	-	-	-	-0.0601 (-0.53)*	-	-0.0984 (-0.48)*
$\beta_{\tau\ Mode\_BMT\_car}$	If the person is using daily Bus Tram or Metro (1) or not (0)	-	-0.34 (-1.56)*	-	-0.349 (-1.6)*	-	-0.402 (-1.04)*
$\beta_{\tau\ Mode\_carpool\_car}$	If the person is a carpooler (1) or not (0)	-	0.325 (2.34)	-	0.352 (2.48)	-	0.458 (1.79)*
$\beta_{\tau\ Willing\_to\_work\_car}$	If the person is willing to work in an AV (-1 if yes, 1 if no)	-	0.236 (2.92)	-	0.229 (2.71)	-	0.367 (2.41)
$\beta_{\tau\ Able\_to\_work\_car}$	If the person is able to do his/her job in a car (-1 if yes, 1 if not)	-	-0.00162 (0.98)*	-	-	-	-
$\beta_{\tau\ Buy\text{-}AV\_car}$	If the person is willing to buy an AV (-1 if yes, 1 if not)	-	0.188 (2.23)	-	0.133 (1.51)*	-	0.213 (1.38)*
β_φ							
$\beta_{\varphi\ Convenience\_AV\_car}$	Attitude toward convenience of an AV (the higher the more convenient)	-	-	-0.13 (-4.97)	-0.064 (-2.14)	-	-
	No. parameters	10	15	45**	52**	13	20
	No. of observations	1752	1752	1752	1752	1752	1752
	Null-Log-Likelihood	-1924.77	-1924.77	-1924.77	-1924.77	-1924.77	-1924.77
	Final-Log-likelihood	-1595.47	-1569.35	-1581.8	-1566.36	-1508.64	-1494.62
	Adjusted Rho-Square	0.166	0.177	0.178	0.186	0.209	0.213

* = not significant at a 95% confidence interval.

**=it also includes the remaining parameters of the joint estimation model

AVO = Chauffeur-office, AVL = Chauffeur-leisure.

4.5 Value of travel time

Based on the parameter estimates of the discrete choice models, mean VOTTs can be derived. Since we assume utility is linear-additive and assume no unobserved taste heterogeneity for β_{TC} (hence, β_{TC} is not a random variable), the VOTT can readily be computed from the parameter estimates in Table 3 and Table 4 by computing the ratio of β_{TT} over β_{TC}. However, in the Panel ML models since β_{TT} is randomly distributed in two models, also the VOTT takes the distribution of β_{TT}. In our Mixed Logit models coefficients β_{TT} are normally distributed, so also the inferred VOTT is normally distributed. Thus, to determine the VOTT distribution the following equation has been used (Hess et al., 2004; Sillano and Ortúzar, 2005):

$$\frac{\beta_{TT}}{\beta_{TC}} \sim N\left(\frac{\mu_{TT}}{\beta_{TC}}, \frac{\sigma_{TT}}{\beta_{TC}}\right) \quad (21)$$

Table 5 shows the obtained VOTTs for the AVs experiment. Results indicate that the mean VOTT for AV-office travelers is in general lower compared to conventional car users and AV-leisure users. On the other hand, the mean travel time valuation of AV-leisure users is slightly higher than the VOTT of conventional car users, however, this is not statistically significant. The lower VOTT for AV-office users shows that people are willing to pay less money to reduce their travel time if one is able to use their time productively in an AV. The VOTT obtained for the conventional car in the ML model is not far from the results obtained for the Netherlands by Yap et al. (2016) (Yap et al., 2016) (9.30-9.90 euros/hour) and Kouwenhoven et al. (2014) (Kouwenhoven et al., 2014) (9.25 euros per hour). For the experiment with chauffeur-driven cars, the results for the VOTT can also be found in Table 5.

The differences between the AV and Chauffeur scenarios are significant as shown before and in the VOTTs we can conclude that the chauffeur case leads always to a lower VOTT, which we believe is connected to the distrust that still some people have regarding being driven by a 'machine'. A similar conclusion was taken a previous research regarding the use of AVs as public transport (Yap et al., 2016, 2015).

The Welch's t-test is used to determine whether two means differ significantly from each other. Welch's t-test is a derivative of the Student's t-test and is more reliable when the samples have unequal variances and sample sizes (Welch, 1947). The equation of Welch's t-test is given as follows (Welch, 1938):

$$t = \frac{\bar{X}_1 - \bar{X}_2}{\sqrt{\frac{s_1^2}{N_1} + \frac{s_2^2}{N_2}}} \quad (22)$$

Where $\bar{X}_1$ and $\bar{X}_2$ are the sample means, and s_1 and s_2 are the sample variances and N_1 and N_2 are the samples sizes. To compute the associated degrees of freedom, the Welch-Satterthwaite equation is used. The following equation approximates the degrees of freedom (v):

$$v \approx \frac{\left(\frac{s_1^2}{N_1} + \frac{s_2^2}{N_2}\right)^2}{\frac{s_1^4}{N_1^2 v_1} + \frac{s_2^4}{N_2^2 v_2}} \quad (23)$$

Where v_x is equal to N_x-*1*, and N_x are the sample sizes.

The table of critical t-values is used to determine if a difference in parameters is statistically significant. The results of the test are also presented on the last part of Table 5 where it can be seen that on all cases we cannot reject the hypothesis that both the coefficient of the travel time of the leisure vehicle and the conventional one are the same. For most of the estimated VOTTs the office car VOTTT is significantly different from the leisure VOTT and also in many cases from the conventional vehicle VOTT.

In these calculations we use the Delta method to compute the standard errors of the VOTT. The delta method gives a good approximation of the true standard error of a parameter (Daly et al., 2012) under the assumption that the maximum likelihood estimates are normally distributed – which is the case if the sample is large enough. However, our sample is of moderate size. Therefore, we cross-validate the standard errors that we have obtained with the delta method by using an alternative method which does not rely on the assumption of normality (Armstrong et al., 2001), see Appendix D. The results show that the 95% confidence intervals coincide fairly well across the two methods. This gives support for our finding that the VOTT for conventional car and the VOTT for AV office car are significantly different from one another.

Table 5: Mean VOTT estimates and standard deviations in [€/hour] for the AVs scenario and chauffeur scenario excluding non-traders

VOTT		**MNL model**				**Hybrid choice model**				**Panel model**				**Average over all AV models**	**Average over all Chauffeur models**	**Average**
		No Socio Dem.		With Socio Dem.		No Socio Dem.		With Socio Dem.		No Socio Dem.		With Socio Dem.				
		AVs	chauffeur	AVs	chauffeur	AVs	Chauffeur	AVs	Chauffeur	AVs	Chauffeur	AVs	Chauffeur			
Conventional car	**Mean**	7.80	6.87	7.99	6.92	7.81	6.90	8.02	6.93	8.33	7.04	8.01	7.05	7.99	6.95	7.47
	Std dev.	-	-	-	-	-	-	-	-	4.13	2.82	2.89	2.76	-	-	-
AV-Office	**Mean**	5.85	4.16	5.91	4.23	5.85	4.20	5.93	4.23	7.65	5.35	7.30	5.29	6.41	4.58	5.50
	Std dev.	-	-	-	-	-	-	-	-	4.48	3.18	3.93	2.83	-	-	-
AV-Leisure	**Mean**	8.71	6.91	8.91	7.01	8.72	6.97	8.91	7.03	9.75	7.70	9.61	7.83	9.10	7.24	8.17
	Std dev.	-	-	-	-	-	-	-	-	4.54	3.04	4.61	3.04	-	-	-
Welch's t-test on the differences between the VOTTs																
VOTT AVO -VOTT car		-1.86	-2.91	-1.96	-2.91	-1.84	-2.91	-1.99	-2.92	-0.60*	-1.77	-0.66*	-1.87			
VOTT AVL -VOTT car		0.81*	0.05*	0.83*	0.09*	0.81*	0.07*	0.80*	0.10*	1.22*	0.66*	1.45*	0.78*			
VOTT AVL - VOTT AVO		2.49	2.66	2.68	2.72	2.51	2.69	2.68	2.74	1.77	2.26	2.02	2.47			

* = not significant at a 95% confidence interval.

5 MAIN CONCLUSIONS AND IMPLICATIONS FOR COST BENEFIT ANALYSIS

5.1 Main conclusions from the study

Both the theoretical insights from the microeconomic theory and the empirical results from the DCMs indicate that people who use an AV in which it is possible to perform work activities should have a lower mean VOTT compared to the VOTT of conventional car travelers. On the other hand, people traveling with an AV in which it is possible to have leisure time may have the same VOTT compared to conventional car travelers. It may happen that the experience of safety, for example, is different between riding an AV or driving a car, people may not be trusting the technology yet. Nevertheless, the microeconomics model also points for the possibility of no change in the VOTT in a leisure AV.

The average VOTT of conventional car travelers across both experiments (AVs and chauffeur experiments) yields a value of €7.47 per hour (Table 5). The average VOTT of AV-office travelers is around €5.50 per hour (-26% compared to the VOTT of the conventional car) and the average VOTT of AV-leisure users is around €8.17 per hour (+9.4% compared to the VOTT of the conventional car) taking into account the models which were estimated excluding non-traders. The conclusion is that people who travel in an AV in which they can work are, on average, willing to pay less money to reduce their travel time compared to conventional car travellers, while people who travel in an AV in which they can only have leisure time are on average willing to pay the same to reduce their travel time compared to conventional car travelers. The model results also indicate unanimously that if one chooses the AV with office interior one prefers to save time at the office (substituting travel time for time at home) over working additional time in the morning peak.

Looking at the results of the AV experiment these seem to indicate that traveling alone is preferred over traveling with companions in an AV. This behavior is observed in the conventional car as well. People who are willing to work in an AV have a preference for AVs. Furthermore, car-poolers prefer strongly an AV, while current BMT and car travelers prefer the conventional car. At last, it seems that part-time employees and elderly people (>60 years) tend to choose the conventional car. The non-trader analyses implied that almost half of respondents that are retired, 'other' employed, older than 60 years old, and/or lower educated are non-traders, whereas 66.7% of the primary school educated respondents were respondents. Almost all non-traders chose always the conventional car.

5.2 Implications for Cost-Benefit Analysis

The VOTT is of great importance in CBA for the assessment of the socio-economic impact of new transport projects. It is estimated that the VOTT savings account for approximately 60 to 80 percent of the monetized benefits of new infrastructure (P J Mackie et al., 2001). A change in VOTT could, therefore, cause changes in the benefits accruing from those new transport projects. In this section, we intend to go deeper on how the results of this research have an impact on the current practice of CBA in the Netherlands and it explores the effects of AVs on other modes of transport.

A CBA is a mandatory analysis for all large infrastructural projects in the Netherlands and other countries. It aims at monetizing all direct, indirect and external effects of an infrastructure project (Centraal Planbureau, 2013). A CBA compares the effects of a project with the status quo: the reference scenario (Mouter, 2013). In this case, a social VOTT is used for monetizing travel time resulting from a transport project (Kouwenhoven et al., 2014).

We find that the VOTT is significantly lower for office AV users. Given that 60 to 80 percent of the monetized benefits are derived from travel time savings, this decrease of the VOTT can have major impacts on transport project appraisals. However, a lower VOTT for AV-office users indicates that these trips are more attractive than current ones with conventional cars. The potential implication of this is that AVs may induce new travel demand (new trips) which, in turn, could lead to higher monetized benefits. However, more trips mean extra traffic, which leads to more congestion. Puylaert (2016) has already concluded that the introduction of level 1, 2 and 3 AVs may result in more traffic and more congestion. On the other hand, AVs have the ability to change the road capacity especially if they are able to form platoons and cooperate with each other. Even with intermediate automated driving capabilities such as adaptive cruise control there could be improvements in traffic-flow stability and efficiency, and therefore an increase on road capacity (Arem et al., 2006; Arnaout and Bowling, 2011; Hoogendoorn et al., 2014; Schakel et al., 2010; Tampère et al., 2009). A higher road capacity relates to less congestion when other factors are kept constant. Again, the effect of a lower VOTT for AV-office users compared to conventional vehicle users on traffic flow performance is a topic needing further research.

With a VOTT reduction, it may well happen that people will be willing to take longer trips. In the last 2 decades of the 20th century, the average travel time per day per person in the Netherlands (travel time budget: TTB) increased from about 58 minutes to approximately 72 minutes (van Wee et al., 2006). However, during the economic crisis, the TTB decreased to 61.8 minutes (CBS Statline, 2016). The concept of (a constant) TTB has been researched, see e.g. (Golob et al., 1981; Hupkes, 1982; Mokhtarian and Chen, 2004; Roth and Zahavi, 1981). Van Wee et al. (2006) gave explanations as to why the TTB increased over time in the Netherlands. One of their explanations was that there was an increase on the possibilities for combining travel with other activities leading to a reduction of the disutility of travel time. It is therefore likely that travel times will increase rather than the number of trips (van Wee et al., 2006). Therefore, the introduction of the AV, which facilitates the combination of travel and other activities, could lead to an even higher TTB in the Netherlands. Considering that the average travel speed remains the same, this could result in more distance traveled in the Netherlands.

Based on travel time and the VOTT, this study indicates that the monetized benefits of new infrastructure could drop compared to the current situation. This raises the question as to whether investing in new infrastructure is necessary since longer travel times are more acceptable due to the ability to do work. Despite the fact that we have not tested if the VOTT of AV-travellers remains the same when they are stopped in traffic congestion when only the travel time savings are taken into account, investments in new roads could be reconsidered.

Nonetheless, new infrastructure aims not only to improve the travel time, but the travel time reliability as well (Kouwenhoven et al., 2014). To monetize an improvement in predictability of travel time, the value of travel time reliability (VOR) has been proposed (Carrion and Levinson, 2012). Since the duration of a journey in an AV could be of lesser importance in the future, its reliability could become more important. As mentioned before, AVs could lead to more traffic, and thus longer journey times. More traffic on the roads could result in lower travel time reliability.

The low VOTT for AV users could also have an impact on the use of public transport. Traveling in an AV-office could be a good substitute for traveling by train: the train is a commuting mode in which travelers can currently work as well however it is not door-to-door (Fickling et al., 2009; Kroes and Koopmans, 2014; Scheltes and Correia, 2017). The VOTT of train travelers in the Netherlands is estimated at €9.25 per hour (Kouwenhoven et al., 2014). This VOTT is significantly higher than the VOTT found for AV with office interior travelers. A substitution of train travelers by AV travelers has several potential consequences: Firstly, the intensity of the road traffic increases, because more trips are generated which results in more congestion and more emissions (assuming the same vehicle technology); Secondly, the demand for travelling by train decreases which could imply that investments in rail as a whole become less socially desirable. The introduction of fully-automated vehicles could have an effect on bike usage, BMT and carpooling as well, since AVs could be a substitute for these modes of transport. It is imaginable that this could have major consequences.

6 RECOMMENDATIONS AND FUTURE RESEARCH

Our results have indicated that the VOTT of AV-leisure users could be the same or even higher compared to the VOTT of conventional car users. This is not in line with what is intuitive and being defended by several experts. We, therefore, recommend that more research should specifically be done on measuring the VOTT of AV-leisure users, exploring further what is understood as leisure by the respondents, what they feel is possible to do in a vehicle, and also relating those activities with what they are doing currently should be explored. Nevertheless, through a microeconomics point of view, we have shown that actually this type of vehicle may not accrue great advantages in a balance between leisure time and the salary needed to enjoy that time. The difference between the leisure car and the conventional vehicle would be then credited only to the distrust among today's Dutch population in using an AV which they haven't experienced. In what regards to the vehicle in which a person can work, there is a statistically significant difference on the VOTT when compared to the conventional vehicle. The lower perceived VOTT is connected to the salary that the person earns while riding the vehicle as demonstrated by the microeconomic theory. More research has to be done regarding the different travel times, trip motives and professions for which this would make sense.

We are also recommending further research on travel time reliability when traveling with an AV or the experience of being in traffic congestion when riding an AV. Regarding the work interior vehicle we have not pre-screened for the type of job that the person currently has, we have assumed that the person would have to imagine being able to do work inside the vehicle, while we know that for example, a factory worker would hardly be able to do his/her job in those conditions. Analyzing the bias introduced by this element could be very important to get a better estimation of the changes in VOTT.

Future research may consider as well a richer choice context. In our study we focused on car commute trips only. However, it seems plausible that AVs will also have a major impact on other modes of transport. Therefore, for future research, it is recommended to include non-car modes too and also shared mobility. Moreover, in our experiment, we did not give the option of just riding an AV without any specific activity inside the car, this can make a lot of sense as many people may opt to just being passengers of these vehicles. In an alternative experimental design, the activity can be given as an attribute of an AV alternative and not constitute separate alternatives. Finally, AVs are likely to also impact higher-order choices such as residential location choice and job location choice. Future research should study these effects as well.

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APPENDIX A

First order conditions of equations (**2**) and (**5**) are:

$$\frac{\partial U}{\partial G}(w) - \frac{\partial U}{\partial L} + \frac{\partial U}{\partial W} - \theta \times (1 + \alpha w) = 0 \qquad \text{(A. 1)}$$

and,

$$\theta \times [\tau - t_i + (-1 - \alpha w)W - \alpha w t_i + \alpha c_i)] = 0 \qquad \text{(A. 2)}$$

Where θ is the multiplier of constraint (**5**). As $\theta > 0$ is the most general case, we can solve for W^* in equation (A. **2**), which results in:

$$W^*(c_i, t_i) = \frac{\tau - t_i - \alpha w t_i + \alpha c_i}{1 + \alpha w} \qquad \text{(A. 3)}$$

Substituting W^* in the Utility (Equation (**2**)) we get the conditional indirect utility function, which is:

$$V_i \equiv U\left[\left(\left(\frac{w\tau - c_i}{1 + \alpha w}\right)\right), \left(\alpha\left(\frac{w\tau - c_i}{1 + \alpha w}\right)\right), \frac{\tau - t_i - \alpha w t_i + \alpha c_i}{1 + \alpha w}, t_i\right] \qquad \text{(A. 4)}$$

From this we can obtain:

$$\frac{\partial V_i}{\partial t_i} = 0 + 0 - \frac{\partial U}{\partial W}\left(\frac{1}{1 + \alpha w} + \frac{\alpha w}{1 + \alpha w}\right) + \frac{\partial U}{\partial t_i} = -\frac{\partial U}{\partial W} + \frac{\partial U}{\partial t_i} \qquad \text{(A. 5)}$$

and,

$$\frac{\partial V_i}{\partial c_i} = -\frac{\partial U}{\partial G}\left(\frac{1}{1 + \alpha w}\right) - \frac{\partial U}{\partial L}\left(\frac{\alpha}{1 + \alpha w}\right) - \frac{\partial U}{\partial W}\left(\frac{\alpha}{1 + \alpha w}\right) \qquad \text{(A. 6)}$$

Substituting $\frac{\partial U}{\partial L}$ from the first-order condition:

$$\frac{\partial V_i}{\partial t_i} = -\frac{\partial U}{\partial W} + \frac{\partial U}{\partial t_i} \tag{A. 7}$$

and,

$$\frac{\partial V_i}{\partial c_i} = -\frac{\partial U}{\partial G} + \alpha\theta \tag{A. 8}$$

From which it's possible to obtain:

$$VOTT = \frac{\frac{\partial V_i}{\partial t_i}}{\frac{\partial V_i}{\partial c_i}} = \frac{\frac{\partial U}{\partial W} - \frac{\partial U}{\partial t_i}}{\frac{\partial U}{\partial G} - \alpha\theta} = \frac{\frac{\partial U}{\partial W}}{\frac{\partial U}{\partial G} - \alpha\theta} - \frac{\frac{\partial U}{\partial t_i}}{\frac{\partial U}{\partial G} - \alpha\theta} \tag{A. 9}$$

With $\frac{\partial U}{\partial G} - \alpha\theta$ being the marginal utility of income.

APPENDIX B

First order conditions of equations (2) and (17) are:

$$\frac{\partial U}{\partial G}(w) - \frac{\partial U}{\partial L} + \frac{\partial U}{\partial W} - \theta \times (1 + \alpha w) = 0 \tag{B. 1}$$

and,

$$\theta \times [\tau + \alpha c_i - W(1 + \alpha w)] = 0 \tag{B. 2}$$

Where θ is the multiplier of constraint (17). As $\theta > 0$ is the most general case, we can solve for W^* in equation (B. **2**, which results in:

$$W^*(c_i, t_i) = \frac{\tau + \alpha c_i}{1 + \alpha w} \tag{B. 3}$$

Substituting W^* in the Utility (Equation (**2**)) we get the conditional indirect utility function, which is:

$$V_i = U\left[\left(\left(\frac{w\tau - c_i}{1 + \alpha w}\right)\right), \left(\tau - \frac{\tau + \alpha c_i}{1 + \alpha w} - t_i\right), \frac{\tau + \alpha c_i}{1 + \alpha w}, t_i\right] \tag{B. 4}$$

From this we can obtain:

$$\frac{\partial V_i}{\partial t_i} = -\frac{\partial U}{\partial L} + \frac{\partial U}{\partial t_i} \tag{B. 5}$$

and,

$$\frac{\partial V_i}{\partial c_i} = -\frac{\partial U}{\partial G}\left[\frac{1}{1 + \alpha w}\right] - \frac{\partial U}{\partial L}\left(\frac{\alpha}{1 + \alpha w}\right) + \frac{\partial U}{\partial W}\left(\frac{\alpha}{1 + \alpha w}\right) \tag{B. 6}$$

Substituting $\frac{\partial U}{\partial L}$ from the first-order condition:

$$\frac{\partial V_i}{\partial c_i} = -\frac{\partial U}{\partial G}\left(\frac{1}{1 + \alpha w}\right) - \left[\frac{\partial U}{\partial W} - \theta \times (1 + \alpha w) + \frac{\partial U}{\partial G}(w)\right]\left(\frac{\alpha}{1 + \alpha w}\right) + \frac{\partial U}{\partial W}\left(\frac{\alpha}{1 + \alpha w}\right) \tag{B. 7}$$

and,

$$\frac{\partial V_i}{\partial c_i} = -\frac{\partial U}{\partial G} + \theta\alpha \qquad \text{(B. 8)}$$

From which it’s possible to obtain:

$$\frac{\frac{\partial V_i}{\partial t_i}}{\frac{\partial V_i}{\partial c_i}} = \frac{-\frac{\partial U}{\partial L}+\frac{\partial U}{\partial t_i}}{-\frac{\partial U}{\partial G}+\theta\alpha} = w + \frac{\frac{\partial U}{\partial W}}{\frac{\partial U}{\partial G}-\theta\alpha} - \frac{\frac{\partial U}{\partial t_i}}{\frac{\partial U}{\partial G}-\theta\alpha} \qquad \text{(B. 9)}$$

Because $\frac{\frac{\partial U}{\partial L}}{\frac{\partial U}{\partial G}-\theta\alpha} = w + \frac{\frac{\partial U}{\partial W}}{\frac{\partial U}{\partial G}-\theta\alpha}$

With $\frac{\partial U}{\partial G} - \theta\alpha$ being the marginal utility of income.

APPENDIX C

Automated vehicles experiment Exploratory Factor Analysis (EFA)

In Table 6 it can be seen the results of the Exploratory Factor Analysis (EFA) for the AV experiment excluding the non-traders. Some indicators show double factor loadings. In these occasions, an indicator has a high loading on one factor and a loading close to 0.30 on another factor. However, a simple structure is maintained such that it is not assumed that double factor loadings cause any problems. Attitudinal indicators with a communality lower than 0.25 or with a factor loading lower than 0.50 were excluded from the analysis.

Results show a three-factor solution including 11 of the 18 indicators. The first factor includes mainly indicators that are related with the automated driving technology, therefore, it is given the name “*trust in the technology of automated driving”*. The indicators with high loading on factor two belong to a category that was named: *“convenience of automated driving*”. The last factor reflects the attitude towards the safety aspects of automated driving, and is named *“safety of automated driving”*.

Table 6: Estimation results of the EFA with the Likert scale indicators (factor loadings <0.30 are not shown)

		Factor 1	Factor 2	Factor 3
ST3	I trust that a computer can drive my car with no assistance from me	-0.310		0.834
ST4	I would be comfortable entrusting the safety of a close family member to an automated vehicle	-0.344		0.832
ST7	I like it that I can delegate the driving to the automated driving system if I am due to certain circumstances not able to drive myself		0.712	
ST8	I like it that the automated vehicle produces fewer pollutant emissions		0.640	
ST9	I like it that the vehicle can park itself at cheaper parking spots away from my destination		0.624	
ST10	I am afraid that the automated vehicle will malfunction	0.743		
ST11	I dislike the idea of automated driving	0.710	-0.393	

ST12	I am afraid that the automated vehicle will not be fully aware of what is happening around	0.793		
ST13	I do not like it that I do not have control of how the automated vehicle drives	0.738		-0.332
ST14	I think that the automated driving system provides me more safety compared to manually driving	-0.310	0.314	0.587
ST17	I like it if AVs can adapt routes due to congestion		0.728	

Chauffeur experiment Exploratory Factor Analysis

The results of the EFA for the chauffeur case excluding non-traders can be seen in Table 7. Some of the indicators load double on multiple factors. Indicators 3, 4, 7, 11 and 15 have double loadings, however the one loading is very high and the other loading is very low (close to 0.30). So, for an EFA this is not assessed as problematic, because a simple structure is maintained again.

In total, 11 of the 18 indicators are used to estimate three latent factors. The estimated results show many similarities with the estimated results of the latent variable model with the AV-case data. In both cases three factors are estimated, from which factor 2 includes the exact same indicator variables. The third factor now only consists of two indicators instead of three. Factor 1, on the other hand, consists of five indicator variables, from which indicator 15 was not in the former EFA. The additional variable in the first factor is in line with the other indicators. Because most of the indicators are the same as in the former EFA the same factors names are applied. The first factor is defined as "*trust in the technology of automated driving*", the second factor is defined as "*convenience of automated driving*", and the last factor is called "*safety of automated driving*".

Table 7: Estimation results of the EFA with the Likert scale indicators for the chauffeur case study (factor loadings <0.30 are not shown)

		Factor 1	Factor 2	Factor 3
ST3	I trust that a computer can drive my car with no assistance from me	-0.312	0.323	0.805
ST4	I would be comfortable entrusting the safety of a close family member to an automated vehicle	-0.357		0.802
ST7	I like it that I can delegate the driving to the automated driving system if I am due to certain circumstances not able to drive myself		0.705	0.308
ST8	I like it that I can delegate the driving to the automated driving system if I am due to certain circumstances not able to drive myself		0.766	
ST9	I like it that the vehicle can park itself at cheaper parking spots away from my destination		0.765	
ST10	I am afraid that the automated vehicle will malfunction	0.643		
ST11	I dislike the idea of automated driving	0.783	-0.304	
ST12	I am afraid that the automated vehicle will not be fully aware of what is happening around	0.851		
ST13	I do not like it that I do not have control of how the automated vehicle drives	0.759		
ST15	I wish that automated vehicles were not around in the future	0.573	-0.368	

ST17	I like it if automated vehicles can adapt routes due to congestion	0.671

APPENDIX D

MNL - No Socio. - AV scenario

		delta method (normal approx)			t-test (Armstrong)		
	Point est.	Std err (delta method)	Lower bound	Upper bound	Middle value	Lower bound	Upper bound
VOTT_ConvCAR	7.80	0.617	6.59	9.00	7.64	6.19	9.10
VOTT_AVO	5.85	0.697	4.48	7.22	5.71	4.18	7.25
VOTT_AVL	8.71	0.764	7.21	10.20	8.52	6.85	10.19

MNL - No Socio. - chauffeur scenario

		delta method (normal approx)			t-test (Armstrong)		
	Point est.	Std err (delta method)	Lower bound	Upper bound	Middle value	Lower bound	Upper bound
VOTT_ConvCAR	6.87	0.617	5.66	8.08	6.75	5.54	7.97
VOTT_AVO	4.16	0.697	2.80	5.53	4.07	2.70	5.45
VOTT_AVL	6.91	0.764	5.42	8.41	6.79	5.28	8.29

MNL - With socio. - AV scenario

		delta method (normal approx)			t-test (Armstrong)		
	Point est.	Std err (delta method)	Lower bound	Upper bound	Middle value	Lower bound	Upper bound
VOTT_ConvCAR	7.99	0.740	6.54	9.44	7.84	6.37	9.30
VOTT_AVO	5.91	0.752	4.44	7.39	5.78	4.29	7.26
VOTT_AVL	8.91	0.823	7.29	10.52	8.71	7.09	10.34

MNL - With Socio. - chauffeur scenario

		delta method (normal approx)			t-test (Armstrong)		
	Point est.	Std err (delta method)	Lower bound	Upper bound	Middle value	Lower bound	Upper bound
VOTT_ConvCAR	6.92	0.616	5.71	8.13	6.81	5.59	8.02
VOTT_AVO	4.23	0.687	2.88	5.57	4.14	2.79	5.49
VOTT_AVL	7.01	0.755	5.53	8.49	6.88	5.39	8.37

Hybrid - No Socio. - AV scenario

		delta method (normal approx)			t-test (Armstrong)		
	Point est.	Std err (delta method)	Lower bound	Upper bound	Middle value	Lower bound	Upper bound
VOTT_ConvCAR	7.81	0.737	6.37	9.26	7.66	6.20	9.12

VOTT_AVO	5.85	0.773	4.34	7.37	5.71	4.19	7.24
VOTT_AVL	8.72	0.841	7.07	10.37	8.53	6.86	10.19

Hybrid - No socio. - Chauffeur scenario

		delta method (normal approx)			t-test (Armstrong)		
	Point est.	Std err (delta method)	Lower bound	Upper bound	Middle value	Lower bound	Upper bound
VOTT_ConvCAR	6.90	0.618	5.69	8.12	6.79	5.57	8.01
VOTT_AVO	4.20	0.692	2.85	5.56	4.11	2.75	5.48
VOTT_AVL	6.97	0.760	5.48	8.46	6.84	5.35	8.34

Hybrid - With Socio. - AV scenario

		delta method (normal approx)			t-test (Armstrong)		
	Point est.	Std err (delta method)	Lower bound	Upper bound	Middle value	Lower bound	Upper bound
VOTT_ConvCAR	8.02	0.741	6.57	9.48	7.87	6.41	9.34
VOTT_AVO	5.93	0.751	4.46	7.40	5.79	4.31	7.27
VOTT_AVL	8.91	0.822	7.30	10.52	8.72	7.10	10.35

Hybrid - With socio. - Chauffeur scenario

		delta method (normal approx)			t-test (Armstrong)		
	Point est.	Std err (delta method)	Lower bound	Upper bound	Middle value	Lower bound	Upper bound
VOTT_ConvCAR	6.93	0.616	5.72	8.14	6.82	5.60	8.03
VOTT_AVO	4.23	0.687	2.89	5.58	4.14	2.79	5.49
VOTT_AVL	7.03	0.755	5.55	8.51	6.90	5.41	8.39

Panel ML - No Socio. - AV scenario

		delta method (normal approx)			t-test (Armstrong)		
	Point est.	Std err (delta method)	Lower bound	Upper bound	Middle value	Lower bound	Upper bound
VOTT_ConvCAR	8.33	0.791	6.78	9.88	8.18	6.62	9.75
VOTT_AVO	7.65	0.823	6.04	9.26	7.49	5.86	9.11
VOTT_AVL	9.75	0.850	8.08	11.41	9.54	7.86	11.22

Panel ML - No socio. - Chauffeur scenario

		delta method (normal approx)			t-test (Armstrong)		
	Point est.	Std err (delta method)	Lower bound	Upper bound	Middle value	Lower bound	Upper bound
VOTT_ConvCAR	7.04	0.638	5.79	8.29	6.93	5.67	8.18
VOTT_AVO	5.35	0.709	3.96	6.74	5.24	3.84	6.63
VOTT_AVL	7.70	0.764	6.21	9.20	7.55	6.04	9.06

Panel ML - With Socio. - AV scenario

		delta method (normal approx)			t-test (Armstrong)		
	Point est.	Std err (delta method)	Lower bound	Upper bound	Middle value	Lower bound	Upper bound
VOTT_ConvCAR	8.01	0.733	6.57	9.44	7.86	6.42	9.31
VOTT_AVO	7.30	0.791	5.74	8.85	7.14	5.58	8.70
VOTT_AVL	9.61	0.832	7.98	11.24	9.41	7.77	11.05

Panel ML - With socio. - Chauffeur scenario

		delta method (normal approx)			t-test (Armstrong)		
	Point est.	Std err (delta method)	Lower bound	Upper bound	Middle value	Lower bound	Upper bound
VOTT_ConvCAR	7.05	0.634	5.80	8.29	6.93	5.68	8.18
VOTT_AVO	5.29	0.693	3.93	6.65	5.17	3.81	6.54
VOTT_AVL	7.83	0.760	6.34	9.32	7.67	6.17	9.17

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